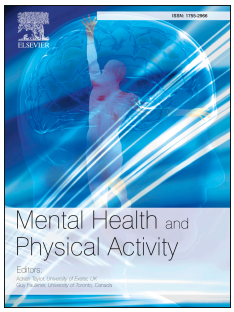
Accepted Manuscript



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PII: S1755-2966(16)30086-2

DOI: 10.1016/j.mhpa.2017.04.001

Reference: MHPA 210

To appear in: *Mental Health and Physical Activity*

Received Date: 31 October 2016

Accepted Date: 10 April 2017

Please cite this article as: Babic, M.J., Smith, J.J., Morgan, P.J., Eather, N., Plotnikoff, R.C., Lubans, D.R., Longitudinal associations between changes in screen-time and mental health outcomes in adolescents, *Mental Health and Physical Activity* (2017), doi: 10.1016/j.mhpa.2017.04.001.

Longitudinal associations between changes in screen-time and mental health outcomes in adolescents.

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Word counts: Abstract: 195 Main text: 3585

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Abstract:

Introduction

The primary aim was to examine longitudinal associations between changes in screen-time and mental health outcomes among adolescents.

Methods

Adolescents (N = 322, 65.5% females, mean age = 14.4 ± 0.6 years) reported screen-time and mental health at two time points over a school year. Multi-level linear regression analyses were conducted after adjusting for covariates.

Results

Changes in total recreational screen-time (β = -.09 p = .048) and tablet/mobile phone use (β = -.18, p < .001) were negatively associated with physical self-concept. Changes in total recreational screen-time (β = -.20, p = .001) and computer use (β = -.23, p = .003) were negatively associated with psychological well-being. A positive association was found with television/DVD use and psychological difficulties (β = .16, p = .015). No associations were found for non-recreational screen-time.

Conclusion

Changes in recreational screen-time were associated with changes in a range of mental health outcomes.

Key words: Screen-time, Mental Health, Adolescents, Longitudinal

Introduction

The World Health Organization define mental health as a state of well-being and effective functioning in which an individual realizes their abilities, is resilient to stresses of life and is able to make a positive contribution to their community (Herrman, Saxena, & Moodie, 2005). Mental health problems (ill-being) are conditions that negatively affect an individual's mood, thinking and behavior (e.g., depression, anxiety, psychological difficulties and psychological distress) (Manderscheid et al., 2010). These disorders account for 45% of the global burden of disease among adolescents (Gore et al., 2011), affecting one in five young people (Asare, 2015). Despite their prevalence and burden to society, the underlying factors contributing to mental health problems among adolescents are poorly understood (Erskine et al., 2015). Given half of all cases of mental health problems develop by age 14 and remain untreated until adulthood (Erskine et al., 2015), there is an urgent need to identify modifiable determinants of mental health during adolescence. The period of adolescence marks a transition between primary to secondary school which may be particularly important.

Excessive screen-time has emerged as a behaviour that may contribute to mental health (both well-being and ill-being) during adolescence (Hamer, Yates, Sherar, Clemes, & Shankar, 2016). The use of screens is often necessary for educational purposes, and some recreational screen-time (i.e., using television, DVD, computer, and tablet/mobile phone) may support young people's well-being (Houghton et al., 2015). However, time spent using screens for leisure has dramatically increased in recent decades (Houghton et al., 2015), and now typically exceeds what can be considered 'healthy' use. Indeed, the vast majority of adolescents (70-80%) exceed the recreational screen-time guidelines of less than two hours per day (Hardy, 2013; Morley et al., 2012; Owens, Crone, Croix, Gidlow, & James, 2013).

With the availability and popularity of screen-based media increasing among youth, further work is needed to examine the effects of media engagement on mental health (Tremblay et al., 2011). Currently, few studies have explored associations between screen-time and the psychological antecedents of mental health (e.g., poor self-concept, aspects of wellbeing or psychological difficulties). Physical self-concept refers to the judgement of several aspects of one's physical self, i.e., appearance, strength, body fat and coordination (Marsh, Richards, Johnson, Roche, & Tremayne, 1994). Psychological well-being refers to the contentment with life and experiencing a richness of positive emotions (Straatmann, Oliveira, Rostila, & Lopes, 2016). Psychological difficulties refer to feelings of stress, loneliness, psychosocial feelings (Goodman, 1997). An improved understanding of the influence of screen-time on such psychological constructs is merited, principally as the majority of previous research has focused on indicators of mental ill-being (e.g., anxiety and depression).

Systematic reviews have concluded that excessive screen-time is negatively associated with well-being and positively associated with ill-being in young people (Costigan, Barnett, Plotnikoff, & Lubans, 2013; Tremblay et al., 2011). More specifically, studies have demonstrated that exposure to high levels of screen-time is negatively associated with physical self-concept (Suchert, Hanewinkel, & Isensee, 2016; Suchert, Hanewinkel, Isensee, & Group, 2015) and psychological well-being (Muusses, Finkenauer, Kerkhof, & Billedo, 2014). While other studies have found screen use is positively associated with depression, anxiety (Cao et al., 2011; Kremer et al., 2014), psychological difficulties (Liu, Ming, Yi, Wang, & Yao, 2016; Parkes, Sweeting, Wight, & Henderson, 2013), and psychological distress (Booker, Skew, Kelly, & Sacker, 2015; Hamer, Stamatakis, & Mishra, 2009; Parkes et al., 2013) among adolescents.

The evidence for the influence of screen time on mental health in young people is building, but has been limited by a number of methodological shortcomings. For example, the majority of studies have been cross-sectional (Allen & Vella, 2015), involved the examination of only one screen medium (usually television) (Hamer et al., 2009), measured a narrow selection of mental health indicators (typically depression) (Kremer et al., 2014), and failed to statistically control for potential confounding variables (e.g., adiposity and physical activity) (Mathers et al., 2009; Rosen et al., 2014). Developing a more comprehensive understanding of the associations between screen-time and mental health outcomes in adolescents is a critical step toward addressing the high prevalence of mental health problems in this population.

The primary aim of the present study was to examine longitudinal associations between changes in screen-time (total and device specific) and multiple indicators of mental health (well-being and ill-being) among a sample of adolescents. We hypothesized that changes in recreational screen-time will be: 1) negatively associated with changes in physical self-concept and psychological well-being; and 2) positively associated with changes in psychological difficulties, after controlling for potential confounders. A secondary aim was to examine the association between non-recreational screen-time (i.e., for homework) and these mental health outcomes. We hypothesized that non-recreational screen-time would not be associated with mental health outcomes.

Methods:

Participants

Data for the present investigation were drawn from the Switch-off 4 Healthy Minds study. A detailed description of the original study protocol and outcomes have been published previously (Babic et al., 2015; Babic et al., 2016). Ethics approval for the study was obtained

from the Human Research Ethics Committees of the University of Newcastle, Newcastle-Maitland Catholic Schools Office and the Diocese of Broken Bay. Schools, parents and participants provided informed consent. Catholic secondary schools (N = 20) located in the Hunter region of New South Wales, Australia were invited to participate and the first eight schools to provide written consent were accepted. The study focused on students in the first year of secondary school (i.e., grade 7) who had recently transitioned from primary school. These students completed an eligibility questionnaire asking them to report their total time spent using screen devices on a typical school day. Students failing to meet national screen-time guidelines (i.e., > 2hours/day) were considered eligible and invited to participate. The first 40 students from each school to return signed consent letters were included. Time 1 (T1) data were collected at each school between April and June, 2014 and Time 2 (T2) data (96% of the original sample) were collected between October and December, 2014.

Measures:

All assessments were conducted at schools by trained research assistants. Basic demographic information including: sex, country of birth, socio-economic status (SES) based on household postcode, and the number of children who speak English at home were collected (Table 1). Self-report measures were collected in exam-like conditions using an online survey with Apple iPads and physical measures were conducted discretely by a same-sex assessor.

Recreational screen-time

Screen-time was measured using the Adolescent Sedentary Activity Questionnaire (ASAQ) (Hardy, Booth, & Okely, 2007). The ASAQ required participants to self-report the time spent using a variety of screen devices on each day of the week, including weekends. Specifically, participants were asked to report time spent using various screen devices, which included: television, DVD, computer, and tablet/mobile phone for entertainment purposes on a usual

school week. The final item (i.e., tablet/mobile phone) was not included in the original ASAQ instrument but was added to reflect current trends in adolescents' use of screen media. Non-recreational screen-time consisted of computer use for homework. Mean daily screen-time was calculated by adding the time spent using each screen device on each day of the week and dividing by the number of reported days (i.e., 7). The ASAQ has previously reported acceptable test–retest reliability in girls (ICC = 0.70, 95% CI: 0.40, 0.85), and boys (ICC = 0.84, 95% CI: 0.69, 0.91) (Hardy et al., 2007).

Mental health

The physical self-concept subscale from Marsh's Physical Self-Description Questionnaire (Marsh, 1996) was used to provide a measure of self-concept in the physical domain. Students responded to six items on a 6-point scale (1 = '*False*', to 6 = '*True*') to how true each statement was for them (e.g., '*I am a physically strong person'*). Higher scores on this measure indicate better physical self-concept. The internal consistency of the physical self-concept subscale among the present sample was high (Cronbach's $\alpha = 0.95$).

Deiner and colleagues' Flourishing Scale (Diener et al., 2010) was used to measure participants' psychological well-being. The Flourishing Scale is a brief 8-item summary measure of a person's self-perceived success in key areas such as engagement, relationships, self-esteem, meaning, purpose and optimism (Diener et al., 2010). Participants were asked to respond using a 7-point scale (1 = strongly disagree, to 7 = strongly agree) to each item (e.g., '*I lead a purposeful and meaningful life'*). A summary score is calculated as the sum of each item with a possible range of 8 to 56**.** A high score represents a person with many psychological resources and strengths (Diener et al., 2010)**.** The Flourishing Scale has shown acceptable validity and reliability among adolescents (Silva & Caetano, 2013).

To measure ill-being, participants completed the Strength and Difficulties Questionnaire (Goodman, 1997), which is a behavioral screening questionnaire divided into five subscales: emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems and prosocial behavior (Truman et al., 2003). Four of these are potential problems, and one is strength-related (prosocial). Participants were asked to respond on a 3-point scale ("not true" to "certainly true") to each item (e.g., '*I worry a lot*'). Each subscale is comprised of five items and the subscale score can range from zero to 10. The 'difficulties' summary score is calculated by summing the scores of the four 'difficulties' subscales (possible range = 0 - 40) (i.e. all subscales excluding pro-social). Each one-point increase in the total difficulty score corresponds to an increase in the risk of mental health disorders (Goodman, 1997). The Strength and Difficulties Questionnaire has been validated in youth 11 years or over (Goodman, Meltzer, & Bailey, 1998).

Adiposity

Weight was measured without shoes, in light clothing using a portable digital scale (Model no. UC-321PC, A&D Company Ltd, Tokyo Japan) and height was recorded using a portable stadiometer (Model no. PE087, Mentone Educational Centre, Australia). Body mass index (BMI) was calculated using the standard equation (weight [kg] / height $[m]^2$) and BMI z-scores were calculated using the 'LMS' method (Onis et al., 2007). All assessments were conducted by trained, same sex research assistants.

Physical activity

Physical activity was assessed over seven days using GENEActiv (Model GAT04, Activinsights Ltd, Cambridgeshire England) wrist worn accelerometers, and activity intensity was determined using existing cut-points (Phillips, Parfitt, & Rowlands, 2013). Valid wear time was defined as a minimum of ten hours per day on at least three days. GENEActiv wrist

worn accelerometers have displayed acceptable intra-and inter-instrumental reliability and provide a valid and reliable estimate of physical activity in young people (Phillips et al., 2013). Non-wear time was defined as 30 minutes of consecutive zeros. Students providing valid accelerometer wear time are reported in Table 3.

Statistical analysis

Analyses were performed using MPlus, version 7.11 for Windows (Muthén & Muthén, Los Angeles, CA) and IBM SPSS Statistics for Windows version 22 (2010 SPSS Inc., IBM Corp., Armonk, NY), with statistical significance being set at $p < 0.05$. Multi-level linear regression analyses were used to assess associations between screen-time (total and device specific) at T2 and the presence of mental health at T2. Analyses were adjusted for: T1 measures of the exposure and outcome variables, group allocation, school clustering, sex, SES, T1 BMI and T1 physical activity. Previous studies have demonstrated that sex (Syed & Schneider, 2016), SES (Pulsford, Griew, Page, Cooper, & Hillsdon, 2013), BMI and physical activity (Marshall, Biddle, Gorely, Cameron, & Murdey, 2004) are associated with screen-time in young people. Participants with missing data were not included in the sensitivity analyses, and results were not affected due to high retention at T2. Paired samples t-tests were used to examine changes in screen-time and mental health outcomes between T1 and T2.

Results

Eligibility screening was completed by 1154 students, of whom 935 (81%) were considered eligible. Ninety-six percent of individuals were retained across the study (308/322). Characteristics of the study sample are presented in Table 1. Descriptive statistics of screen-time and mental health (at both time points) by sex, including means and standard deviations are reported in Table 2. Table 3 reports the associations between screen-time and mental health indicators. Mean screen-time and mental health scores at both time points by sex are

presented in Figure 1 and 2 respectively. Mean total screen-time among all participants significantly declined from 302 mins/day at T1 to 266 mins/day at T2 ($p < 0.001$). No significant changes in mental health outcomes were evident.

Recreational screen-time and mental health outcomes

Changes in total recreational screen-time (β = -.09, p = .048) and tablet/mobile phone use (β = -.18, p < .001) were negatively associated with physical self-concept. Changes in total recreational screen-time (β = -.20, p = .001) and computer use (β = -.23, p = .003) were negatively associated with psychological well-being. A positive association was found between television/DVD use and psychological difficulties (β = .16, p = .015).

Non-recreational screen-time and mental health outcomes

No associations were found between any of the indicators of mental health and changes in screen use for homework.

Discussion

The primary aim of this study was to examine associations between changes in recreational screen-time and changes in mental health outcomes among a sample of adolescents in the first year of secondary school. Significant associations were found between changes in total and device-specific recreational screen-time and a range of mental health outcomes. No clear device-specific trends emerged. There was no association between non-recreational screen-time and mental health outcomes.

Changes in both total recreational screen-time and tablet/mobile phone use were negatively associated with changes in physical self-concept. Previous cross-sectional studies among adolescents have reported negative associations between screen-time (television/DVD and video games use) and physical self-concept (Suchert et al., 2016) as well as physical attractiveness (Suchert, Hanewinkel, Isensee, et al., 2015). However, no significant

associations were found in a cross-sectional study examining the relationship between screen-time (across multiple devices) and physical self-concept in a sample of adolescent girls from schools located in low income communities (Nihill, Lubans, & Plotnikoff, 2013). It is not clear how the use of screen-based devices might influence physical self-concept, but it is likely to be a complex process. It is possible that the emerging influence of social media technology commonly used by adolescents on tablets/mobile phones (such as Facebook, Instagram, Snapchat and DailyBooth) may explain the adverse associations in physical-self-concept observed in the current study. Social media typically involves the sharing of images and photos, which may encourage adolescents to compare themselves with their peers (Zwier, Araujo, Boukes, & Willemsen, 2011). As a consequence of engaging with these social media platforms, discrepancies between broadcasted ideals and self-perceptions of adolescents may have negative mental health consequences due to inflated social pressure to conform, feelings of body inadequacy (Eyal & Te'eni-Harari, 2013), and unhealthy changes in behaviour.

Changes in total recreational screen-time and computer use were negatively associated with psychological well-being. Our findings are consistent with the recent ATLAS school-based obesity prevention program for adolescent boys, which found that reductions in recreational screen-time partially mediated the effect of the intervention on well-being assessed using the same measure (Lubans et al., 2016). Notably, computer use may negatively impact adolescents' psychological well-being through a number of mechanisms. One such potential mechanism relates to cyberbullying (i.e., harassment through technology via chat forums or online gaming). Previous studies have reported increased negative feelings (e.g., helplessness) (Spears, Slee, Owens, & Johnson, 2009), levels of depression, social dissatisfaction, withdrawal (Perren, Dooley, Shaw, & Cross, 2010), and lower levels of self-esteem (Jackson, von Eye, Fitzgerald, Zhao, & Witt, 2010) in response to cyberbullying. Alternatively, as most adolescents use computers and are connected to the internet (DeBell &

Chapman, 2006), compulsive internet use may be another mechanism responsible for the present findings. An increasing number of adolescents experience difficulties in regulating internet use (Muusses et al., 2014; Widyanto & Griffiths, 2006), and compulsive internet users are more depressed, stressed, lonely, often have lower self-esteem (Muusses et al., 2014; Widyanto & Griffiths, 2006) and demonstrate lower psychological well-being (Muusses et al., 2014; Widyanto & Griffiths, 2006).

Associations between changes in screen-time and psychological difficulties were inconclusive and only television/DVD use was found to be significantly associated with this outcome. Prior cross-sectional (Busch, Ananda Manders, & Rob Josephus de Leeuw, 2013) and longitudinal (Booker et al., 2015) studies have demonstrated exposure to screen-time may be associated with analogous psychiatric difficulties. Comparably, numerous studies have produced inconsistent findings (Booker et al., 2015; Parkes et al., 2013), or report no association (O'Connor et al., 2016) in young people. It is possible the varying findings may be due to differences in the measurement of screen-time (in addition to the combining of time engaged in television and DVD viewing) and/or the duration of follow-up periods. Establishing causal mechanisms responsible for impairments presents a challenge, as television/DVD use may influence mental health in a variety of ways.

Previous studies suggest elevated levels of psychological distress can lead to changes in behavior in adolescents. For example, studies have shown that television use (especially if the content is violent) may contribute to conduct problems (Liu et al., 2016; Parkes et al., 2013), and may predict aggression and attention problems (Strasburger, Jordan, & Donnerstein, 2010; Zimmerman & Christakis, 2007). In addition, the nature of screen viewing (how adolescents watch, what they watch, and with whom) may have important implications. Television/DVD use may impact on excitement, concentration and attention levels (Parkes et al., 2013); contribute to feelings of loneliness, anxiety and unhappiness as

they are often viewed in solitude (Bohnert & Garber, 2007; Gentile et al., 2011; Sund, Larsson, & Wichstrøm, 2011); and reduce prosocial behavior (associated with reduced levels of empathy through exposure to violent content) (Anderson & Bushman, 2001).

Alternatively, the negative effect of screen-time on mental health may be due to the displacement of opportunities to participate in activities that promote mental health (Pea et al., 2012; Primack, Swanier, Georgiopoulos, Land, & Fine, 2009). Such activities may include sleep (Kaneita et al., 2009), physical activity (Sanchez-Villegas et al., 2008) or social activities (Primack et al., 2009). At present, there is limited evidence to conclude whether, or to what degree, associations between screen-time and mental health are explained by the content and context of screen viewing versus sedentariness itself. It is possible there are direct effects of sedentariness and low energy expenditure on the structure and functioning of the brain. However, the etiology of mental health problems is complex and likely caused by complex interactions between biological, sociological and behavioral factors. Teasing out the specific cause and effect relationships between screen-time and mental health outcomes should be a focus of future research.

The current study builds on previous research by examining associations between changes in multiple screen devices and indicators of well-being and ill-being during the first year of secondary school. Strengths of this study include the high participant retention, robust multi-level modeling, use of objectively measured physical activity, and adjustment for relevant covariates. However, there are some limitations that should be noted. Although the associations between screen-time and mental health were statistically significant, the magnitude of effects were small (Range -.23 to .16). It has previously been suggested that a minimum effect size of .2 is required for an association to be considered meaningful (Lipsey, 1990). Considering the associations observed in the present study were typically below this threshold, it is possible our findings are trivial. However, the magnitude of effects may reflect

the fact that participants had relatively good mental health, and/or other psychological resources to buffer them from mental health problems (e.g. supportive family environment, social capital etc.). Alternatively, the adverse effects of increasing screen use may accumulate over time and stronger associations might be seen with longer duration follow-up. Majority of participants were female and ethnically homogeneous, limiting generalizability of findings to the broader Australian population. Participants were considered eligible if they exceeded screen-time guidelines, thus could be considered 'high' screen-time users.

With few objective measures of screen-time that can be feasibly be used for research, recreational screen-time was measured by self-report which remains a significant challenge in accurately assessing sedentary behavior due to the possibility of recall and social desirability biases (Atkin et al., 2012). The current study focused solely on the volume of daily screen-time and did not measure the content being viewed on the various devices examined. It remains unknown whether it is the volume or content of screen-based recreation that explains associations between screen use and mental health, and our findings do not provide evidence of causality. With causality not being directly inferred it is possible young people with poor mental health prefer to spend time engaged in screens (Suchert, Hanewinkel, & Isensee, 2015), therefore the relationship between mental health and excessive screen-time is potentially bidirectional (Hume et al., 2011). It is not possible to conclusively attribute all of the negative mental health effects reported in this study to screen-time since sleep patterns and social influences were not assessed.

Conclusion

This study makes a unique contribution by examining how changes in total and device-specific screen-time relate to changes in a variety of mental health indicators in adolescents during the first year of secondary school. Significant associations were found between changes in total and device-specific recreational screen-time and mental health outcomes, no

clear device-specific trends emerged. Our findings, although important, identify the need for further research examining how different devices impact on mental health, relative to their multiple purposes (i.e., gaming, communication, education). Further longitudinal and experimental studies are needed to improve our understanding of the casual mechanisms that explain how screen-time impacts upon mental health outcomes.

Competing interests

The authors have no competing interests to declare.

Author contributions

All authors contributed to developing, editing, and approving the final version of the paper.

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Table 1: Characteristics of the study sample

Characteristics	Total (N = 322)
Age, y, mean, SD [a]	14.40 ± 0.6
Born in Australia, n	322 (100%)
Sex, n	
Female	211 (66%)
Male	111 (34%)
English language spoken at home, n	316 (98%)
Cultural background, n	
Australian	316 (98%)
European	4 (2%)
African	0 (0%)
Asian	2 (0%)
Middle eastern	0 (0%)
Other	0 (0%)
Socioeconomic position, n [b]	
1-2	13 (4%)
3-4	84 (26%)
5-6	188 (58%)
7-8	25 (8%)
9-10	12 (4%)
Weight, kg, mean, SD [c]	51.49 ± 12.9
Height, cm, mean, SD [c]	156.98 ± 7.3
BMI, $kg.m^{-2}$ [d]	20.73 ± 4.2
Weight status, n	
Underweight	37 (12%)
Healthy weight	167 (52%)
Overweight	75 (23%)
Obese	43 (13%)

[a] Abbreviations: y = years, SD = standard deviation

[b] Socioeconomic position determined by population decile using Socio-Economic Indexes For Areas of relative socioeconomic disadvantage based on residential postcode (1 = lowest, 10 = highest).

[c] Abbreviations: SD = standard deviation

[d] Abbreviations: BMI = body mass index, SD = standard deviation

Table 2: Levels of screen-time and mental health across time points in the total sample and by sex.

Outcome	**T1**			**T2**		
Recreational screen-time	**All mean (SD)**	**Females mean (SD)**	**Males mean (SD)**	**All mean (SD)**	**Females mean (SD)**	**Males mean (SD)**
Total screen-time	302.60 (194.80)	290.09 (194.84)	326.37 (193.38)	266.55 (195.10)	258.57 (209.35)	281.54 (164.95)
Television/DVD	141.83 (95.20)	139.84 (94.92)	145.60 (96.06)	124.52 (102.97)	121.86 (107.49)	129.53 (94.17)
Personal computer use	38.69 (70.10)	26.32 (46.72)	62.20 (96.55)	33.56 (66.94)	23.56 (57.11)	52.35 (79.24)
Tablet/mobile phone use	122.08 (101.30)	123.92 (107.18)	118.57 (89.40)	108.46 (92.08)	113.16 (97.86)	99.65 (79.80)
Non-recreational screen-time						
Homework	42.43 (36.09)	43.34 (36.42)	40.69 (35.56)	37.75 (37.35)	37.12 (32.65)	38.93 (45.00)
Mental health outcomes						
Physical self-concept	27.63 (7.41)	27.44 (7.66)	27.97 (6.94)	27.34 (8.23)	26.72 (8.68)	28.50 (7.20)
Psychological well-being	46.61 (7.78)	47.33 (7.55)	45.24 (8.07)	46.57 (8.15)	47.20 (7.97)	45.39 (8.40)
Psychological difficulties	15.46 (4.05)	15.64 (3.88)	15.11 (4.34)	14.98 (4.64)	15.01 (4.36)	14.92 (5.15)

Note: SD = Standard deviation. T1 = Time 1 and T2 = Time 2. All screen-time measured in minutes/day

Table 3: Associations of screen-time (T2) and mental health (T2) for the total sample over the first year of secondary school

Screen-time at (T2)	Mental health (T2)	Model 1 B (SE)	Model 1 *β* (SE)	*p* value	R^2
Total recreational screen-time	Physical self-concept	-0.003 (0.002)	*-0.09* (0.046)	.048	0.563
	Psychological well-being	-0.008 (0.002)	*-0.20* (0.059)	.001	0.357
	Psychological difficulties	0.004 (0.002)	*0.16* (0.090)	.087	0.418
Television/DVD	Physical self-concept	0.002 (0.003)	*0.03* (0.039)	.471	0.545
	Psychological well-being	-0.007 (0.007)	*-0.10* (0.088)	.257	0.340
	Psychological difficulties	0.007 (0.003)	*0.16* (0.064)	.015	0.417
Personal computer use	Physical self-concept	-0.004 (0.007)	*-0.04* (0.062)	.565	0.549
	Psychological well-being	-0.025 (0.008)	*-0.23* (0.081)	.003	0.361
	Psychological difficulties	0.009 (0.005)	*0.14* (0.072)	.054	0.417
Tablet/mobile phone use	Physical self-concept	-0.015 (0.003)	*-0.18* (0.040)	< .001	0.585
	Psychological well-being	-0.008 (0.005)	*-0.11* (0.056)	.078	0.347
	Psychological difficulties	0.001 (0.004)	*0.02* (0.089)	.799	0.405
Homework	Physical self-concept	0.019 (0.012)	*0.09* (0.057)	.124	0.551

	Psychological well-being	-0.002 (0.015)	*-0.01* (0.074)	.874	0.335
	Psychological difficulties	-0.001 (0.023)	*-0.01* (0.182)	.968	0.402

Note. T2 = Time 2, B = unstandardized regression coefficient, β = standardized regression coefficient, R^2 = coefficient of determination, SE = standard error. Results are adjusted for: group allocation, clustering, sex, SES, T1 measurements, BMI and physical activity. 245 and 264 students recorded valid accelerometer wear time at Time 1 on weekend days and weekdays, respectively. 180 and 175 students recorded valid accelerometer wear time at Time 2 on weekend days and weekdays, respectively.

Figure 1: Mean screen-time usage across time points in the total sample and by sex.

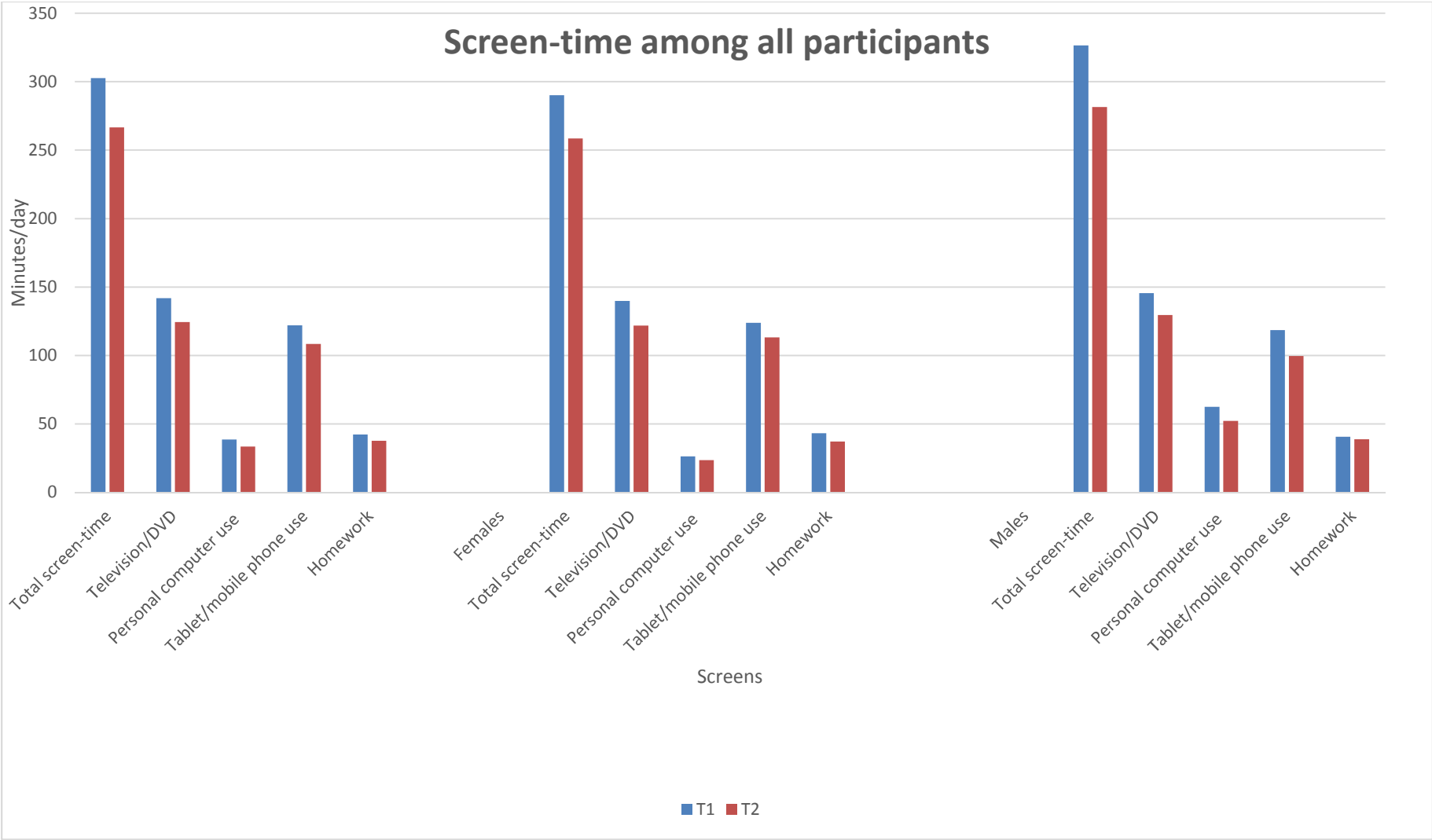


Figure 2: Mean mental health scores across time points in the total sample and by sex.

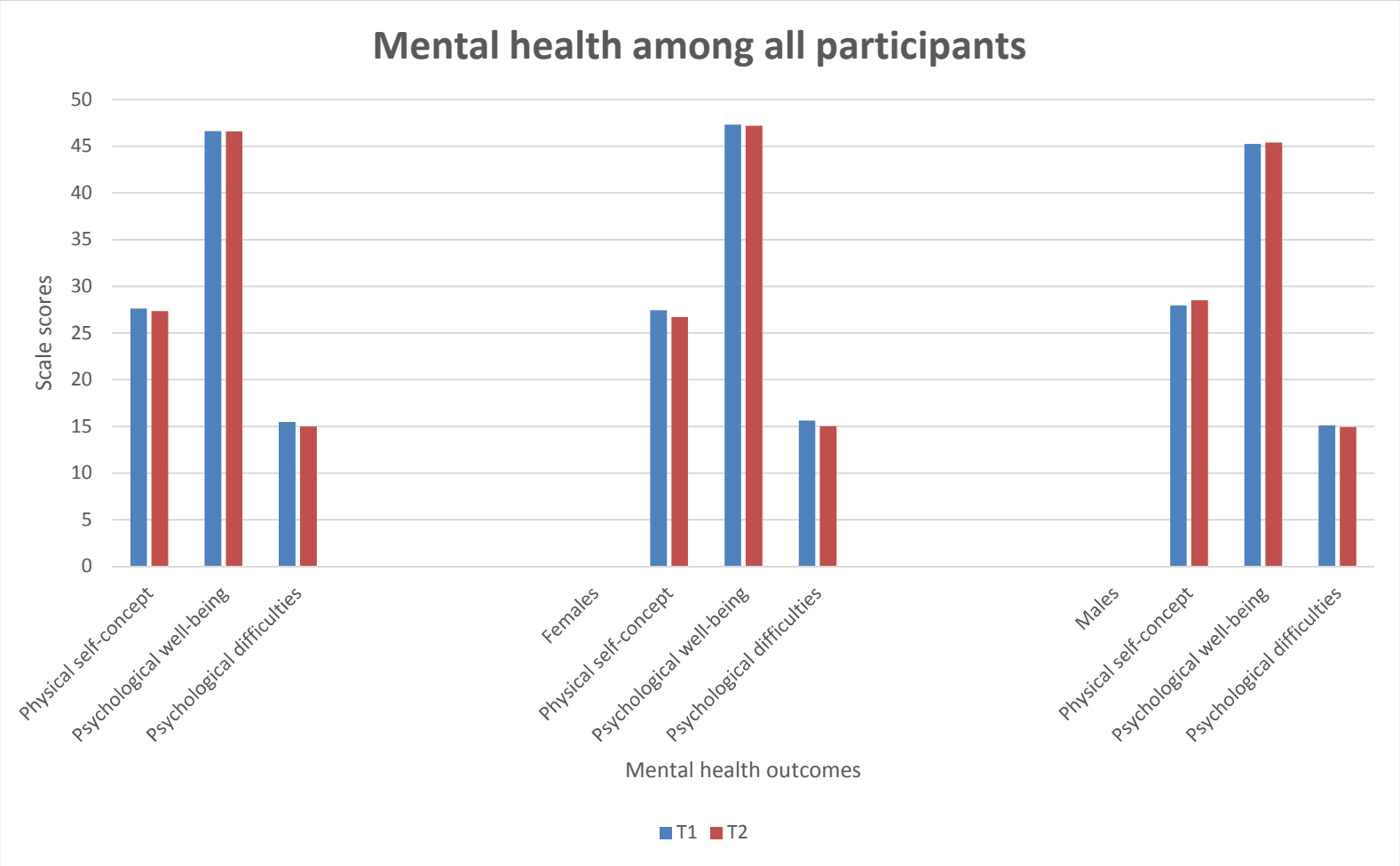
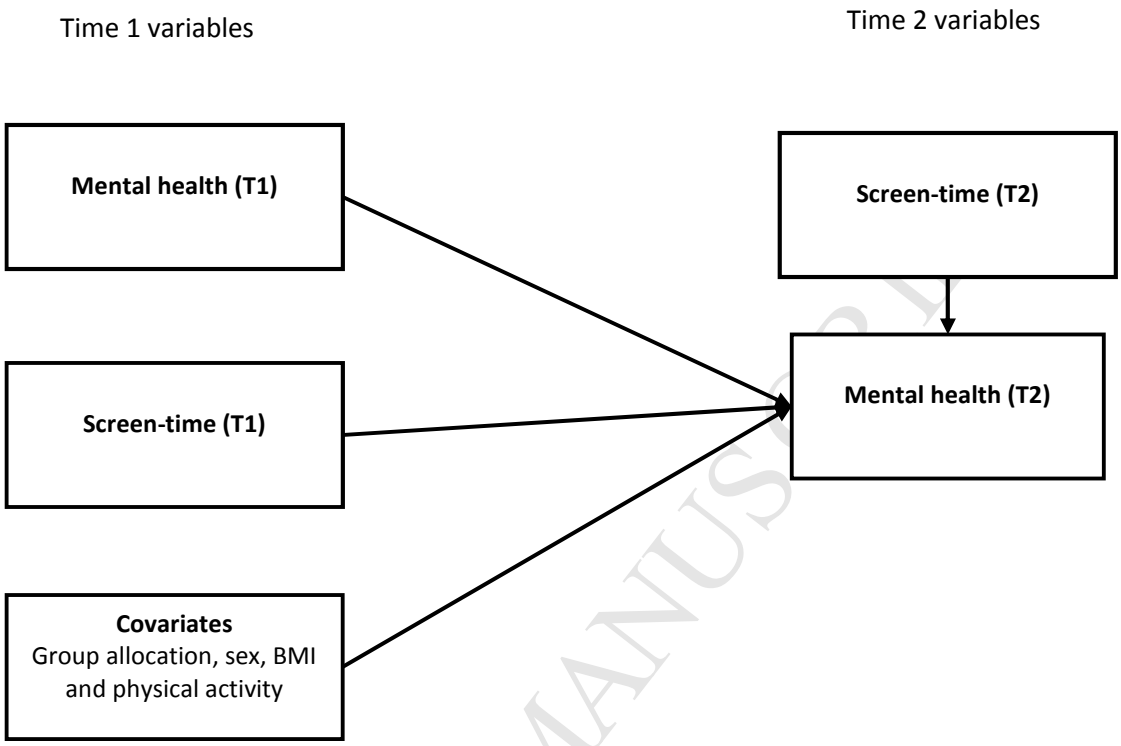


Figure 3: Statistical Model



Highlights

- Recreational screen-time was negatively associated with mental health.
- Non-recreational screen-time had no association with mental health.