



The association of adolescents' smoking with the physical activity levels of their friends

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ABSTRACT

Background: Smoking is inversely related to people's Physical Activity Level (PAL). As the behavior of friends may affect the choices and behavior of adolescents, having friends with a high PAL may potentially protect against adolescent smoking. This study aims to assess whether adolescents' smoking is associated with the PAL of their friends.

Methods: SILNE-R survey data of 11,918 adolescents from 55 different schools in 7 European cities was used to determine weekly smoking, individual PAL, PAL of friends, school PAL, and smoking of friends. Multilevel, multivariable logistic regression analysis were used to assess the association between the PAL of friends and weekly smoking. Several socio-demographic variables were included as covariates in the analysis.

Results: Our results indicated that 10.8% of the respondents was smoking weekly. Weekly smoking was most common among adolescents whose friends had a PAL of 0–42.0 min per day (14.5%). Respondents were significantly more likely to be smoking weekly if their friends were on average 0–42 min vs. 80–180 min physically active (OR 1.27 [95% CI 1.04–1.55]). This association existed independently of the individual PAL of respondents. Stratification for smoking of friends yielded equal results, although the association appeared to be somewhat stronger for those with smoking friends (OR 1.38 [95% CI 1.06–1.82]).

Conclusion: Adolescents are less likely to smoke weekly if they associate with friends who spend >80 min per day on physical activity. Initiatives aimed at the prevention of smoking among adolescents may benefit from organizing group-based physical activity programs.

1. Introduction

Smoking among adolescents remains a serious public health problem. In 2018, more than one in six (18%) 15-year-olds in Europe had smoked at least once in the past month (OECD, Union E, 2020). Adolescents are more susceptible to addictive behavior (Hanna et al., 2001) and early onset of smoking can lead to significant deterioration of health later in life (Prevention NCFCD, Smoking HPOO, 2012).

Smoking is inversely related to people's Physical Activity Level (PAL), with a high PAL being associated with a lower smoking rate (Chasandra et al., 2015; Leatherdale et al., 2008; McDermott et al.,

2009). Hence, promoting physical activity has been incorporated as a component of smoking cessation and smoking prevention interventions. For example, participation in organized sports activities is a core element of the Icelandic Prevention Model (IPM) (Kristjansson et al., 2020), a successful approach to substance use prevention, which has led to a substantial decline in the smoking prevalence of adolescents in Iceland (Kristjansson et al., 2016).

The association between smoking and PAL may not exclusively stem from processes on the individual level. During adolescence, friends become progressively influential in determining behavior, particularly since the desire for approval of friends elevates (Gruenenfelder-Steiger

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et al., 2016). Research indicates that adolescent behavior may be predicted by how one perceives the behavior of their friends (i.e. descriptive social norms) (Liu et al., 2017; Schuler et al., 2019; Stevens et al., 2022; Wally and Cameron, 2017; Ball et al., 2010; Firestone et al., 2015). For example, adolescents are more likely to smoke if their friends do so (Simons-Morton and Farhat, 2010). This can be explained along two underlying mechanisms: selection (i.e., selecting friends who have similar norms and behaviors) and socialization (i.e., friends influence and shape each other's norms and behaviors and therefore become more similar over time) (de la Haye et al., 2013; Bandura, 1986).

Potentially, engaging in physical activity can lead to the emergence of a non-smoking social norm, which may not only be related to one's own PAL, but also to that of its friends. The selection mechanism may cause adolescents with high PALs to become friends with those who have similar PALs (Macdonald-Wallis et al., 2012). Given the inverse association between PAL and smoking, it can be presumed that both this adolescent and his/her friends are unlikely to smoke. Within such a group of adolescents, the socialization mechanism may lead to a non-smoking social norm. For example, since adolescents with positive attitudes towards physical activity often carry negative attitudes towards smoking, and adolescents participating in sports believe that smoking and engaging in physical activity do not fit together (Bebetsos and Papaioannou, 2003; Olsen et al., 2021).

We hypothesize that these mechanisms may cause adolescents with friends who have high PALs to be less likely to smoke, irrespective of their own PAL. To the best of our knowledge, there have not been published any papers investigating this particular association. Therefore, this study aims to assess whether PAL of friends are associated with smoking behavior of adolescents.

2. Methods

2.1. Study design and population

This study used data from the SILNE-Realist (SILNE-R) project ("Tackling socio-economic inequalities in smoking: learning from natural experiments by time trend analyses and cross-national comparisons") (Lorant et al., 2015). Surveys were carried out in 2016–2017 among 12,991 adolescents from 55 schools in seven medium-sized European cities in Belgium, Finland, Germany, Ireland, Italy, Netherlands, and Portugal. In each school, two grades were selected, which corresponded to 14–16 year-old students. In each country, ethical approval was requested and obtained from local or national authorities and consent to participate was obtained from participants and their parents. More detailed information can be found in the paper describing the survey theory and design of the SILNE project (Lorant et al., 2015).

Respondents who did not provide information about their gender ($n = 18$), age ($n = 15$), or smoking status ($n = 71$), did only provide information about their PAL for 3 or less days ($n = 447$), did not list any friends in the survey ($n = 514$), or for whom the PAL of friends was unknown ($n = 8$), were excluded from the study, resulting in a study sample of $n = 11,918$.

3. Measures

3.1. Dependent variable

3.1.1. Weekly smoking

The smoking status of respondents was determined with two questions: 'Have you ever tried cigarette smoking, even just a few puffs?' and 'How many cigarettes have you smoked the last 30 days?'. Respondents who answered 'No' to the first question, and/or 'I have never smoked, None, 1 to 2 cigarettes during the last 30 days' to the second question, were coded with 0 = no for weekly smoking. Respondents whose answer ranged between '1 to 2 cigarettes per week' to 'more than 30 cigarettes per day' to the second question, were coded with 1 = yes for weekly

smoking.

3.2. Independent variables

3.2.1. Individual PAL

PAL was measured using the question 'On average, how many hours of hard physical activity do you do on each day of the week?'. This included physical activity during physical education class, lunch, evening, and spare time, and was described as "jogging, cycling, team sports, fast dancing and any other physical activities that increase your heart rate and make you breathe hard or sweat". Respondents were able to select 7 options (None, 30 min, 1 h, 1 h and a half, 2 h, 2 h and a half, and 3 or more hours) for each day of the week. The category '3 or more hours' was included in our calculation as 3 h, as it was conducted in a previous study using SILNE-data (Falese et al., 2021). For each respondent, we calculated the mean time in minutes spent on physical activity per day. For respondents who did not provide information about their PAL for the entire week, the calculation was based on the number of days for which the respondent did provide information (4, 5, or 6 days). The individual PAL was then recoded into 4 categories, based on quartiles.

3.2.2. PAL of friends

Respondents were asked to list up to 5 of their best friends within their school. PAL of friends was calculated by summing up the individual PAL of each friend and dividing it by the number of friends listed by the respondent. The calculation was based on those friends who provided information about their PAL. The PAL of friends was then recoded into 4 categories, based on quartiles.

3.2.3. Smoking of friends

Smoking status of friends was dichotomized based on the number of weekly smokers among the friends that the respondents listed as their best friends. Those with 1 or more friends who smoked, were categorized as respondents with smoking friends. The calculation was based on those friends who provided information about their smoking status.

3.2.4. School PAL

Social norms regarding physical activity may not solely occur within the friend context. Schools are one of the key contexts in an adolescent's life, and PAL appear to differ per school (Lenhart, 2015; Bann et al., 2019). School PAL were calculated by the sum of the individual PAL of adolescents at a particular school divided by the number of adolescents at that school.

4. Co-variates

Socio-demographic variables such as age, gender, country, migration background, weekly income, academic achievement, parental education, family composition, and parental smoking were included as potential confounders. *Migration background* of respondents was based on having zero, one or two parents who were born in a country other than the country of residence. *Weekly income* and *academic achievement* were included as covariates, as these have been found to be associated with adolescent smoking [29, 30]. *Weekly income* was divided into five categories: 0–5; 5–10; 10–20; 20–40; >40 euro per week. *Academic achievement* was based on the respondent's mark that best described their achievement over the past school year, categorized into five categories (insufficient, low, average, good, or high) and then recoded into three categories: low, middle, and high. *Parental education* was based on the level of education of the most highly educated parent and then divided into three categories: low (no schooling, primary school, and/or lower level of secondary school), middle (completed secondary school and/or lower level of college), and high (college or university degree). *Family composition* was based on the number of parents that were living in the home where the respondent lived all or most of the time (divided into two categories: 1 parent or 2 parents). *Parental smoking* was based on the

Table 1
Descriptive characteristics of the study sample.

	Total		Those who smoke weekly	
	n	%	n	%
Age (years)	11,918	100.0	1298	100.0
12–15	8758	73.5	677	52.2
>16	3160	26.5	621	47.8
Gender				
Boys	5848	49.1	622	47.9
Girls	6070	50.9	676	52.1
Migration background				
None	8890	74.6	984	75.8
1 parent	1433	12.0	175	13.5
2 parents	1413	11.9	112	8.6
Missing	182	1.5	27	2.1
Country				
Belgium	1688	14.2	310	23.8
Finland	1608	13.5	83	6.4
Germany	1397	11.7	59	4.5
Ireland	2023	17.0	95	7.3
Italy	1730	14.5	364	28.0
Netherlands	1784	15.0	169	13.0
Portugal	1688	14.2	218	16.8
Weekly income				
0–5 euro	2581	21.7	154	11.9
5–10 euro	2519	21.1	249	19.2
10–20 euro	2920	24.5	338	26.0
20–40 euro	1519	12.7	216	16.6
> 40 euro	1395	11.7	248	19.1
Missing	984	8.3	93	7.2
Academic achievement				
Low	1892	15.9	374	28.8
Middle	8254	69.3	823	63.4
High	1581	13.3	74	5.7
Missing	191	1.6	27	2.1
Family composition				
1 parent	1917	16.1	272	21.0
2 parents	9432	79.1	908	69.7
Missing	569	4.8	119	9.2
Parental education				
Low	1682	14.1	235	18.1
Middle	3756	31.5	468	36.0
High	5472	45.9	496	38.2
Missing	1008	8.5	99	7.6
Parental smoking				
None	7832	65.7	561	43.2
1 or more	3846	32.3	710	54.7
Missing	240	2.0	27	2.1
Smoking of friends				
No	8825	74.0	390	30.0
Yes	3093	26.0	908	70.0

number of biological parents that smoked (divided into two categories: none, one or more).

5. Analysis

Data were analysed using SPSS Statistics, V.28.0. First, we performed descriptive analyses to describe the characteristics of the respondents and the distribution of the independent variables in our study sample.

Table 2
The distribution of weekly smoking, smoking of friends and individual PAL according to PAL of friends.

	Total	Weekly smoking		Smoking of friends		Individual PAL (minutes/day)	
	n	n	%	n	%	m	SD
PAL of friends	11,918	1298	10.8	3093	26.0	69.8	39.6
0–42.0 min	2982	431	14.5	805	27.0	53.9	36.7
42.0–60.3 min	2977	354	11.9	844	28.4	63.4	36.4
60.3–80.4 min	2981	277	9.3	748	25.1	74.2	37.5
80.4–180.0 min	2978	236	7.9	696	23.4	87.9	39.5

Second, we performed a multilevel analysis to control for potential clustering within the data. Evidence for clustering within the data was provided by an intercept-only model ($p < 0.001$), for which the intra-class correlation coefficient was calculated at 0.21. The association between PAL of friends and weekly smoking was analysed by conducting a multilevel, multivariable logistic regression analysis. Several models were conducted, that all adjusted for the covariates as listed above. We first analysed the association between PAL of friends and weekly smoking, then we included adjusting for individual PAL and lastly we additionally adjusted for smoking of friends. As smoking of friends has been determined as a key predictor for adolescent smoking (De Vries et al., 2003; Loke et al., 2016), we conducted a stratified analysis and included an interaction term between PAL of friends and smoking of friends. Lastly, we analysed whether school PAL was associated with weekly smoking of adolescents. Furthermore, all analyses were also conducted using daily smoking and monthly smoking as outcome variables, but this did not alter our results. For all analyses, a significance level of $p < 0.05$ was used.

6. Results

The characteristics of the total study sample and of those who smoke weekly are presented in Table 1. Most respondents were aged between 12 and 15 years (73.5%), female (50.9%), had no migration background (74.6%), lived in a 2-parent household (79.1%), had at least one parent who was higher educated (45.9%), and had no parents or friends who smoked (65.7%, 74.0%). Most respondents who smoked weekly were based in Italy (28.0%) or Belgium (23.8%), had a weekly income of 10–20 euro (28.0%), had “middle” academic achievement scores (63.4%), and had 1 or more parents who smoked (54.7%) and 2 or more friends who smoked (38.8%).

Table 2 presents the distribution of respondents in terms of weekly smoking, smoking of friends and individual PAL, according to PAL of friends. Weekly smoking was present among 10.8% of the total study population and 26.0% of the respondents had at least 1 friend who smoked. Weekly smoking was most common among respondents with friends whose PAL was 0–42 min per day (14.5%). The prevalence of smoking among friends hardly differed for the four categories of PAL of friends, ranging from 23.4% (80.4–180 min) to 28.4% (42–60.3 min). The mean individual PAL was 69.8 min per day, ranging from 53.9 min for the group with the lowest PAL of friends to 87.9 min for the group with the highest PAL of friends.

The results of the multilevel logistic regression analysis are presented in Table 3. Respondents were significantly more likely to be smoking weekly if they had friends who were on average 0–42 min physically active, compared to having friends who were on average 80.4–180 min physically active (OR 1.27 [95% CI 1.04–1.55]). The odds for smoking weekly was 1.14 [95% CI 0.95–1.38] for those with lower individual PAL (0–38.6 min) compared to those with higher individual PAL (94.3–180.0 min). Adjusting for individual PAL did not alter the OR for PAL of friends and weekly smoking (OR 1.24 [95% CI 1.02–1.52]).

Table 4 presents the association between PAL of friends and weekly smoking in those with and without smoking friends. Although the association between PAL of friends and weekly smoking remained visible

Table 3
The association between PAL of friends and weekly smoking.

	n	Weekly smoking			
		Model 1 ^a		Model 2 ^a	
		OR [95%CI]	p	OR [95%CI]	p
PAL of friends					
0–42.0 min	2982	1.27 [1.04–1.55]	<0.05	1.24 [1.02–1.52]	<0.05
42.0–60.3 min	2977	1.22 [1.00–1.49]	<0.05	1.22 [1.00–1.48]	0.054
60.3–80.4 min	2981	1.09 [0.89–1.33]	0.401	1.09 [0.89–1.33]	0.409
80.4–180.0 min	2978	REF		REF	
Individual PAL					
0–38.6 min	2783			1.14 [0.95–1.38]	0.163
38.6–64.3 min	2845			0.92 [0.76–1.11]	0.405
64.3–94.3 min	2999			1.03 [0.86–1.24]	0.740
94.3–180.0 min	3314			REF	

^a Controlled for variables: age, gender, country, migration background, weekly income, academic achievement, family composition, parental education, and parental smoking.

Table 4
The association between PAL of friends and weekly smoking, stratified for smoking of friends.

	Weekly smoking					
	Without smoking friends			With smoking friends		
	n	OR [95%CI]	p	n	OR (95%CI)	p
PAL of friends						
0–42.0 min	2177	1.24 [0.94–1.63]	0.129	805	1.38 [1.06–1.82]	<0.05
42.0–60.3 min	2133	1.04 [0.79–1.37]	0.779	844	1.28 [0.99–1.66]	0.060
60.3–80.4 min	2233	1.02 [0.78–1.33]	0.894	748	1.11 [0.85–1.43]	0.445
80.4–180.0 min	2282	REF		696	REF	
Individual PAL						
0–38.6 min	1939	1.07 [0.82–1.40]	0.630	838	1.24 [0.97–1.58]	0.091
38.6–64.3 min	2146	0.88 [0.67–1.15]	0.355	700	1.07 [0.83–1.37]	0.623
64.3–94.3 min	2269	1.05 [0.81–1.35]	0.715	724	1.00 [0.79–1.28]	0.997
94.3–180.0 min	2471	REF		831	REF	

Note. Controlled for variables: age, gender, country, migration background, weekly income, academic achievement, family composition, parental education, and parental smoking.

in both groups, the association appeared to be somewhat stronger (OR 1.38 [95% CI 1.06–1.82]) for those with smoking friends. However, adding an interaction term (PAL of friends x smoking of friends) did not show a significant different association for those with and without smoking friends (Supplementary Table 1). The results for adjusting for smoking of friends can be found in Supplementary Table 2.

Table 5 presents the results of analyzing the association between school PAL and weekly smoking. Both models showed wide confidence intervals and associations at school level could not be demonstrated with statistical significance (OR 1.27 [95% CI 0.60–2.68] for schools with lower PA levels compared to schools with higher PA levels).

Table 5
The association between school PAL and weekly smoking.

	n	Weekly smoking			
		Model 1 ^a		Model 2 ^b	
		OR (95%CI)	p	OR (95%CI)	p
School PAL					
39.1–61.3 min	3396	1.35 [0.64–2.86]	0.432	1.27 [0.60–2.68]	0.529
61.3–71.1 min	3129	1.20 [0.61–2.35]	0.602	1.15 [0.59–2.25]	0.682
71.1–80.7 min	2494	0.98 [0.59–1.63]	0.950	0.96 [0.58–1.59]	0.884
80.7–95.1 min	2899	REF		REF	
PAL of friends					
0–42.0 min	2177	1.26 [1.03–1.54]	<0.05	1.24 [1.01–1.52]	<0.05
42.0–60.3 min	2133	1.22 [1.00–1.48]	0.052	1.21 [0.99–1.48]	0.059
60.3–80.4 min	2233	1.09 [0.89–1.33]	0.408	1.09 [0.89–1.32]	0.416
80.4–180.0 min	2282	REF		REF	

^a Controlled for variables: age, gender, country, migration background, weekly income, academic achievement, family composition, parental education, parental smoking, and PAL of friends.

^b Controlled for variables mentioned at ^a, including individual PAL.

7. Discussion

7.1. Key findings

This study aimed to assess whether weekly smoking of adolescents is associated with the PAL of their friends. We found that higher PAL of friends, which relates to a daily average of at least 80 min of physical activity, had a protective effect on weekly smoking of adolescents. PAL of one's friends was even more strongly related to smoking than one's own PAL.

7.2. Interpretation of findings

Our results support our initial hypothesis that adolescents with friends who have high PAL are less likely to smoke. This finding may be explained along the selection and socialization processes that work within social networks of adolescents. Selection may cause highly active and non-smoking adolescents to form friendships with peers who have similar PAL and/or who also don't smoke. In addition, socialization may lead adolescents to conform with the PAL and the smoking status of their friends, which simultaneously leads to the emergence of a non-smoking social norm. This norm may not simply emerge from one single behavior, but also result from having friends with a generally healthy lifestyle.

The current study found that smoking was more strongly related to friends' PAL than to one's own PAL. This suggests that the beneficial effect of friends' PAL may not solely be attributed to friends stimulating one's own PAL, but that it also revolves around whether friends actually exercise together. This suggestion is supported by studies reporting that participation in team sports decreases the odds of smoking (Kleppang et al., 2018; O'Loughlin et al., 2014; Harrison and Narayan, 2003; Pate et al., 2000). Participating in team sports builds strong social networks (Eime et al., 2013), and involvement in team sports has been associated with fewer mental health difficulties (Boone and Leadbeater, 2006; Taliaferro et al., 2008; Gore et al., 2001; Steiner et al., 2000), lower risk-taking behavior (Steiner et al., 2000), and enhanced social acceptance and self-esteem (Boone and Leadbeater, 2006; Pedersen and Seidman, 2004), all of which may relate to decreased smoking rates. However, there are also studies that have reported that individual sport participants are less likely to smoke than those participating in a team sport (Mattila et al., 2012; Rolandsson et al., 2014), and that the probability of

smoking depends on the type and intensity of sports (O'callaghan et al., 1999; Sigfúsdóttir et al., 2009; Horn et al., 2013; Mays et al., 2012).

If the protective effect of friends' PAL could mainly be attributed to being active together, it could be argued that this effect stems mainly from undertaking activities as a group. For example, the Icelandic Prevention Model has been grounded in theories that state that adolescents' deviant behavior can be avoided by participation in organized leisure activities (Akers, 1973; Chilton, 1971). These organized leisure activities may not be limited to physical activity, but can also include music, drama, and cultural activities. It is uncertain which kind of collective activities are most effective in terms of smoking prevention. A study in New Zealand reported that attending church, going to the movies, watching sports and playing team sports were all protective of smoking [49]. Several studies showed the importance of organized, supervised leisure activities for adolescents, as unsupervised gathering or "hanging out" with peers may lead to developing deviant behavior (Guo et al., 2011; Sigfúsdóttir et al., 2011; Thorlindsson et al., 2007; Mahoney and Stattin, 2000; Greene and Banerjee, 2009; Lee and Vandell, 2015).

7.3. Strengths and potential limitations

This analyses were based on a large sample size. The adolescents came from several European countries, which enhances the international generalisability of our findings. However, a few limitations should be taken into account when interpreting the results. First, due to the cross-sectional study design, we were not able to draw firm conclusions on causality. It's unlikely that the involved causal pathways solely follow one direction. Both selection and socialization processes may have contributed to the reported association between own smoking and friends' PAL, and these processes may have reinforced each other. Second, all analyses in which we included data on smoking of friends should be interpreted with caution. As both our exposure variable (PAL of friends) and outcome variable (weekly smoking) may influence smoking of friends, in addition to the other way around, the risk of collider bias should be considered (Holmberg and Andersen, 2022). Controlling or stratifying for the collider (smoking of friends) may have biased the reported association between PAL of friends and weekly smoking. We therefore gave more weight to results obtained without control for friends' smoking. Third, respondents could only mark students from their schools as their best friends. Respondents may also engage with adolescents from outside their school, for example with members of sports team they are participating in. We might have missed the influence of those friends. However, as adolescents spend a large part of their time at school, it can be expected that most respondents are spending much of their time with friends from school.

8. Conclusion

Increasing physical activity in adolescents is crucial, not only since its previous established health benefits, but also because of the reduced risk of smoking. Initiatives aimed at reducing smoking should contemplate interventions and programs aimed to increase of collective physical activity among adolescents, e.g. by organizing structured activities involving physical activity. Such initiatives may not only enhance physical activity among adolescents, but also prevent smoking among all who join in.

Role of the funding source

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CRedit authorship contribution statement

R.A. Smit: Conceptualization, Methodology, Formal analysis, Writing – original draft. **M.A.G. Kuipers:** Conceptualization, Methodology, Writing – review & editing. **B. Federico:** Writing – review & editing. **L. Clancy:** Writing – review & editing. **J. Perelman:** Writing – review & editing. **A.D. Rozema:** Conceptualization, Methodology, Writing – review & editing. **A.E. Kunst:** Conceptualization, Methodology, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ypmed.2023.107652>.

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