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Which healthy lifestyle factors are associated with a lower risk of suicidal ideation among adolescents faced with cyberbullying?

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Abstract (word count: 245)

Cyberbullying is associated with negative mental health outcomes including adolescent suicidal ideation. This requires effective and accessible preventive efforts. Healthy lifestyles are factors adolescents themselves can modify that may lower their risk of suicidal ideation. The aim of this study was to examine associations between physical activity, (outdoor) sport participation, a healthy diet, higher sleep duration and low levels of smoking and alcohol use, and suicidal ideation when faced with cyberbullying. A cross-sectional survey was administered in 2014-2015 to 1037 adolescents (12-18 years, M age=15; 50% girls) in Flanders, Belgium. Logistic regression analyses were conducted to assess direct effects of cyberbullying involvement (victim, perpetrator, bystander) on suicidal ideation, and interaction effects between cyberbullying involvement, healthy lifestyles and suicidal ideation. Results showed that cyberbullying victimization, perpetration and bystanding were associated with higher suicidal ideation, but that the association with cyberbullying perpetration disappeared when corrected for other cyberbullying involvement forms. More physical activity, sleeping longer, more often taking a healthy diet and lower levels of smoking were associated with lower suicidal ideation. Some associations of healthy lifestyles with suicidal ideation disappeared at higher levels of cyberbullying involvement. Low alcohol consumption and (outdoor) sport participation were not associated with suicidal ideation, and sport participation was even associated with higher suicidal ideation at low levels of cyberbullying involvement. These findings suggest a novel approach to suicide prevention may be warranted, by strengthening healthy lifestyles as factors that adolescents themselves can modify to increase their resilience and reduce suicidal ideation.

Keywords

Cyberbullying; suicidal ideation; adolescent; healthy lifestyles; physical activity; diet; smoking; alcohol; sleep; sport.

Word count of manuscript: 3773 words excluding titles, subtitles, tables, graphs, captions, in-text citations and references

Introduction

Cyberbullying is commonly defined as bullying that takes place via digital media. A meta-analysis of 80 studies showed that cyberbullying affected 15% to 16% of study participants that mainly included youth [1]. Studies moreover showed that cyberbullying peaks in 12-15 year olds [2]. Although less prevalent than traditional, offline bullying, it may have a stronger impact on certain psychosocial outcomes than traditional bullying [3-6]. Especially regarding suicidal ideation, cyberbullying involvement was a stronger predictor than traditional bullying involvement [6, 7]. Both cyberbullying victimization and perpetration were positively associated with suicidal ideation and behavior [4, 8-11]. To our knowledge, no studies have investigated suicidal ideation among bystanders of cyberbullying. Research on traditional bullying, however, showed higher suicidal ideation among bystanders than non-bystanders [12, 13], possibly due to indirect co-victimization; cognitive dissonance from not helping a person in need; or worrying about being victimized next [12, 13]. Similar mechanisms and results may be expected for suicidal ideation among bystanders of cyberbullying.

Suicide is the second most important cause of adolescent mortality after traffic accidents [14], with a lifetime prevalence of self-reported suicide attempts of 10.5% among European adolescents [15]. Suicidal behavior is a complex process, starting with suicidal ideation ('thinking about ending one's life'), planning suicide ('thinking about methods, places, timeframe'), to attempting and possibly ending in suicide [14]. The Stress-Diathesis Model of Suicidal Behaviour posits that suicidal behaviour results from an interplay between proximal stress factors and a distal personal vulnerability or diathesis [16]. Peer victimization, such as cyberbullying, is a proximal risk factor and is considered neither necessary nor sufficient to move from suicidal ideation to enactment [17]. Cyberbullying involvement can increase the risk of suicidal ideation by feelings of loneliness and hopelessness [9, 18], and a lack of effective coping skills to address cyberbullying [19]. Healthy lifestyles, such as diet, sleep, physical activity, and absence of addictive behaviours, may reduce adolescents' vulnerability to stress and help youngsters to cope with cyberbullying. Healthy lifestyles can increase youngsters' resilience and mental well-being [20]. Educating and supporting youngsters in managing their own mental health is empowering, destigmatizing, and can have a large impact at population level [21]. Research showed that healthy lifestyles, such as sport participation and vigorous physical activity [22], a healthy diet [23], and sufficient sleep duration [24-27] were associated with lower youth suicidal ideation. Conversely, unhealthy lifestyles such as alcohol consumption [28, 29] and smoking [30, 31] showed an increased risk of youth suicidal ideation. Daily physical activity (PA) related to lower suicidal ideation and behavior, but not significantly so for victims of traditional bullying [32]. Whereas cyberbullying involvement may create a stress factor, healthy lifestyles may decrease adolescents' vulnerability to stress or diathesis. From the perspective of the Stress-Diathesis Model of Suicidal Behaviour, adolescents with healthy lifestyles may face cyberbullying involvement and

experience a lower risk of suicidal behaviour, whereas youngsters with unhealthy lifestyles may show higher risks of suicidal behaviour when involved in cyberbullying.

To our knowledge, no research has investigated whether this positive role of healthy lifestyles also applies to those involved in cyberbullying. The aim of this study was to examine: 1) associations between cyberbullying involvement (as perpetrator, victim, or bystander) and suicidal ideation (research question RQ1); and 2) the moderating role of healthy lifestyles, such as sleep duration, lower levels of smoking or alcohol use, PA and sports, and a healthy diet, against suicidal ideation (RQ2-3). We hypothesized that all forms of cyberbullying involvement will be associated with higher suicidal ideation (H1); that less smoking (H2) and alcohol (H3); and sleeping longer (H4), PA and sports (H5), and a healthy diet (H6), will be associated with a lower suicidal ideation when involved in cyberbullying. Our results may support youngsters in strengthening factors they can modify themselves to protect their mental health, and may encourage health professionals in designing prevention programs to lower suicide risk in adolescents involved in cyberbullying.

Material and methods

Participants and data-collection

A random sample of secondary schools was selected from a government database of schools in Flanders. Twenty-six schools were contacted, eight agreed to participate between November 2014-May 2015. The study aimed to collect data among all grades 7-12 (aged 12-18) in each school, which was not always feasible. Adolescents gave active informed consent, parents provided passive informed consent. Participants completed an anonymous survey at school during one class hour, supervised by researchers. The study received approval from the Ethics Committee of the Ghent University Hospital.

Measures

Socio-demographic information

Socio-demographic variables included age, gender, type of education, country of birth, sexual orientation, family living situation, self-reported weight and height (used to calculate Body Mass Index, BMI), and family affluence [33]. All demographic variables were derived from the HBSC questionnaire [34], except for sexual orientation. *Sexual orientation* was measured by examining the gender of each participant in relation to their sexual attraction [35] (attracted to 'girls', 'boys', 'both girls or boys' or 'I am not sure').

Cyberbullying involvement

Questions on cyberbullying involvement were preceded by a definition of bullying, distinguishing it from unintentional acts or arguments between children of equal power, and were rated on a 5-point frequency scale reflecting involvement in the past six months [36]. Questions for cyberbullying

involvement included experiences as a victim, perpetrator and bystander (1 item each). The items that measured cyberbullying involvement are available in Supplementary Material.

Healthy lifestyles

All healthy lifestyle items, except sleep duration, were taken from the HBSC survey (see Supplementary material). Several health-related lifestyles among adolescents are interrelated. Previous studies found that energy-balance related behaviors, such as PA, sedentary behavior and healthy diet, formed one group of health-related lifestyles among adolescents [37-39], whereas addictive behaviors such as alcohol consumption and smoking formed a second group [37-39]. In previous research, sleep duration was included with (low) addictive behaviors in some adolescent samples, and with health-promoting behaviors in other adolescent samples [40]. Prior to our main analyses, we conducted a Principal Component analysis (Varimax rotation) on healthy lifestyles, resulting in two factors (Table 1). The purpose of this analysis was to find lifestyles that were highly related to each other, and to avoid that an association between one of these lifestyles and suicidal ideation may be due to a third variable, i.e. another healthy lifestyle that is highly associated with the healthy lifestyle under analysis and the dependent variable. For this reason, highly related lifestyles that were part of one factor were jointly entered into the regression model.

Table 1. Principal Component analysis results for healthy lifestyle variables

	Factor 1 ‘Addictive behaviors and sleep duration’	Factor 2 ‘Energy-balance related behaviors’
	Rotated factor loadings	
Alcohol consumption	0.81	
Smoking	0.76	
Perceived sleep duration	-0.62	
Physical activity		0.83
Healthy diet		0.63

Model Adjusted R²=57.6

Addictive behaviors and perceived sleep duration

An index was made combining several questions on *tobacco use frequency*, ranging from never smoked to smoking ≥ 11 cigarettes per day (=median among daily smokers). *Alcohol use* was assessed by summing the frequency of 6 different types of alcohol consumption (0-never; 4-daily. Summed score range 0-24). *Sleep duration* was assessed by asking participants to think of when they usually go to bed and get up. This was used to calculate the number of hours slept per night. We suggest this self-reported sleep duration should be considered as a qualitative perception of their sleep and not as a purely quantitative indication of sleep duration. Self-reported sleep showed weak correlations with sleep log information [41], and may also reflect sleep quality, perception of desired sleep and psychosocial factors [41]. Since it has stronger associations with health and psychosocial outcomes

than objective sleep assessments [41, 42], this self-report measure was used rather than objective measures.

Energy-balance related behaviors

A *healthy diet* was measured by assessing the number of days per week adolescents had taken breakfast. Regular breakfast consumption is important for meeting daily quality recommendations in a youngster's diet [43] and was associated with adolescent mental well-being in prior studies [44-46]. *Physical activity* was measured by the number of days they achieved ≥ 60 minutes of moderate to vigorous PA, defined in the questionnaire as: "bodily movements that make your heart beat faster and make you feel out of breath at some moments". *Sport participation* assessed participation in leisure-time sports (yes/no) and leisure-time outdoor sports (yes/no).

Suicidal ideation

Suicidal ideation was measured by an item from the Flemish HBSC study, assessing the extent to which participants had experienced suicidal thoughts in the past 6 months (5-point scale). Content validity was assessed in consultation with the Flemish Expertise Centre for Suicide Prevention and the suicide hotline in Flanders. Given the skewed distribution for this variable, it was dichotomized into 'never' and 'at least once' in the past 6 months.

Analysis

Multiple logistic regression analyses assessed the direct association between cyberbullying involvement (victimization, perpetration, bystanding) and suicidal ideation (RQ1); and the moderating role of healthy lifestyles, such as addictive behaviors and sleep (RQ2) and energy-balance related behaviors (RQ3) in the relation between cyberbullying involvement and suicidal ideation. Analyses were controlled for socio-demographic factors that significantly influenced suicidal ideation. Collinearity diagnostics were conducted examining variance inflation factor VIF (≤ 10) and tolerance (≥ 0.1). Cross-tabulations were checked for empty combinations of cells or low expected frequencies [47]. Continuous independent variables were centered on the mean. Graphical presentations of moderator analyses were made using PROCESS 2.16.3 for SPSS, and based on parsimonious model results. Graph labels 'low-medium-high' for continuous moderating variables represent the mean value (medium) plus (high) or minus (low) one standard deviation. All analyses were conducted in SPSS 25.0.

Results

The initial sample consisted of 1062 adolescents, from which 25 were removed due to unreliable answering patterns (e.g. satisficing answers, no variation in answering options on scales where positive and negative items are reversed in order), resulting in an analysed sample of 1037 adolescents (Table 2).

Table 2. Sample characteristics

	Full sample (n=1037)
Gender	
Male	50.2%
Female	49.8%
Age	M=15.17 ± 1.86
Family affluence	
Low – medium	17.6%
High	82.4%
Nationality	
Born in Belgium	94.0%
Born abroad	6.0%
Family situation	
Living with both parents	64.1%
Other family situation	35.9%
Body Mass Index	
BMI	M=19.56 ± 3.70
Sexual orientation	
Heterosexual	93.0%
Non-heterosexual	7.0%
Cyberbullying involvement in past 6 months	
Cyberbullying victim (at least once)	7.4%
Cyberbullying perpetrator (at least once)	9.0%
Cyberbullying bystander (at least once)	49.5%
Suicidal ideation in past 6 months	
Suicidal thoughts (at least once)	22.0%
Physical activity and sport participation	
≥60 min. PA (number of days/week)	M=3.33 ± 2.09
Participates in leisure time sports	66.0%
Participates in outdoor leisure time sports	36.8%
Healthy diet	
Breakfast (number of days/week)	M=5.38 ± 2.19
Alcohol consumption	
Frequency of alcohol consumption (0-24)	M=3.36 ± 3.85
Smoking	
Current smokers	12.5%
Perceived sleep duration	
Average hours of sleep/night	M=7.87 ± 1.42

Gender and sexual orientation were used as control variables (Supplementary material, Table A1). VIF showed no multicollinearity among independent variables. Tables 3-4 show associations between cyberbullying involvement and healthy lifestyles with suicidal ideation. The header of each column indicates which type of cyberbullying involvement is reported in the results.

All forms of cyberbullying involvement were significantly associated with higher suicidal ideation (Table 3). When jointly assessing forms of cyberbullying involvement, cyberbullying victimization (OR=2.36, 95% CI 1.62;3.45; RR=1.84) and bystanding (OR=1.44, 95% CI 1.24; 1.68; RR=1.35) remained significant predictors, but cyberbullying perpetration did not (OR=1.16, 95% CI 0.79; 1.70, RR=1.12). These results provide partial confirmation of hypothesis H1: victimization and bystanding were indeed associated with higher suicidal ideation, but contrary to expectations, cyberbullying perpetration did not when corrected for the involvement in cyberbullying victimization and bystanding.

Students who smoked less reported lower suicidal ideation (corrected for cyberbullying victimization and perpetration, but not bystanding), but these associations did not differ depending on the levels of cyberbullying involvement. This provides partial support for H2: while less smoking is associated with less suicidal ideation, it does not specifically moderate the influence of cyberbullying involvement on suicidal ideation. Lower alcohol consumption did not predict suicidal ideation, disconfirming H3. Perceived sleep duration was a consistent, strong, predictor of suicidal ideation: a longer sleep duration was associated with less suicidal ideation (H4), irrespective of the degree of cyberbullying involvement.

A healthy diet was significantly associated with lower suicidal ideation (corrected for cyberbullying victimization and perpetration, but not bystanding) (Table 4). Moreover, there was a significant interaction effect of a healthy diet and cyberbullying involvement (victimization, perpetration), providing partial confirmation for H5. Suicidal ideation is higher at more frequent cyberbullying involvement than at medium or less frequent involvement (Fig. 1-2). Adolescents with a healthier diet had lower odds of suicidal ideation than those with less healthy diets. This difference by healthy diet decreased as cyberbullying involvement (victimization, perpetration) increased.

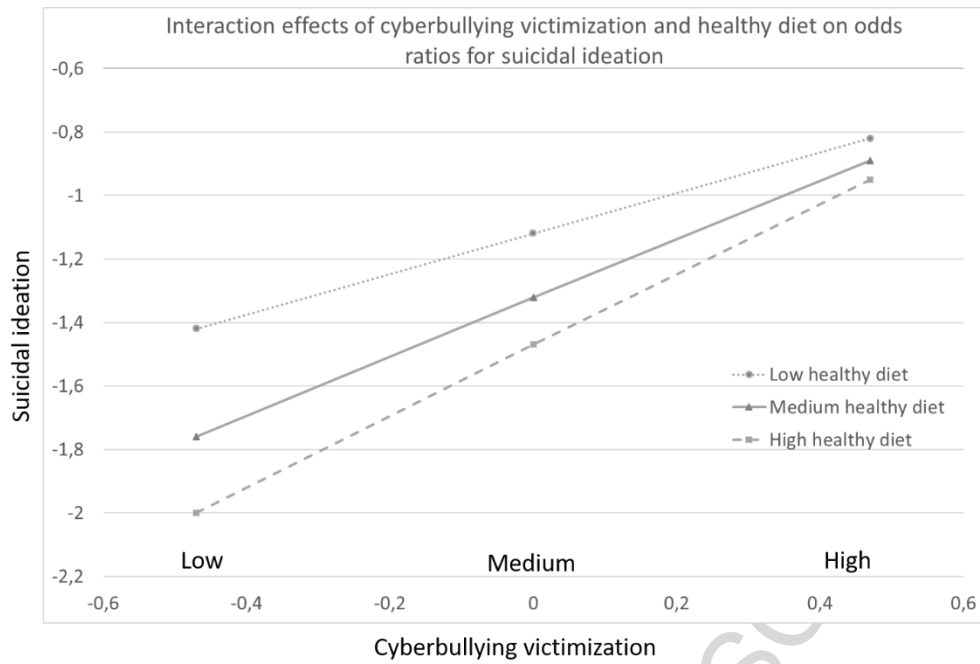


Figure 1. Interaction effect of cyberbullying victimization and healthy diet on suicidal ideation

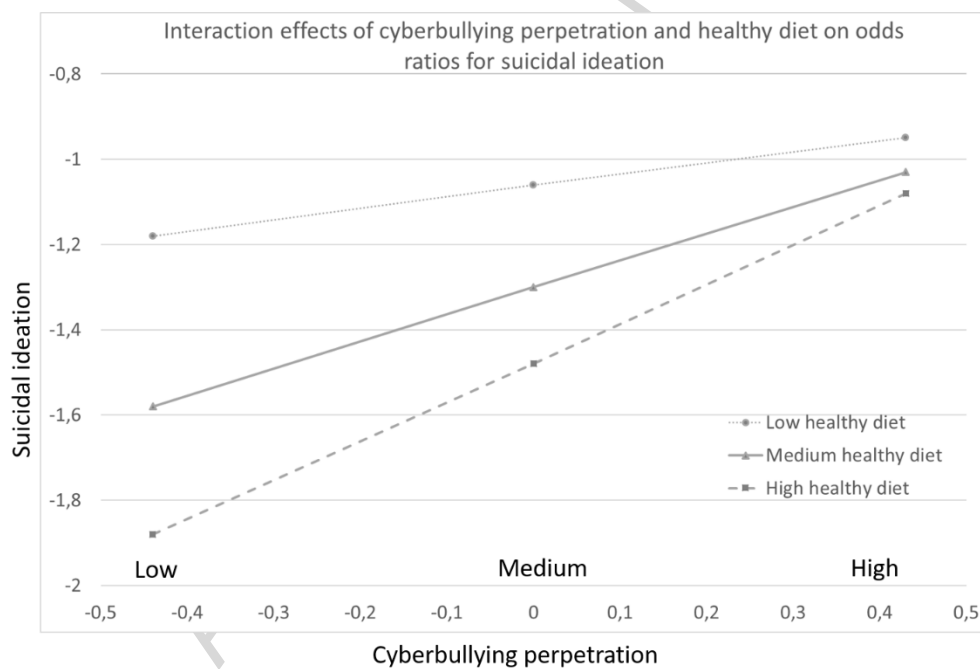


Figure 2. Interaction effect of cyberbullying perpetration and healthy diet on suicidal ideation

More PA significantly predicted lower suicidal ideation (correcting for cyberbullying bystander), and both PA and sport participation were significant moderators in the relation between cyberbullying bystander and suicidal ideation (H6). More frequent cyberbullying bystander was associated with higher odds for suicidal ideation than less frequent cyberbullying bystander. Odds of suicidal

ideation were lower at higher levels of PA than at lower PA levels. This difference by PA however decreased when frequency of cyberbullying bystanding increased (Fig. 3).

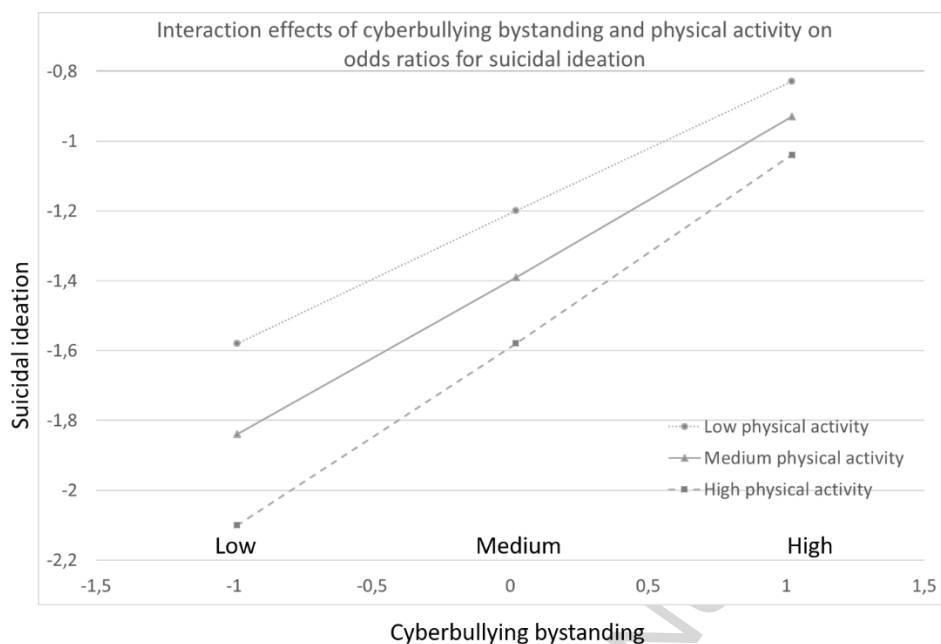


Figure 3. Interaction effect of cyberbullying bystanding and physical activity on suicidal ideation

Contrary to expectations, sport participation showed a negative interaction effect with cyberbullying bystanding on suicidal ideation: while more frequent cyberbullying bystanding was associated with higher suicidal ideation, adolescents who participated in sports had higher odds of suicidal ideation at less frequent bystanding than those who did not participate in sports. This difference disappeared at more frequent cyberbullying bystanding (Fig. 4).

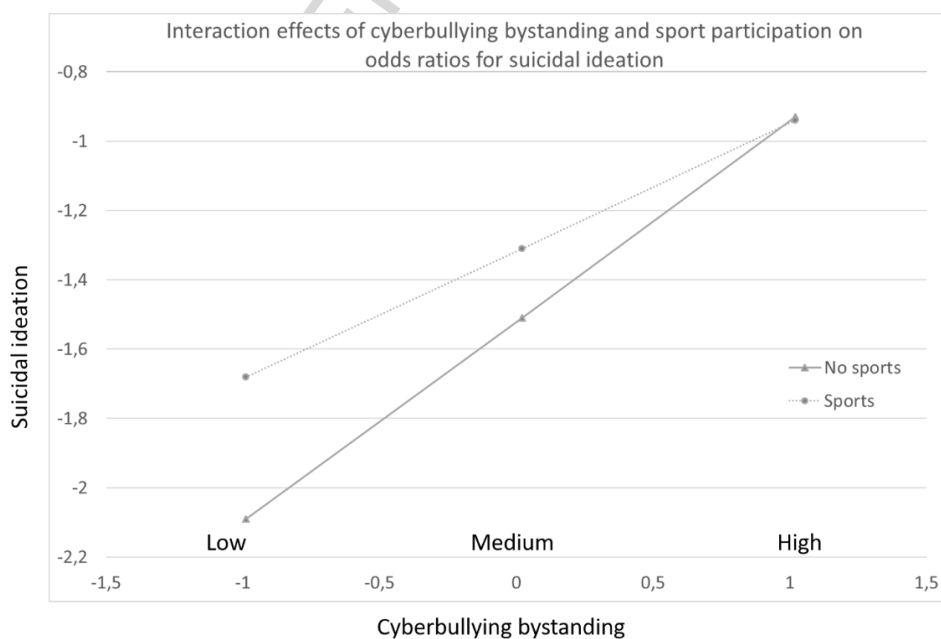


Figure 4. Interaction effect of cyberbullying bystanding and sport participation on suicidal ideation

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Table 3. Regression analysis on the moderating role of addictive behaviors and perceived sleep duration in the relation between cyberbullying involvement and suicidal ideation

	Dependent variable: suicidal ideation		
	Cyberbullying victimization	Cyberbullying perpetration	Cyberbullying bystanding
Full model results (direct effects)	-2LL=998.91; R ² =.08; $\chi^2(3)=49.91, p<0.001$	-2LL=949.28; R ² =.06; $\chi^2(3)=39.27, p<0.001$	-2LL=928.16; R ² =.09; $\chi^2(3)=57.25, p<0.001$
	Odds ratio's (95% CI)		
Cyberbullying involvement	2.05 (1.51; 2.77)	1.82 (1.32; 2.50)	1.52 (1.32; 1.77)
Gender (ref. girls)	0.47 (0.34; 0.64)	0.46 (0.33; 0.63)	0.44 (0.32; 0.62)
Sexual orientation (ref. heterosexual)	1.80 (1.03; 3.15)	2.07 (1.18; 3.63)	2.02 (1.14; 3.58)
Full model results (Interaction effects)	-2LL=911.57; R ² =.13; $\chi^2(9)=81.04, p<0.001$	-2LL=922.10; R ² =.11; $\chi^2(9)=71.00, p<0.001$	-2LL=902.48; R ² =.13; $\chi^2(9)=84.59, p<0.001$
	Odds ratio's (95% CI)		
Cyberbullying involvement	2.53 (1.71; 3.75)	1.91 (1.31; 2.77)	1.50 (1.28; 1.77)
Gender (ref. girls)	0.41 (0.29; 0.58)	0.40 (0.28; 0.56)	0.40 (0.29; 0.57)
Sexual orientation (ref. heterosexual)	1.75 (0.95; 3.24)	1.88 (1.02; 3.46)	1.63 (0.87; 3.06)
Alcohol consumption	1.02 (0.97; 1.07)	1.02 (0.97; 1.07)	1.00 (0.95; 1.06)
Smoking	1.17 (0.99; 1.38)	1.16 (0.98; 1.37)	1.09 (0.90; 1.31)
Perceived sleep duration	0.80 (0.70; 0.90)	0.78 (0.69; 0.88)	0.81 (0.71; 0.91)
Alcohol * cyberbullying involvement	0.95 (0.89; 1.02)	0.99 (0.91; 1.08)	1.00 (0.96; 1.04)
Smoking * cyberbullying involvement	0.95 (0.71; 1.26)	0.97 (0.71; 1.34)	1.06 (0.93; 1.22)

Sleep * cyberbullying involvement	1.00 (0.83; 1.22)	1.02 (0.84; 1.24)	0.98 (0.87; 1.09)
Parsimonious model results (Interaction effects)	<i>-2LL=929.66; R²=.11; $\chi^2(4)=72.49, p<0.001$</i>	<i>-2LL=937.09; R²=.10; $\chi^2(4)=65.55, p<0.001$</i>	<i>-2LL=942.72; R²=.12; $\chi^2(3)=74.94, p<0.001$</i>
	Odds ratio's (95% CI)		
Cyberbullying involvement	2.06 (1.48; 2.88)	1.84 (1.33; 2.57)	1.51 (1.30; 1.74)
Gender (ref. girls)	0.42 (0.30; 0.59)	0.42 (0.30; 0.58)	0.43 (0.31; 0.59)
Smoking	1.18 (1.02; 1.37)	1.17 (1.01; 1.36)	/
Perceived sleep duration	0.80 (0.71; 0.90)	0.77 (0.68; 0.86)	0.78 (0.69; 0.87)

R²: Nagelkerke R²

Table 4. Regression analysis on the moderating role of energy-balance related behaviors in the relation between cyberbullying involvement and suicidal ideation

	Dependent variable: suicidal ideation		
	Cyberbullying victimization	Cyberbullying perpetration	Cyberbullying bystanding
Full model results (Interaction effects)	$-2LL=907.54; R^2=.13;$ $\chi^2(11)=79.46, p<0.001$	$-2LL=929.96; R^2=.09;$ $\chi^2(11)=58.59, p<0.001$	$-2LL=914.99; R^2=.11;$ $\chi^2(11)=70.41, p<0.001$
	Odds ratio's (95% CI)		
Cyberbullying involvement	3.59 (1.81; 7.14)	2.56 (1.26; 5.17)	1.97 (1.48; 2.62)
Gender (ref. girls)	0.48 (0.34; 0.68)	0.51 (0.36; 0.71)	0.46 (0.33; 0.65)
Sexual orientation (ref. heterosexual)	2.08 (1.16; 3.71)	2.14 (1.20; 3.83)	2.00 (1.11; 3.60)
Diet	0.92 (0.85; 0.99)	0.90 (0.84; 0.97)	0.93 (0.86; 1.01)
Physical activity days	0.95 (0.86; 1.04)	0.92 (0.84; 1.01)	0.92 (0.84; 1.01)
Sport participation (ref. no sports)	1.37 (0.87; 2.14)	1.45 (0.93; 2.26)	1.43 (0.91; 2.26)
Outdoor sport participation (ref. no outdoor sports)	0.80 (0.52; 1.22)	0.77 (0.51; 1.16)	0.83 (0.55; 1.26)
Diet * cyberbullying involvement	1.27 (1.11; 1.46)	1.23 (1.02; 1.47)	0.99 (0.93; 1.05)
PA days * cyberbullying involvement	0.98 (0.84; 1.15)	1.02 (0.83; 1.24)	1.09 (1.00; 1.19)
Sport participation (ref. no sports)* cyberbullying involvement	0.55 (0.19; 1.61)	0.76 (0.25; 2.29)	0.63 (0.42; 0.94)
Outdoor sport participation (ref. no outdoor sports)* cyberbullying involvement	2.91 (1.00; 8.52)	0.80 (0.30; 2.15)	1.06 (0.72; 1.56)
Parsimonious model results (Interaction effects)	$-2LL=968.87; R^2=.10;$	$-2LL=981.33; R^2=.08;$	$-2LL=942.76; R^2=.11;$

	$\chi^2(5)=62.89, p<0.001$	$\chi^2(5)=54.42, p<0.001$	$\chi^2(7)=70.38, p<0.001$
	Odds ratio's (95% CI)		
Cyberbullying involvement	2.50 (1.70; 3.69)	1.89 (1.33; 2.68)	2.05 (1.55; 2.72)
Gender (ref. girls)	2.21 (1.60; 3.05)	0.46 (0.33; 0.63)	0.45 (0.32; 0.63)
Sexual orientation (ref. heterosexual)	1.91 (1.09; 3.36)	2.18 (1.25; 3.83)	1.89 (1.05; 3.39)
Diet	0.91 (0.85; 0.98)	0.90 (0.84; 0.96)	/
Physical activity days	/	/	0.91 (0.83; 1.00)
Sport participation (ref. no sports)	/	/	1.26 (0.85; 1.87)
Diet * cyberbullying involvement	1.14 (1.02; 1.26)	1.89 (1.03; 1.37)	/
PA days * cyberbullying involvement	/	/	1.09 (1.00; 1.19)
Sport participation (ref. no sports)* cyberbullying involvement	/	/	0.66 (0.46; 0.95)

R²: Nagelkerke R²

Discussion

This study examined associations between cyberbullying involvement and suicidal ideation, and the role of healthy lifestyles. This was to our knowledge the first study to assess these associations for cyberbullying involvement. Given the negative impact of cyberbullying on mental health, insights are needed in the relation between cyberbullying and suicidal ideation, and on how adolescents can protect themselves against suicidal ideation via healthy lifestyles they can modify in their everyday lives.

Suicidal ideation was high: 22% of adolescents had thought about ending their life at least once in the past six months (although this happened only once for 11%). Our findings showed that all types of cyberbullying involvement significantly predicted suicidal ideation (when not taking involvement in other forms of cyberbullying involvement into account), confirming earlier research on cyberbullying victimization [4, 6, 9-11] and perpetration [8, 48]. The association with cyberbullying perpetration, however, disappeared when accounting for other types of cyberbullying involvement. Since suicidal ideation is highest for youngsters who are both victim and perpetrator of cyberbullying [48], the association between cyberbullying perpetration and suicidal ideation may come from overlapping roles with victimization, and become non-significant when victimization is controlled for. To assess this assumption, we tested interaction effects between types of cyberbullying involvement in relation to suicidal ideation, but none were however significant (see Table A2 in Supplementary Material). This may require further attention in future research with larger samples. Our study was the first to show cyberbullying bystanding predicted suicidal ideation, and that, as in traditional bullying, bystanders also experience negative psychosocial outcomes. Since many adolescents had witnessed cyberbullying, this is an important finding. Programs that target interventions of bystanders to end cyberbullying, such as Friendly ATTAC [49, 50], Noncadiamointrappola [51], or Media Heroes [52], should pay attention to reducing negative psychosocial outcomes for these bystanders resulting from increased exposure to cyberbullying. These programs can reduce feelings of dissonance between actions and intentions by promoting active bystander intervention, but may also increase co-victimization or fears of becoming the next victim [12, 13]. Training on coping strategies for bystanders in managing their own fears and co-victimization experiences, and ongoing psychosocial support for bystanders in peer-led models are recommended.

Several healthy lifestyles were significantly associated with a lower suicidal ideation, either as main effect or in interaction with cyberbullying involvement. PA frequency contributed to lower suicidal ideation as a main effect (corrected for cyberbullying bystanding) and in interaction with cyberbullying bystanding. The positive contribution of weekly moderate to vigorous PA to a lower suicidal ideation is consistent with some previous research [22, 53, 54], but inconsistent with other research showing no significant associations when sport frequency was also included [55, 56]. Earlier research showed that regular PA was (borderline) significantly associated with lower adolescent

suicidal ideation when faced with traditional bullying victimization [32]. A healthier diet, by regularly taking breakfast, contributed to a lower suicidal ideation, both as a main effect, and in interaction with cyberbullying victimization and perpetration. Regular breakfast consumption has shown to be associated with better adolescent mental health [44] and lower suicidal ideation [57]. Having a regular and quality breakfast positively impacts mental health by facilitating higher quality-of-life, daily and social activities, social support and physical fitness [58], and getting sufficient nutrients [45], such as restoring levels of glucose needed in the brain after glucose deprivation during the night [59]. It is moreover assumed that regularly taking breakfast is indicative of sitting down as a family for meals and positive family functioning [44]. Regular family meals were positively associated with adolescents' mental health, presumably through better child-parent communication and family cohesion [60]. For both PA and a healthy diet, the associations with a lower suicidal ideation decreased when cyberbullying involvement was more frequent. This suggests that while healthy lifestyles are valuable tools to promote youth mental health, in severe situations other forms of mental health promotion or support are nevertheless needed.

Our findings furthermore point to the importance of a longer perceived sleep duration for lower adolescent suicidal ideation. Systematic reviews demonstrated that disturbed sleep was a risk factor for suicidal ideation [61, 62]. Bidirectional associations were noted in prospective studies between disturbed sleep and mental health problems [62], which suggest a need for early interventions in sleeping problems to avoid the occurrence of a negative vicious cycle with mental health. Sleep is important for adolescents' neuronal recuperation, synaptic homeostasis, brain plasticity [63], emotional regulation [63, 64] and stress-related coping strategies [63]. Especially REM (Rapid Eye Movement) sleep is assumed to help resolve emotional conflict, but a good architecture of all sleep phases is important for an overall healthy functioning, both mentally and physically [63]. Lower levels of smoking were associated with less suicidal ideation, in line with previous research [61, 65]. Different mechanisms have been hypothesized in literature for the association between smoking and suicidal ideation, including smoking as an inadequate form of self-medication to reduce suicidal risk or its precursors such as low affect or anxiety; smoking as a marker of suicidal ideation, both being influenced by a third factor such as parental attachment [66]; and smoking as a psychological and physical toxin that increases suicidal risk, e.g. by reductions in serotonin levels [67]. This underlines the importance of smoking prevention in mental health promotion programs.

Certain hypothesized lifestyles were not associated with suicidal ideation, such as low alcohol consumption, sport participation and outdoor sport participation. Associations between suicidal ideation and alcohol abuse or dependencies [61, 68, 69], heavy episodic drinking [29], drinking before teenage years [28] or drinking to cope with depression [29], are well-documented. Alcohol consumption levels in our sample may have been too low compared to disordered forms of drinking recorded in previous studies to show associations with suicidal ideation. Sport participation was also

not associated with suicidal ideation, taking PA levels into account. Although many studies have examined psychosocial benefits of sport participation, research on associations with suicidal ideation is much scarcer, but did find protective effects of sport participation [70]. Earlier studies investigating influences of both PA and sports on suicidal ideation, showed sport but not PA to be associated with lower suicidal ideation [55, 56]. Some methodological differences may explain these discrepancies in findings. Unlike previous research, our study investigated frequency of PA but not of sport participation. Possibly, it is the regularity of movement rather than the type of (sport) activity, that influences suicidal ideation. Second, our study assessed sport participation that could be performed in team, solitary, in organized or non-organized settings. Earlier research investigated team sport participation, which implies a social element to sports. Sports our study participants referred to may have been either solitary, non-formally organized or team/club sports. This may cause different results between studies, since club or team sport participation is assumed as more important than PA for mental health thanks to positive peer involvement [70]. Our study, on the contrary, moreover showed a negative effect in association with cyberbullying bystanding on suicidal ideation: at less frequent bystanding, sport participation was associated with higher suicidal ideation, but this difference diminished as bystanding became more frequent. Sport activities are often also accompanied by stress and negative peer and adult experiences [71]. Possibly sport participation increases exposure to other predictors of suicidal ideation. This underlines the importance of the role of sport coaches to guarantee a positive (peer) climate. Our study adds to scarce research on outdoor sport participation and mental health: a review showed positive effects on adolescent mental health but did not investigate suicidal ideation [72], whereas a study among adults found no effect on suicidal ideation [73]. In our study, outdoor sport participation was not associated with suicidal ideation. Further research is needed to assess which specific attributes of PA and sports are associated with lower adolescent suicidal ideation.

Conclusion

Healthy lifestyles such as regular physical activity, regularly taking breakfast, more sleep and lower levels of smoking are associated to lower suicidal ideation. These are factors that youngsters themselves may be able to modify to reduce their risk of suicidal ideation. Cyberbullying victimization and bystanding independently predicted suicidal ideation. The healthy lifestyles that were significantly associated with suicidal ideation were similar for the general adolescent population as in relation to cyberbullying involvement. This underlines the value of adding healthy lifestyle promotion to adolescent mental health promotion or cyberbullying prevention programs, and shows that tailoring may not be needed on different lifestyle components depending on adolescents' cyberbullying involvement. Specific attention may however be needed to cyberbullying bystanding and severe cases of cyberbullying involvement. Since cyberbullying bystanding significantly predicted suicidal ideation, programs aiming to actively involve bystanders to reduce cyberbullying

should counter possible negative side-effects that may stem from increased cyberbullying exposure for bystanders. Moreover, the association of healthy lifestyles with lower suicidal ideation diminished at more frequent cyberbullying involvement, suggesting a need for other forms of help in severe situations. In sport settings, attention may furthermore be needed to create a positive (peer) climate to reduce suicidal ideation. Given this evidence, these healthy lifestyles should be actively promoted, in preference jointly since lifestyles are often clustered [37-40] and can positively reinforce each other [74].

Limitations and strengths

This study had some limitations. As the study was cross-sectional, associations between healthy lifestyles and low suicidal ideation may result from self-selection where adolescents with better mental health take more part in these healthy lifestyles. Intervention or longitudinal studies are needed to assess outcomes of healthy lifestyles changes on suicidal ideation, and investigate bidirectional associations or associations in the reverse direction. Insights from the field of depression, where changes in healthy diet, sleep, and no substance abuse lowered the risk of depression [20], already provide some support for our recommendation to increase healthy lifestyles as a way to promote mental health and prevent suicide. The majority of the study sample was very affluent, in line with the high affluence of the population in this region. Our study findings may however not generalize to less affluent regions. Future research among less affluent adolescents should also take into account potential environmental barriers to perform these healthy lifestyles, such as food insecurity, neighborhood safety, and cost restrictions to sport participation. Our study used short scales to assess multiple healthy lifestyles without overburdening participants, which did not allow to assess specific attributes of lifestyles, e.g. social aspects, in relation to suicidal ideation. More research is needed here. Although data was self-reported, we expect low social desirability biases given the survey's anonymity. Our study was the first to document how lifestyles are associated with lower suicidal ideation when youngsters are faced with cyberbullying involvement, and added to the scarce research on healthy lifestyles to ward off suicidal ideation. The use of internationally validated measures of healthy lifestyles in our study can facilitate generalizability of methods and findings. The study's unique focus on strengthening protective factors rather than on risk factors, may help construct new promising programs for adolescent suicide prevention.

Conflict of interest

The authors declare no conflict of interest.

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Highlights

Cyberbullying involvement is associated with higher adolescent suicidal ideation

Also cyberbullying bystanding is associated with higher suicidal ideation

Physical activity, healthy diet, less smoking, and more sleep lower the suicidal risk

(Outdoor) sports and less alcohol use do not protect against suicidal ideation

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