The Bidirectional Relationship Between Social Media Disorder and Depressive Symptoms in Adolescence

Corine Bos

Utrecht University

Student number: 5980429

E-mail: c.h.bos@students.uu.nl

Faculty: Social Sciences

Master program: Youth Studies

Supervisor: R. J. J. M. van den Eijnden

Second assessor: W. Boendermaker

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Abstract

Cross-sectional studies have established an association between social media disorder (SMD) and depressive symptoms. However, it is unknown if SMD may exacerbate depressive symptoms or if depressive symptoms may exacerbate SMD. This longitudinal examined the bidirectional relationship between SMD and depressive symptoms among adolescents. Furthermore, it was examined if sleep problems, friendship quality, and face-to-face contact with friends can explain the relationship between SMD and depressive symptoms. Data were derived from the ”Digital Youth Project” and were collected with a one-year interval. The sample consisted of 1416 students, ages 11 to 16. Results showed that higher levels of SMD predicted higher levels of depressive symptoms one year later and vice versa. Furthermore, an increase in sleep problems and a decrease in friendship quality partly explain the effect of SMD on depressive symptoms, while face-to-face contact with friends did not. It is concluded that SMD may negatively impact several areas of adolescent life and that depressive symptoms may be a risk factor for developing SMD. Future research should further investigate the mechanisms through which SMD develops and what other implications SMD may have. Only then, effective prevention and intervention programs, aiming at the mental health of adolescents, can be developed.

Keywords: social media disorder, depressive symptoms, sleep, friendship, adolescent

Samenvatting

Verschillende studies hebben een verband tussen sociale media verslaving (SMD) en depressieve symptomen aangetoond. Echter zijn er nauwelijks longitudinale studies naar SMD, waardoor het onbekend is of SMD depressieve symptomen versterkt, of andersom. Deze longitudinale studie onderzocht daarom de bi-directionele relatie tussen SMD en depressieve symptomen onder adolescenten en mogelijk verklarende mechanismen in deze relatie. Data zijn verkregen via het "Digital Youth Project". Adolescenten (N = 1416) tussen de 11 en 16 jaar oud hebben jaarlijks klassikaal een online vragenlijst ingevuld. De resultaten lieten zien dat een hogere mate van SMD meer depressieve symptomen één jaar later voorspelde en andersom. Ook voorspelde een hogere mate van SMD meer slaapproblemen en een verminderde vriendschapskwaliteit, wat het verband tussen SMD en depressieve symptomen deels verklaarde. Face-to-face contact met vrienden werd echter niet negatief beïnvloed door SMD. Dus, SMD heeft mogelijk negatieve gevolgen voor verschillende levensgebieden van adolescenten én depressieve symptomen zijn mogelijk een risicofactor voor het ontwikkelen van SMD. Toekomstig onderzoek is nodig om inzicht te krijgen in hoe SMD ontwikkelt en welke gevolgen het mogelijk met zich meebrengt. Deze kennis is nodig om effectieve preventieve en interventies programma's te ontwikkelen, om de negatieve gevolgen van SMD te voorkomen en behandelen.

Trefwoorden: sociale media verslaving, depressieve symptomen, slaap, vriendschap, adolescent

The Bidirectional Relationship Between Social Media Disorder and Depressive Symptoms in Adolescence

Numbers from the Statistics Netherlands (CBS) indicate that 25% of the Dutch adolescents use social media for at least three hours a day (CBS, 2015). Based on a trend among young adults, it is expected that also adolescents' social media use is ever increasing (CBS, 2018). This is worrisome, since overuse of social media may be a sign of social media disorder (SMD; Andreassen, 2015). Furthermore, adolescence may be the most vulnerable stage in life when it comes to developing internet-related disorders, such as SMD (Shek & Sun, 2013). Moreover, about half of the Dutch 12- to 16-year olds already consider themselves to be addicted to social media (Van den Eijnden, 2017).

Researchers have proposed that SMD is a specific form of Internet addiction (Starcevic & Billieux, 2017) and only recently a scale was developed to measure SMD (Van den Eijnden, Lemmens, & Valkenburg, 2016). In this scale, SMD is characterized by the same symptoms that are used for Internet Gaming Disorder (Van den Eijnden et al., 2016). It includes symptoms such as withdrawal, pre-occupation, and negative consequences like conflict due to addictive social media use (American Psychiatric Association, 2013).

The review study of Andreassen (2015) on social network addiction (SNS) listed several negative outcomes of SNS, such as depressive symptoms, impaired sleep, and impaired relationships. This finding suggests that also SMD may have several negative implications, since SMD includes social network use and therefore SNS. The assumption that SMD has an association with depressive symptoms, is further supported by several empirical studies that found significant correlations between social network or social media addiction and depressive symptoms (Akkin Gürbüz, Demir, Özcan, Kadak, & Poyraz, 2017; Hanprathet, Manwong, Khumsri, Yingyeun, & Phanasathit, 2015; Van Rooij, Ferguson, Van de Mheen, & Schoenmakers, 2017). However, since these studies are cross-sectional in nature, it is unclear if SMD may exacerbate depressive symptoms, or vice versa. Therefore, also a bidirectional relationship between SMD and depressive symptoms is possible.

As mentioned, SMD might affect adolescents' sleep and interpersonal relationships (Andreassen, 2015). Moreover, these negative implications might be explanatory mechanisms in the proposed relationship between SMD and depressive symptoms. Therefore, the present longitudinal study examined the bidirectional relationship between SMD and depressive symptoms. Moreover, sleep problems, friendship quality, and face-to-face contact with

friends were examined as possible mediators in the expected relationship between SMD and depressive symptoms.

The effect of depressive symptoms on social media disorder

Depressive symptoms may exacerbate the level of SMD over time. An explanation for the latter assumption can be found in the mood enhancement hypothesis (Gámez-Guadix, 2014; Liang, Zhou, Yuan, Shao, & Bian, 2016; Whang, Lee, & Chang, 2003). This hypothesis states that individuals with depressive symptoms will try to alleviate these negative feelings and one way of doing so, might be by using social media. The social media use of an adolescent might increase if the adolescent feels better due to using social media, since behaviour is reinforced by positive consequences. Thus, in the course of time, adolescents who use social media to cope with depressive symptoms, may develop SMD.

To the best of our knowledge, there are no longitudinal studies available examining the relationship between depressive symptoms and SMD. However, results from longitudinal studies on Internet addiction showed that depressive symptoms predict higher levels of Internet addiction over time (Gámez-Guadix, 2014; Chang, Chiu, Leen, Chen, & Miao, 2014; Ko, Yen, Chen, Yeh, & Yeh, 2009; Liang et al., 2016). The results of the longitudinal study by Gámez-Guadix (2014) confirmed the mood enhancement hypothesis; higher levels of depressive symptoms predicted an increased preference for online contact and using the internet for mood regulation. Chang et al. (2014) showed that adolescents' level of depression at the first measurement could predict the initiation and persistence of Internet addiction at the second measurement. Furthermore, this was only found for girls in the study by Ko et al. (2009) and only for boys in the study by Liang et al. (2016). Although minor inconsistencies regarding gender exist, longitudinal studies on Internet addiction predominantly suggested that depressive symptoms precede subsequent higher levels of Internet addiction. Therefore, it was hypothesised that higher levels of depressive symptoms would predict higher levels of SMD later on.

The effect of social media disorder on depressive symptoms

It is also likely that SMD may exacerbate the amount of depressive symptoms over time. Longitudinal studies supporting this assumption are lacking. However, several longitudinal studies on Internet addiction showed that higher levels of Internet addiction predicted an increase in depressive symptoms over time (Chang, et al., 2014; Gamex-Guadix, 2014; Ko et al., 2014; Liang et al., 2016). Two studies found that, among young adolescents,

high Internet addiction scores were predictive of subsequent depressive symptoms (Ko et al., 2014; Liang et al., 2016). The effect of Internet addiction on depressive symptoms was only found for girls by the study of Liang et al. (2016) while the study of Ko et al. (2014) found the effect to be stronger for girls. Furthermore, adolescents who showed remission in Internet addiction symptoms after one year, also showed a decrease in depressive symptoms (Chang et al., 2014; Ko et al., 2014). Thus, it was hypothesised that higher levels of SMD would predict more depressive symptoms later on.

There are several explanatory mechanisms in explaining how SMD may exacerbate the level of depressive symptom. First of all, SMD is a type of addiction and a characteristic feature of addiction according to the DSM-V, is that it is problematic and leads to misery or impairments in functioning (American Psychiatric Association, 2013). Thus, it may be that SMD leads to problems or impaired functioning, which in turn enhance depressive symptoms. Based on the review of Andreassen (2015), three possible outcomes of SMD were examined as mediators in the relationship between SMD depressive symptoms. These outcomes are sleep problems, friendship quality, and face-to-face contact with friends.

Sleep problems as mediator

SMD may affect the amount of sleep problems, since sleep problems are common among people with Internet addiction (Cain & Gradiser, 2010). According to Cain and Gradiser (2010), SMD may affect adolescents' sleep in several ways. Firstly, since SMD includes excessive use of social media, it is possible that social media use displaces time that would otherwise be used to sleep. Secondly, it is presumed that social media use, like receiving and sending digital messages or checking social media, increases psychological arousal. This can hinder the state of relaxation that is needed to fall asleep. Lastly, the bright light that electronics, like smartphones, emit when using social media, negatively influences the neurological pathways that are involved in falling asleep. Considering that SMD involves excessive usage of technology, also during evening hours, it could have an unfavourable impact on sleep problems. In turn, more sleep problems may enhance depressive symptoms, since the meta-analysis of Baglioni et al. (2011) reported that chances of depression doubled when sleep was disordered.

Prior cross-sectional studies showed that SNS (Vernon, Barber, & Modecki, 2015) and Internet addiction (An et al., 2014) were significantly correlated to sleep disturbances. The study of Tan, Chen, Lu, and Li (2016) found that problematic internet use, sleep disturbances

and depressive symptoms all were highly correlated. Moreover, the longitudinal study of Chen and Gau (2015) showed that higher levels of Internet addiction predicted more sleep related problems among adolescents. Thus, it was hypothesized that an increase in sleep problems would mediate the expected relationship between SMD and depressive symptoms.

Face-to-face contact with friends and friendship quality as mediators

Due to the suspected impact of SMD on relationships (Andreassen, 2015), friendships may play a role in the relationship between SMD and depressive symptoms. However, until now it is unknown if SMD affects friendship quality and the amount of face-to-face contact with friends. This is a concern, since friendships are of great importance in adolescence (Waldrip, Malcolm, & Jensen-Campbell, 2008). The social displacement hypothesis by Kraut et al. (1998) suggests that the time spent online displaces the time someone spends on offline interactions, preventing investment in face-to-face contact. This, in turn, could result in a lower quality of relationships, which may be related to depressive symptoms (Liang et al., 2016). However, since this hypothesis was developed while the internet and technologies were upcoming, it may not fully apply to the current social media use among adolescents. Besides, social media also provide new ways of communicating and have shown positive effects on relationships as well (Best, et al., 2014). Therefore, although there is no theoretical or empirical argumentation, it may also be that social media help people with SMD to meet up with friends or to invest in friendships. Thus, it is unknown if SMD involves less face-to-face and lower quality of friendships, that may promote depressive feelings.

The study by Kowert, Domahidi, and Quandt (2014) explored online gaming behaviour in relation to friendships and found that offline gaming was related to less friendships, and lower quality of these friendships. In contrast, online gaming, which includes a social aspect, was not related to less friendships, and lower quality of these friendships. Thus, it may be that the social aspect is important and has a protective effect. Since SMD also contains the social aspect, the found results would opt against the mediating effect of face-to-face contact and friendship quality. However, the study of Kowert et al. (2014) did not investigate addictive behaviour, as it is the case with SMD in this study. As far as aware, there are no studies that examined the effect SMD on friendship quality and the amount of face-to-face contact with friends. Therefore, it is important to address this issue in the current study. Although there is no empirical evidence, based on the social displacement hypothesis it was

hypothesized that a decrease friendship quality and decrease in face-to-face contact with friends would mediat the relationship between SMD and depressive symptoms.

Present study

Based on the available literature, several negative implication of SMD were expected. This is worrisome, considering the increasing amount of heavy social media use and the amount of self-declared SMD among adolescents (CBS, 2015; Van den Eijnden, 2017). Due to the gap in the literature, it is currently unknown if SMD may exacerbate depressive symptoms, or vice versa. Appropriate interventions and prevention programs can only be developed when there is knowledge about the possible reciprocal relationship between SMD and depressive symptoms. For instance, if depressive symptoms and SMD reinforce each other, this should be considered when developing depression prevention programs. Thus, with knowledge about the relationship between SMD and depressive symptoms, negative implications may be prevented.

Since longitudinal studies on SMD are lacking, this longitudinal study aimed to address the gap in the literature by answering the following question: “Is there a bidirectional relationship between SMD and depressive symptoms in adolescence and is the effect of SMD on depressive symptoms mediated by an increase sleep problems and a decrease in friendship quality and face-to-face contact with friends?”. The complete research model is displayed in Figure 1. The literature points at a bidirectional relationship between SMD and depressive symptoms and therefore it was expected that more depressive symptoms would predict higher levels of SMD one year later (hypothesis 1) and that higher levels of SMD would predict more depressive symptoms one year later (hypothesis 2). Since SMD may enhance sleep problems, which in turn could promote depressive symptoms, it was expected that an increase in sleep problems would mediate the effect of SMD on depressive symptoms (hypothesis 3). Furthermore, given the social displacement hypothesis, SMD might have a negative effect on friendship quality and on face-to-face contact with friends, which in turn may have a negative effect on depressive symptoms. Therefore, a decrease in friendship quality (hypothesis 4) and a decrease in face-to-face contact with friends (hypothesis 5) were expected to mediate the effect of SMD on depressive symptoms. Furthermore, some significant gender differences were found in studies on Internet addiction in relation to depressive symptoms. Therefore, the influence of gender on the bidirectional relationship between SMD and depressive symptoms was studied as well.

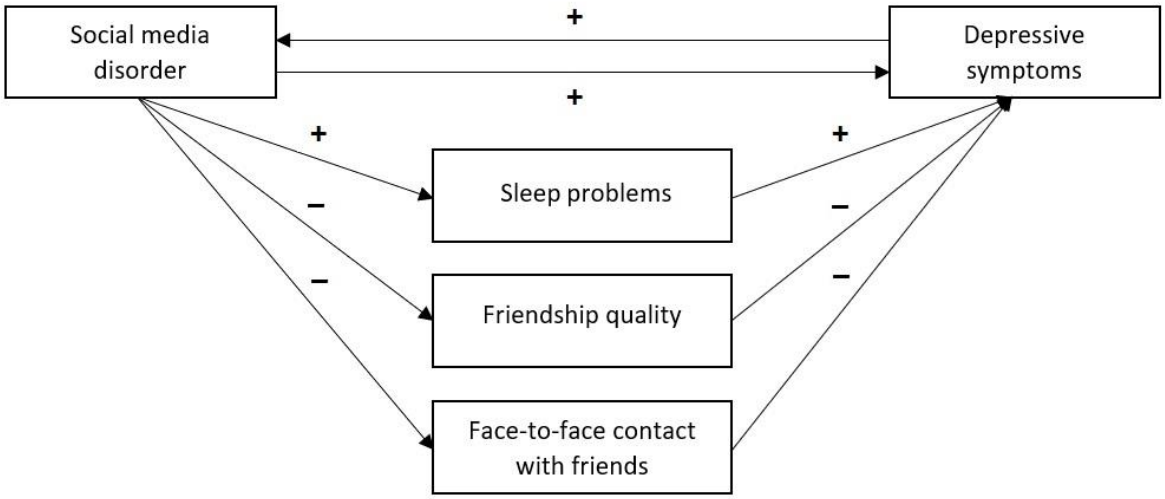

Figure 1. Research model of the bidirectional relationship between SMD and depressive symptoms. Sleep problems, friendship quality and face-to-face contact with friends are mediators in the relationship between SMD and depressive symptoms.

Method

Procedure and Participants

The current study used data from an ongoing longitudinal study at Utrecht University, "The Digital Youth Project". Data were collected among students in 7th and 8th grade classes of several secondary schools. The study procedures were carried out in accordance with the Declaration of Helsinki and were approved by the board of ethics of the Faculty of Social Sciences at Utrecht University (FETC16-076 Eijnden). All participants and their parents were fully informed about the study and were granted the right to refuse participation at any time. Parental permission for participation of their child was obtained through passive informed consent. Participants filled in online self-report questionnaires in the classroom setting, guided by research assistants of Utrecht University. Three waves of data have been collected till now. Due to sampling bias at T1, results would be less generalisable. Therefore, only the last two waves, T2 and T3, were used in the current study. T2 and T3 were conducted in February – April 2016 and 2017 respectively.

In total, 1927 adolescents participated in T2 or T3. However, only adolescents that

participated in both measurements were included in the final sample (response: 74%). Nonresponse was mainly due to the drop-out of whole classes. An attrition analysis was performed with the drop-out group (only participated at T2) and the completers group, (participated at T2 and T3). Results showed that the drop-out group scored significantly higher on SMD at T2. Furthermore, the drop-out group relatively consisted of more boys, adolescents with a low school-level and adolescents with a migration background, compared to students who participated in both measurements. The full description and calculations are included in Appendix A. After data cleaning, the final sample consisted of 1416 participants (55% male and 45% female), with an age range of 11 to 16 years (M = 13.3, SD = 0.90). School-level was distributed as follows: 45% low (VMBO), 29% middle (VMBO/HAVO and HAVO) and 26% high (HAVO/VWO and VWO). A migration background was present in 24% of the sample.

Measurements

Social media disorder. The recently developed and validated Social Media Disorder scale by Van den Eijnden et al. (2016) was used to measure SMD. The scale consists of nine statements about own feelings and behaviours towards social media use, that can be answered with yes or no. For instance, "During the past year, have you…", "… often used social media secretly?" and "…regularly used social media to take your mind off your problems?". Normally, a cut-off point for SMD is 5 or more "yes" answers (Van den Eijnden et al., 2016). However, only a small number of participants answered 5 or more questions with yes. Therefore, it was decided to create a count variable resulting in scores between 0 and 9, instead of using the cut-off point. The internal consistency of this scale was low, with a Cronbach's α of .64 at T2 and T3.

Depressive symptoms. The Depressive Mood List (Kandel & Davis, 1982, 1986) was used to assess depressive symptoms. Participants were asked to respond to six statements about their own feelings in the last 12 months. Answers were given on a 5-point scale ranging from 0 (*never)* to 5 (*always*). Examples of items are *"*I feel too tired to do anything*"* and *"*I worry too much about things*".* The mean score on the items was calculated, whereas a higher score indicated a higher level of depressive symptoms. The internal consistency of this scale was high, with a Cronbach's α of .81 at T2 and .83 at T3.

Sleep problems. Sleep problems were measured using 5 out of 15 items

from the Groningen Sleep Quality scale (Meijman, De Vries-Griever, & De Vries, 1988). The five items indicated of the amount of sleep problems participants experienced, although the scale was originally created to assess sleep quality. Answers could be given on a 5-point scale, ranging from 0 (*never)* to 5 (*always).* Participants were asked if they experienced sleep problems during the past week. Examples of items are *"*I feel like I did not sleep well*"* and *"*After I wake up in the night, I can't sleep well anymore*".* A factor analysis was conducted and indicated that the scale was unidimensional. Furthermore, reliability was high with a Cronbach's α of .78 at T3. The full description of the scale can be found in Appendix B.

Friendship quality. Friendship quality was measured using five items that indicated how adolescents experienced their relationship with friends, based on the Dutch version of the Competence Experience Scale for Adolescents (Straathof & Scheffers, 1989). Participants could respond to five statements on a 5-point scale, with answers ranging from 0 (*not correct at all*) to 5 (*totally correct*). For example "I can keep a good friendship for a long time" and "I don't have a really close friend to do things with". A factor analysis was conducted and showed the scale is unidimensional. Reliability analysis indicated a mediocre reliability with a Cronbach's α of .673 at T2 and .667 at T3. A full description of the scale can be found in Appendix B.

Face-to-face contact with friends. Face-to-face contact with friends was measured with four questions regarding the intensity of contact with friends. The items were measured using a 6-point scale ranging from 0 (*never*) to 6 (*often*). Examples of items are "How often are you at your friends' house?" and "How often do you spend time with friends outside of school?". A factor analysis was conducted and indicate the scale was unidimensional. Reliability was high with a Cronbach's α of .84 at T2 and .87 at T3. A full description of the scale can be found in Appendix B.

Data-analysis

IBM SPSS Statistics 24 was used for data-analysis. First, 509 participants who dropped-out on T3, or answered too little items to be included in any analysis, were deleted. Participants whom were not able to completely finish the questionnaire at T2, but did complete it at T3, were kept in the sample to prevent loss of data. Thus, 1417 participants remained in the longitudinal sample. Pairwise deletion of missing values was used for all analyses, since participants with some missing values remained in the sample.

Next, answering trends were explored which resulted in the deletion of one participant.

Scales were made and factor- and reliability analyses were conducted. Outliers on SMD and depressive symptoms were examined using the Mahalanobis distance. In total 27 outliers appeared on the main variables SMD and depressive symptoms. All cases were examined by hand and which showed that all outliers had high scores on SMD. No outlier was deleted since no obvious answering trends were discovered among the outliers and since the used Likert-scales did not permit very deviating answers.

Some demographic variables had to be recoded to serve as control variable. Dummy variables were created for school-level, where low stands for VMBO (reference category) middle stands for VMBO/HAVO and HAVO and high for HAVO/VWO and VWO. For the dummy ethnicity, participants were categorized as having a migrant background if they, or one of their parents, were born abroad. Age was categorised as younger (11-13 years old) and older (14-16 years old).

The assumptions of normality and homoscedasticity were checked separately before each regression analysis. This revealed that the SMD variable violated the assumption of normality. Since there is no nonparametric equivalent for regression available, all regression analyses were bootstrapped (Field, 2015; Twisk, 2007). Furthermore, all mediation analyses were bootstrapped, since this is currently considered to be more reliable (Preacher & Hayes, 2008). Demographic variables were only included as a control variable when they appeared to be confounders. This was determined by running every regression analysis separately with only one demographic variable as a predictor. A demographic variable was considered a confounder if it significantly influenced the parameters of the independent variable and was a significant predictor (Twisk, 2007). Because of this method, the control variables differ per analysis.

First, descriptive statistics were requested. Next, independent sample *t* tests and a one-way ANOVA were conducted to look for subgroup differences on SMD and depressive symptoms at T2. Thereafter, the correlations between the main, mediation and demographic variables were requested. The bidirectional relationship between depressive symptoms and SMD was analysed by using multivariate hierarchical linear regression analysis. The moderating effect of gender was tested by adding the interaction term between the independent variable and gender to the regression models.

Lastly, mediation analyses were conducted using the steps of the Baron and Kenny

method (1986). The first step was testing the effect of the independent on the dependent variable (c). Subsequently, it was tested whether the independent variable had a significant effect on the mediator (a) and if the mediator had a significant effect on the dependent variable (b). Lastly, the independent variable and the mediator were put in the same model to test the effect independent variable, while controlling for the mediator (c'). Mediation occurs when the independent variable no longer has a significant effect on the dependent variable. When the effect of the independent variable is smaller, but still significant, it is partial mediation. In addition, Sobels' test was used to determine the significance of the mediator (Sobel, 1982).

Results

Descriptive statistics

Table 1 shows the descriptive statistics of subgroups' depressive symptoms and SMD at T2. There were significant subgroup differences on depressive symptoms at T2, whereas female, younger, and native adolescents showed higher scores on depressive symptoms. There were significant subgroup differences on SMD at T2 for school-level. Post-hoc testing showed that the only that high school-level (M = 0.77) significantly differed from low school-level (M = 1.43) and middle school-level (M = 1.20). In Table 2, the descriptive statistics of the main and mediating variables are presented. These scores indicated that, on average, depressive symptoms slightly increased between T2 and T3, while there was a minimal decrease in mean score for SMD.

Table 1

Descriptive Statistics of Scores on Depressive symptoms and Social Media Disorder at Baseline, per Pemographic Characteristic

	Depressive symptoms T2			SMD T2		
	N (%)	*M (SD)*	*t / F*	*N (%)*	*M (SD)*	*T / F*
Gender			-5.54***			-0.75
Girl	635 (45.2)	2.31 (0.79)		637 (45)	1.23 (1.59)	
Boy	770 (54.8)	2.08 (0.74)		779 (55)	1.16 (1.44)	
Age			-2.33*			-0.26
11-13	841 (59.9)	2.41 (0.76)		848 (59.9)	1.18 (1.50)	
14-16	564 (40.1)	2.24 (0.77)		568 (40.1)	1.21 (1.51)	
School-level			1.16			23.01***
Low	626 (44.6)	2.14 (0.78)		633 (44.7)	1.43 (1.56)	
Middle	406 (28.9)	2.20 (0.76)		408 (28.8)	1.20 (1.56)	
High	373 (26.5)	2.22 (0.75)		375 (26.5)	0.77 (1.26)	
Ethnicity			2.40*			0.31
Dutch	1076 (76.6)	2.21 (0.76)		1083 (76.5)	1.17 (1.49)	
Other	329 (23.4)	2.09 (0.81)		333 (23.5)	1.26 (1.56)	

Note. $*p < .05$. $**p < .01$. $***p < .001$.

Table 2

Descriptive Statistics of Depressive Symptoms and SMD and the Mediators Sleep Problems, Friendship Quality and Face-to-Face Contact.

	n	*M*	*SD*	Minimum	Maximum
Depressive symptoms T2	1405	2.18	0.77	1.00	4.83
Depressive symptoms T3	1403	2.26	0.79	1.00	5.00
SMD T2	1416	1.19	1.51	0.00	9.00
SMD T3	1403	1.16	1.50	0.00	9.00
Sleep problems T3	1403	2.65	0.89	1.00	5.00
Friendship quality T3	1402	4,35	0.68	1.00	5.00
Face-to-face contact T3	1398	3.44	1.12	1.00	6.00

Correlations

The results from Table 3 showed a strong positive correlation between depressive symptoms and SMD, cross-sectional and longitudinally. Furthermore, SMD and depressive symptoms at both measurements were positively correlated with sleep problems at T3.

Friendship quality was negatively correlated to SMD and depressive symptoms at both measurements. Furthermore, face-to-face contact had a significant positive correlation to SMD, but was not significantly correlated to depressive symptoms. Lastly, result from Table 3 indicated that there was a positive correlation between friendship quality and face-to-face contact with friends. Furthermore, the significance of the correlations between demographic variables and the main variables seems to differ between measurements. As seen in Table 3, gender was significantly correlated to SMD at T3 but not at T2, while gender was significantly correlated to depressive symptoms at both measurements.

Table 3

Correlations Between Social Media Disorder and Depressive Symptoms, the Mediators and the Demographic Variables

	1	2	3	4	5	6	7	8	9	10	11	12
Main variables												
1. SMD T2	-											
2. SMD T3	.44***	-										
3. Depressive symptoms T2	.34***	.23***	-									
4. Depressive symptoms T3	.21***	.31***	.52***	-								
Mediators												
5. Sleep problems T3	.19***	.25***	.40***	.61***	-							
6. Friendship quality T3	-.12***	-.10***	-.13***	-.14***	-.07**	-						
7. Face-to-face contact T3	.14***	.08**	-.01	-.04	.02	.27***	-					
Demographic variables												
8. Gender [a]	.01	.12***	.14***	.27***	.13***	.16***	.06*	-				
9. Age	.03	-.07**	.06*	.02	.01	-.04	.000	-.09***	-			
10. School level low	.17***	.13***	-.04	-.07**	.01	-.04	.12***	-.08**	.16***	-		
11. School level middle	.01	.01	.01	-.01	-.48	.00	-.02	-.01	-.17***	-.57***	-	
12. School level high	-.20***	.09***	.20***	.15***	.04	.03	-.12***	.09***	.00	-.54***	.38***	-
13. Ethnicity [b]	.03	.03	-.08**	.02	.01	-.03	-.09***	.06*	.06*	.09**	-.15	-.09***

Note. For SMD, gender, school-levels, and ethnicity Spearman's rho was used. Pearson's correlation coefficient was used for all other correlations.

[a] Reference category = boys. **[b]** Reference category = native

*p < .05. **p < .01. ***p <.001.

Effect of depressive symptoms on social media disorder

Multivariate hierarchical linear regression analysis was used to examine if depressive symptoms predicted subsequent higher scores on SMD (hypothesis 1). Table 4 shows there was a significant positive effect of depressive symptoms at T2 on SMD at T3 (B = .17, p < .001), even after adjusting for SMD at T2, gender, age and high school-level. The proportion of explained variance in SMD at T3 was by depressive symptoms at T3 was .007. Furthermore, it was tested whether gender is a moderator in this relationship. The interaction term of gender and depressive symptoms was added to the regression model last. However, this was non-significant (B = .58, *ns*), indicating that the effect of depressive symptoms on SMD did not differ for boys and girls.

Table 4

Linear Regression Analysis of Depressive Symptoms at T2, Social Media Disorder at T3 and Moderator Gender (N = 1405)

Predictor	*B*	*SE B*	*β*	*p*	*Δ R^2*
Step 1					.217***
Gender[a]	.31	.07	.10	.000***	
Age	-.91	.04	-.06	.020*	
School level high[b]	-.27	.08	-.08	.001***	
SMD T2	.43	.02	.43	.000***	
Step 2					.007***
Depressive symptoms T2	.17	.05	.09	.000***	
Step 3					.000
Depressive symptoms T2 * Gender	.58	.09	0.47	.54	

Note. [a]Reference category = boys. [b]Reference category = low school level.

*p < .05. **p < .01. ***p <.001.

Effect of social media disorder on depressive symptoms

Subsequently it was tested if SMD predicted a subsequent higher level of depressive Symptoms (hypothesis 2). In step 1 gender, high school-level, and depressive symptoms at T2 were added. Table 5 shows that even after adjusting for these variables, SMD at T2 had a positive significant effect on depressive symptoms at T3 (B = .04, p < .001). The proportion of explained variance in depressive symptoms at T3 by SMD at T2 was .004. Next, the

interaction term of gender and SMD was added. This was significant (B = .05, p = .035) and implies that the effect of SMD on depressive symptoms differed for boys and girls. Figure 1 illustrates the strength between SMD and depressive symptoms separately for boys and girls and shows that the effect of SMD on depressive symptoms was slightly stronger for girls.

Table 5

Linear Regression Analysis Between Social Media Disorder at T2, Depressive Symptoms at T3 and Moderator Gender (N = 1391)

Predictor	*B*	*SE B*	*β*	*p*	*Δ R^2*
Step 1					.316***
Gender[a]	.31	.04	.120	.000***	
School-level high[b]	.10	.04	.06	.011**	
Depressive symptoms T2	.56	.02	.49	.000***	
Step 2					.004**
SMD T2	.04	.01	.07	.000***	
Step 3					
SMD T2 * Gender	.05	.02	.15	.035*	.002*

Note. [a]Reference category = boys. [b]Reference category = low school level.

*p < .05. **p < .01. ***p <.001.

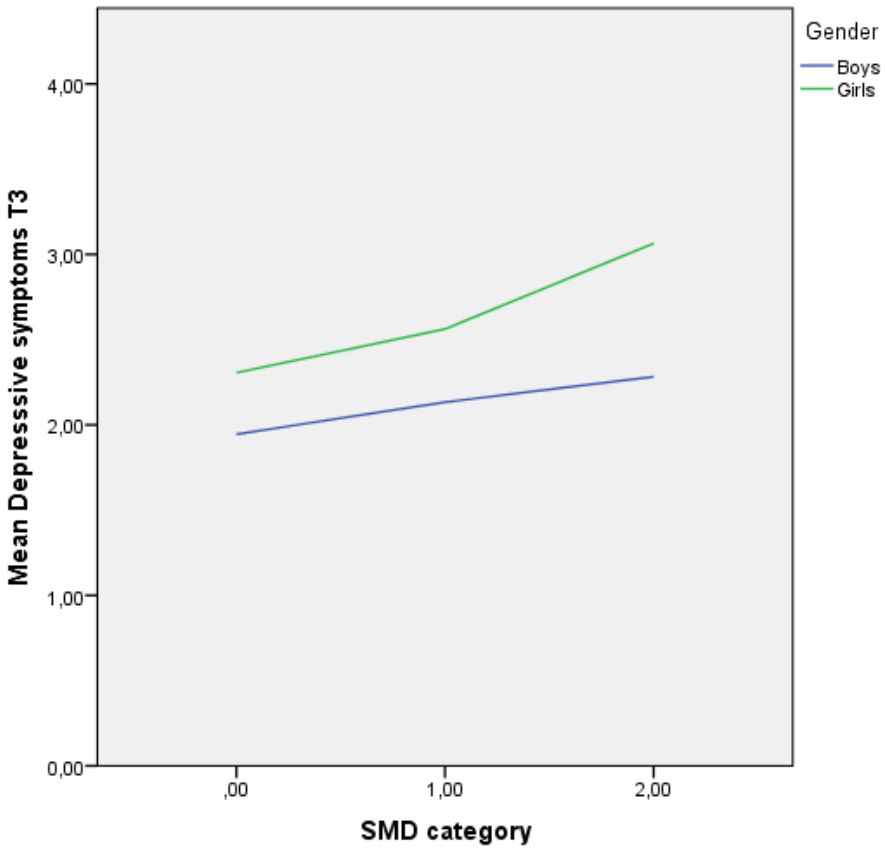

Figure 1. Relationship between SMD at T2 and mean depressive symptoms at T3 separated by gender. Given the small amount of high SMD scores, three groups were created. Adolescents with an SMD score at T2 of 0 were classified as 0 (n = 637), scores from 1 to 3 were classified as 1 (n = 652), and a score of 4 or higher was classified as 2 (n = 127).

Mediators sleep problems, friendship quality and face-to-face contact with friends

The first step of the Baron and Kenny method (1986) were met, which is establishing an effect of the independent on the dependent variable. Therefore it was possible to test for mediators in the relationship between SMD and depressive symptoms. First, the mediating role of sleep problems was examined (hypothesis 3). Table 6 shows that SMD at T2 had a significant positive effect on sleep problems at T3 (B = .11, p < .001), which in turn had a significant positive effect on depressive symptoms at T3 (B = .41, p < .001). Lastly, the complete model, including the mediator and independent variable, showed that both SMD at T2 and sleep problems at T3 had a significant effect on the outcome variable. Thus, the relationship between SMD and depressive symptoms appeared to be partly mediated by sleep

problems, since SMD at T2 was still significant. A Sobel test was conducted and showed that the mediation of sleep problems was significant ($z = 5.31$, $p < .001$). Sleep problems explained .182 of the variance of depressive symptoms at T3.

Next, friendship quality was tested as a mediator (hypothesis 4). The results of Table 7 illustrate that SMD at T2 had a significant negative effect on friendship quality at T3 ($B = -.06$, $p < .001$), which in turn had a negative effect on depressive symptoms ($B = -.14$, $p < .001$). SMD at T2 and friendship quality at T3 both significantly predicted depressive symptoms in the complete model. Thus, the effect of SMD at T2 on depressive symptoms at T3 was partially mediated by friendship quality at T3. A Sobel test was conducted and showed that the mediation of friendship quality was significant ($z = 3.31$, $p > .001$). The explained variance of depressive symptoms by friendship quality (.014) was low, compared to sleep problems (.182).

Lastly, face-to-face contact with friends was tested as a mediator (hypothesis 5). The results from Table 7 show that SMD at T2 had a significant effect on face-to-face. However, this effect was positive, and not negative as hypothesized. Furthermore, face-to-face contact had a marginally significant negative effect on depressive symptoms at T3. Thus, face-to-face contact was not a mediator, although it does seem to have some negative effect on depressive symptoms at T3.

Table 6

Linear Regression Analysis of Mediator Sleep Problems at T3 Between Social Media Disorder at T2 and Depressive Symptoms at T3

Predictor	*B*	*SE B*	*β*	*p*	*Δ R^2*
Outcome Sleep problems T3 (*N* = 1403)					
Step 1					.015***
Gender[a]	.22	.05	.12	.000***	
Step 2					.036***
SMD T2	.11	.02	.19	.000***	
Outcome depressive symptoms T3 (*N* = 1403)					
Step 1					.316***
Gender[a]	.31	.04	.20	.000***	
School-level high[b]	.10	.04	.06	.012*	
Depressive symptoms T2	.50	.02	.49	.000***	
Step 2					.182***
Sleep problems T3	.41	.02	.47	.000***	
Outcome depressive symptoms T3 (*N* = 1391)					
Step 1					.316***
Gender[a]	.31	.04	.20	.000***	
School-level high[b]	.10	.04	.06	.012*	
Depressive symptoms T2	.51	.02	.49	.000***	
Step 2					.184***
SMD T2	.02	.01	.04	.037*	
Sleep problems T3	.41	.02	.47	.000***	

Note. [a]Reference category = boys. [b]Reference category = low school level.

*p < .05. **p < .01. ***p <.001.

Table 7

Linear Regression Analysis of Mediator Friendship Quality at T3 Between Social Media Disorder at T2 and Depressive Symptoms at T3

Predictor	*B*	*SE B*	*β*	*p*	*Δ R^2*
Outcome friendship quality T3 (*N* = 1401)					
Step 1					.027***
Gender[a]	.23	.04	.16	.000***	
Step 2					.016**
SMD T2	-.06	.022	-.127**		
Outcome depressive symptoms T3 (*N* = 1387)					
Step 1					.316***
Gender[a]	.31	.04	.20	.000***	
School-level high[b]	.10	.04	.06	.012*	
Depressive symptoms T2	.51	.02	.49	.000***	
Step 2					.014***
Friendship quality T3	-.14	.03	-.12	.000***	
Outcome depressive symptoms T3 (*N* = 1386)					
Step 1					.316***
Gender[a]	.31	.04	.20		
School-level high[b]	.10	.04	.06		
Depressive symptoms T2	.51	.02	.49		
Step 2					.017
SMD T2	.03	.01	.06	.011*	
Friendship quality	-.13	.03	-.12	.000***	

Note. [a]Reference category = boys. [b]Reference category = low school level

*p < .05. **p < .01. ***p <.001.

Table 8

Linear Regression Analysis of Mediator Face-to-Face Between Social Media Disorder at T2 and Depressive Symptoms at T3

Predictor	*B*	*SE B*	*β*	*p*	*Δ R^2*
Outcome face-to-face T3 (*N* = 1400)					
Step 1					.308***
Gender[a]	.12	.05	.05	.019*	
School-level high[b]	-.181	.06	-.07	.002**	
Step 2					.003*
SMD T2	.04	.02	.05	.024*	
Outcome depressive symptoms T3 (*N* = 1385)					
Step 1					.316***
Gender[a]	.31	.04	.20	.000***	
School-level high[b]	.10	.04	.06	.011*	
Depressive symptoms T2	.51	.02	.49	.000***	
Step 2					.002
Face-to-Face contact T3	-.03	.02	-.04	.055	
Outcome depressive symptoms T3 (*N* = 1384)					
Step 1					.315***
Gender[a]	.31	.04	.20	.000***	
School-level high[b]	.10	.02	.05**	.011**	
Depressive symptoms T2	.51	.02	.49**	.000***	
Step 2					.007**
SMD T2	.04	.01	.08	.002**	
Face-to-Face contact T3	-.04	.02	-.04	.029*	

Note. [a]Reference category boys. [b]Reference category = low school level.

*p < .05. **p < .01. ***p <.001.

Discussion

The present longitudinal study is one of the first that examined the bidirectional relationship between SMD and depressive symptoms. The results demonstrated that higher levels of SMD predicted higher levels of depressive symptoms one year later, and vice versa. Furthermore, the effect of SMD on depressive symptoms was partly mediated by an increase in sleep problems and a decrease in friendship quality, but not by a decrease in face-to-face contact with friends.

The effect of depressive symptoms on social media disorder

The results from this study confirm the first hypothesis, that higher levels of depressive symptoms would predict higher levels of SMD one year later, even after adjusting for previous SMD and confounders. This is the first longitudinal study to examine and confirm the effect of depressive symptoms on SMD. Nevertheless, the current finding is in line with studies that found an effect of Internet addiction on depressive symptoms (Chang et al, 2014; Gamex-Guadix, 2014; Ko et al., 2014; Liang et al., 2016).

The results suggest that depressive symptoms may be a risk factor for developing SMD. The current study provides further ground for the mood enhancement hypothesis (Gámez-Guadix, 2014; Liang et al., 2016; Whang, et al., 2003) which states that social media can be used to cope with depressive feelings, which may stimulate the development of SMD. Although there is a significant linear relationship between depressive symptoms and SMD, the small correlation coefficient suggests that not all adolescents with depressive symptoms develop SMD. Therefore, future research should study which adolescents with depressive symptoms are at higher risk for developing SMD. For example, some personality characteristics have been associated with SMD, like narcissism (Andreassen, Pallesen, & Griffiths, 2017) and low self-esteem (Bányai et al., 2017).

The results suggest that the relationship between SMD and depressive symptoms is moderated by gender, with girls showing a stronger relationship. This is in line with studies on Internet addiction, which also reported girls showing a stronger relationship between Internet addiction and depressive symptoms (Ko et al., 2014; Liang et al., 2016). Although the moderator appeared to be significant, the associated regression coefficients were small. Moreover, as visualised in Figure 1, the positive effect of SMD on depressive symptoms applies to both girls and boys.

The effect of social media disorder on depressive symptoms

The results of this study support the second hypothesis that higher levels of SMD Would predict higher levels of depressive symptoms one year later. This result was found after adjusting for previous depressive symptoms and confounders. Furthermore, the result is in line with several longitudinal studies on Internet addiction, that identified Internet addiction as a predictor of later depressive symptoms (Gámez-Guadix, 2014; Chang et al., 2014; Ko, et al., 2009; Liang et al., 2016).

It appears that the relationship between SMD and depressive symptoms can partly be explained by sleep problems and friendship quality, of which an increase in sleep problems explained the most variance. This is the first longitudinal study to analyse and confirm that an increase in sleep problems partially mediates the effect of SMD on depressive symptoms (hypothesis 3). This is in line with several studies that reported an association between problematic internet or social media use and sleep problems (An, et al., 2014; Tan et al., 2016; Vernon, et al., 2015). As discussed, several mechanisms explain how SMD may enhance sleep problems. These mechanisms are: sleep time displacement, arousal, and affected neurological pathways due to the emitted light by electronics (Cain & Gradiser, 2010). Further research should examine these mechanisms, to adequately prevent sleep problems in adolescents with SMD.

Furthermore, the results show that the effect of SMD on depressive symptoms was partly mediated by a decrease in friendship quality (hypothesis 4), but not by a decrease in the amount of face-to-face contact (hypothesis 5). Thus, the current study indicates that SMD might have an effect on the qualitative aspect and not the quantitative aspect of friendship. The hypothesis that adolescents with SMD reported less face-to-face contact with friends, is not supported. On the contrary, the results indicated that a higher score on SMD significantly predicted a higher score on face-to-face contact with friends. Since there is no literature or empirical data available on SMD in relation to friendships, the reason for this contradictory result is unknown. A suggestion is that adolescents with higher scores on SMD, might have more friendships which results in more offline contact with friends. Furthermore, it might be that these adolescents use social media to arrange meetings with their friends.

Based on the present data, the social displacement theory by Kraut et al. (1998) considering SMD is, partly refuted. The current results suggest that SMD does affect friendship quality, but that this is not due to less face-to-face contact as the theory assumes. Thus, since the results of this study show that relationships might be affected, future research

should examine the implications of SMD on relationships. Especially seen the importance of relationships during adolescence (Waldrip et al., 2008) and since the precise effects and mechanisms of SMD on relationships are currently understudied.

Two possible mechanisms are provided on how SMD may indirectly exacerbate depressive symptoms. However, other explanations might exist that are currently unknown. Firstly, it is possible that the one-sidedness and passiveness of social media use has a direct effect on depressive symptoms. Secondly, theory on addiction in general suggests that addiction leads to impaired functioning on several life-areas, like work or leisure time activities (American Psychiatric Association, 2013). In turn, these negative consequences may negatively affect psychological well-being. Lastly, since SMD involves spending time online, the chance of being exposed to negative reactions or cyber-bullying increases, which may negatively affect psychological well-being (Best et al., 2014). Since the results of this study suggest that SMD enhances depressive symptoms, sleep problems, and less friendship quality, future research should investigate which other negative implications SMD might have.

Limitations

The foremost strength of this study is its longitudinal design, consisting of two measurements. This makes it possible to analyse relationships over time and gain insight into the direction of relationships. Furthermore, this study made use of a large school sample, which makes the results more generalisable to the general population of adolescents. Another strength is the strict hypothesis testing, which required adjusting for the outcome variable on the earlier measurement and adjusting for possible confounders. As a result, this study produced greater reliability and value, despite the small effect sizes and low explained variances.

Besides the strengths of this study, there are several limitations as well. Although the scale of SMD has been validated (Van den Eijnden et al., 2016), the scale provided a low reliability. However, dichotomous measures usually score a lower Cronbach's α compared to continuous measures (Stöber, Dette, & Musch, 2002). Furthermore, the nine items provided a positively skewed outcome variable (46% scored 0). The items used to measure SMD were dichotomous, while other variables used a Likert-scale with ranging from 1 to 5 or 6. Thus, the forced choice between *"yes"* or *"no"* might have led to a less precise and sensitive sum-score than a Likert-scale. Since SMD was the main variable of interest in this study, this might have influenced the results. Also, the large amount of drop-out between T2 and T3

might have influenced the results. Attrition analyses showed significant group differences between the completers and the drop-out group and therefore multiple imputation was considered. However, bootstrapping was necessary and SPSS cannot perform bootstrapping on imputed data. Moreover, using multiple imputation before bootstrapping is argued to be statistically incorrect (Schomaker & Heumann, 2016). Even though the drop-out group scored higher on SMD at T2, results regarding SMD were still significant.

It is noteworthy that this study only used two waves of data to test the mediation effect. Moreover, none of the mediation analyses controlled for the mediation variable at the previous measurement. Three waves of data are required to control for previous measurements and to see the effects over time with more certainty. Furthermore, longitudinal research cannot unambiguously identify causal influences, since there might be unmeasured confounders or reverse causation.

Conclusion and implications

This study provides valuable and new information about the negative implications of SMD. The results of this study indicate there is a bidirectional relationship between SMD and depressive symptoms among adolescents. Furthermore, the results suggest that SMD exacerbates depressive symptoms over time and that depressive symptoms exacerbates SMD over time. Moreover, the impact of SMD on depressive symptoms may partially explained by an increase sleep problems and decrease friendship quality. However, a decrease in the amount of face-to-face contact with friends cannot. SMD should be a priority for further research, considering that social media play an ever-increasing role in the lives of adolescents. Moreover, depressive symptoms are expected to be highly prevalent among adolescents (Nuijen et al., 2017). The current study provides some practical implications and input for further research. Firstly, practitioners should be sensitive for the way that social media use might affect adolescents with depressive symptoms and for the possible negative effects of SMD on sleep, friendships and mental well-being. The mechanisms underlying SMD are understudied and therefore solid research is necessary. Future studies should further examine the negative implications of SMD, as well as the individual and contextual factors that may enhance SMD. Only then interventions and policies can be appropriately tailored to the needs of adolescents, to prevent and treat SMD.

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Appendix A

Results of Attrition Analysis

Attrition analysis was performed to examine if there were differences between the group who only participated at T2 (N = 508), and the who group participated at both T2 and T3 (N = 1416). Results showed there were some significant between-group differences. An independent-samples t-test showed that there was a significant difference in the score on SMD at T2 between the drop-out (M =1.55, SD = 1.73), and the completers group (M = 1.19, SD = 1.51), $t(1922) = 4.40$, $p < .001$, $d = 0.22$, 95% CI [.19, .53]. There was no significant difference in depressive symptoms between the drop-out group (M = 2,22, SD = 0.80) and the completers group (M = 2.18, SD = 0.77), $t(1903) = 0.94$, *ns*. Furthermore, additional chi-square difference tests showed significant groups differences in gender, $\chi^2(1, N = 1924) = 6.20$, $p = .013$, ethnicity, $\chi^2(1, N = 1924) = 13.65$, $p < .001$, and school-level $\chi^2(2, N = 1924) = 79.96$, $p < .001$. Thus, the drop-out group relatively consisted of more boys, adolescents with a low school-level and more adolescents with a migration background, compared to students who participated in both measurements.

Appendix B

Full Description of Customized Scales:

Sleep problems, Friendship Quality, and Face-to-Face Contact with friends

Sleep problems

The scale sleep problems exists of five items from the Groningen Sleep Quality Scale (Meijman, De Vries-Griever, & De Vries, 1988). The original scale has been validated and exists of 15 items. The five used items give an indication of the amount of sleep problems and therefor the expression "sleep problems" is used for the scale. Answers could be given on five-point Likert-scales, ranging from 0 (*never)* to 5 (*always).* Participants were asked to respond to statements about their sleep in the past week. The five statements are: (a) *"*I feel like I did not sleep well*"*, (b) "It takes me more than half an hour to fall asleep", (c) "I feel like I did not get enough sleep", (d) *"*After I wake up in the middle of the night, I can't sleep well anymore", and (e) "I feel well-rested". A higher score indicated a more sleep problems. The last item (e) was asked in a reversed way and therefore this question was recoded. A factor analysis was conducted to test the unidimensionality of the scale. The assumptions for unidimensionality were met, since there were three correlations higher than .3 between the 5 items. Furthermore, there was only one component with an eigenvalue higher than 1 and the scree-plot indicated that the slope of the curve levelled off below 1. The initial solution explained 54,8% of the total variance, which is considered to be good. Next, a reliability analysis was conducted, which indicated a good reliability for research on group level, with a Cronbach's α of .782 at T3.

Friendship quality

Friendship quality was measured using five items that indicate how adolescents experience their relationship with friends. The five items used for this scale stem from the Dutch version of the Competence Experience Scale for Adolescents (Straathof & Scheffers, 1989). Participants could respond to statements on a 5-point scale, with answers ranging from 0 (*not correct at all*) to 5 (*totally correct*). Participants were asked respond to the following statements: (a) "I can keep a good friendship for a long time", (b) "I don't have a close friend with whom I can keep a secret", (c) "I don't have a really close friend to do things with", (d) "I find it hard to get friends that I can really count on", and (e) "I don't have a friend with whom I can share really personal thoughts". Four out of five items were recoded, so a higher score indicated higher friendship quality. A factor analysis was conducted and the

assumptions for unidimensionality were met since 4 items had a correlation higher than .3. Furthermore, there was only one component with an eigenvalue higher than 1 and the scree-plot showed that the slope of the curve levelled off below 1. The initial solution explained 46,4% of the total variance, which is considered almost good. Next, a reliability analysis was conducted, which indicated a mediocre reliability with a Cronbach's α of .673 at T2 and .667 at T3.

Face-to-Face Contact with Friends

Face-to-face contact with friends was measured with four questions regarding the intensity of offline contact with friends. The items were measured using a 6-point scale ranging from 0 (*never*) to 6 (*often*). The four questions are: (a) "How often do you spend time with friends outside of school or in the weekends?", (b) "How often are you at your friends' house?", (c) "How often do you go out or to a party with friends?", and (d) "How often are your friends at your place?". A factor analysis was conducted and the assumptions for unidimensionality were met, since all items had a correlation higher than .3. Furthermore, there was only one component with an eigenvalue higher than 1 and the scree-plot showed that the slope of the curve levelled off below 1. The initial solution explained 71,6% of the total variance, which is considered to be good. Next, a reliability analysis was conducted, which indicated a good reliability for research on group level, with a Cronbach's α of .844 at T2 and .865 at T3.