Physical Activity in Adolescence as a Predictor of Alcohol and Illicit Drug Use in Early Adulthood: A Longitudinal Population-Based Twin Study

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We investigated prospectively whether physical activity level in adolescence predicts use of alcohol and illicit drugs in early adulthood. We studied 4,240 individual twins (1,870 twin pairs). We classified those who consistently reported frequent leisure physical activity at ages 16, 17 and 18½ as persistent exercisers, those exercising less than three times monthly as persistently inactive, and all others as occasional exercisers. To control for familial confounds, within-family analyses compared activity-substance use associations in co-twins discordant for baseline physical activity. Individual-based analyses showed no clear association between baseline physical activity and subsequent weekly alcohol consumption. However, weekly alcohol intoxication (OR = 1.9, p = .002) and problems due to alcohol use (OR = 2.0, p < .001) were more common among persistently inactive participants. After excluding those reporting weekly intoxication at baseline, the risk for alcohol intoxication remained elevated among women occasionally (OR = 2.4, p = .017) or persistently (OR = 5.8, p < .001) inactive at baseline, but this association was not replicated within discordant twin pairs. Individual-based analyses showed that drug use in adulthood was more common among those persistently physically inactive in adolescence (OR = 3.7, p < .001) in comparison to those persistently active. This finding was replicated within discordant twin pairs. Among those with no drug experience during adolescence, persistent inactivity (OR = 1.9, p = .007) increased risk for drug use. We conclude that persistent physical inactivity in adolescence may increase the risk of later problems due to excess alcohol use. Sedentary lifestyle predicts illicit drug use even when controlling for familial factors.

Keywords: longitudinal, twin study, physical activity, alcohol use, illicit drugs

Although some studies have documented beneficial effects of moderate alcohol use, accumulating evidence shows that heavy alcohol consumption increases mortality and, particularly among young adults, risks of alcohol use outweigh benefits (Health risks and benefits of alcohol consumption, 2000). Finnish data show heavy alcohol is associated with increased mortality, even after adjustment for childhood environment, although genetic selection may partly account for the association (Kujala et al., 2002). Alcohol has long played a central role in Finnish substance abuse culture. During recent decades, alcohol-related morbidity and mortality emerged in Finland (Koski et al., 2007) while during the early millennium, weekly drinking to intoxication increased among adolescents (Rimpelä et al., 2006). Regular use of illicit drugs, including cannabis, the most commonly abused drug, has numerous adverse health consequences, such as anxiety, depression and psychosis (Khalsa et al., 2002). When approaching this millennium, drug use in Finland escalated among young adults, where 12% of 15- to 24-year-olds reported lifetime use. On entering the 2000s the trend in problematic use continued to increase (Virtanen & Sjöberg, 2006).

Limited physical activity among adolescents is a significant concern in developed countries. Correlations between physical activity in pre-adolescence and adulthood are low to moderate, while physical activity declines during adolescence (Kemper et al., 2001; Kimm et al., 2002; Malina, 1996). Physical activity in late adolescence tracks better into adulthood than activity before adolescence. Finnish data suggest that

persistent physical activity during adolescence predicts its continuation into young adulthood (Kujala et al., 2007; Paavola et al., 2004). Clustering of unhealthy behaviors is commonly reported (Fine et al., 2004; Paavola et al., 2004; Poortinga, 2007; Pronk et al., 2004; Schuit et al., 2002). For example, adolescents' sedentary lifestyle has been associated with smoking. (Kujala et al., 2007; Pate et al., 1996; Rodriguez & Audrain-McGovern, 2005; Sallis et al., 2000). However, the associations between physical activity and other substance use remain uncertain. For example, no consistent association between physical activity and alcohol consumption exists (Sallis et al., 2000). Moreover, we are not aware of longitudinal investigations on physical activity predicting alcohol abuse.

It is important to recognize clustering of unhealthy behaviors. However, it is more important to ask whether certain health habits during adolescence predict subsequent health behavior in adulthood. We recognize that such associations might be correlational only mediated by third variables, such as differences in socio-economic status or parenting practices. This study employs within-pair analyses of co-twins discordant for physical activity to control for such familial status and parental modeling in the development of health behaviors (Kujala et al., 2002). We investigated whether level and persistence of physical activity in adolescence predicts use of alcohol and illicit drugs in young adulthood. To further explore the causal nature of the predictor to outcome relationship, we complemented the individual level analyses with within-family analyses of co-twins discordant for baseline physical activity.

Method

Sample
Within the *FinnTwin16* study, twins from 5 consecutive birth cohorts were identified from the Population Register Centre of Finland (Kaprio et al., 2002); families of twins being the primary sampling unit. Three consecutive questionnaires were sent to the twins at ages 16, 17 and 18.5, whereas at ages 22–27, a follow-up questionnaire was sent. This procedure is described in detail elsewhere (Kaprio, 2006). After excluding twins with illness or handicap possibly affecting physical activity this study sample consisted of 4,240 twins (1,871 male, 2,369 female), including 1,870 pairs with both twins. The study protocol was approved by Indiana University's Institutional Review Board and the ethics committee of Helsinki metropolitan hospital region.

Measures
At 16, 17 and 18.5, frequency of physical activity outside school was assessed in all three questionnaires, with an identically structured question including six alternatives. Those reporting frequent physical activity (4–5 times or more a week) in all baseline questionnaires were defined as persistently active, those exercising 1 to 2 times a month or less as persistently

inactive, and all others as occasionally active at baseline. Frequency of alcohol use, including intoxication frequency, was assessed in each questionnaire. When approximating the incidence of alcohol intoxications at follow-up, we excluded those with weekly intoxication at baseline. Further, the Zuckermann Sensation Seeking Scale (SSS) was administered at the age 18 baseline survey. This scale was used because sensation-seeking may be one pathway to adolescence substance use (Mustanski et al., 2003). In order to approximate the incidence of illicit drug use, we identified twins who reported no use at baseline but did report use at follow-up. So, at baseline we excluded those with a positive response to one SSS- item: 'I have tried cannabis or would like to try'.

The follow-up questionnaire (mean age 24.4 years) included structured questions on alcohol and illicit drugs use. To provide sufficient contrast for the within-pair analyses of activity-discordant co-twins, we dichotomized most outcomes. Alcohol use and alcohol problems were characterized using several indicators. First, weekly alcohol users and second, those using alcohol to intoxication at least weekly were identified. Third, we used a modified version of the Malmö-Modified Michigan Alcoholism Screening test (MmMAST) (Seppa et al., 1992), an 11-item screening instrument, where a sum score 6 indicated 'elevated risk for alcohol problems'. As continuous alcohol outcomes, we studied maximum number of drinks during 24 hours, number of drinking days during past month, and the Rutgers Alcohol Problem Index (RAPI) — a 23-item screening tool for assessing adolescent problem drinking (White & Labouvie, 1989). Use of illicit drugs was assessed as follows: 'Have you ever used hashish, marijuana or other drugs, or for example sniffed glue?' The five response options were: (1) *Never*, (2) *1–3 times*, (3) *4–9*, (4) *10–19*, and (5) *20 times or more*. We defined regular users as those reporting use of illicit drugs 20 times or more.

Statistical Analyses
After deriving descriptive data, we used logistic regressions to study physical activity as a predictor of substance use in the entire study cohort (4240 individuals). We calculated odds ratios (OR) with 95% confidence intervals (CI) of substance use at follow-up for different categories of baseline physical activity. The persistently actives comprised the reference group. Because the twins were sampled as clusters, the primary unit being the twin pair, the 'cluster' option was used in the analyses. Thus, clustering of correlated observations from twin pairs was controlled for when computing standard errors of the coefficients using robust estimators of variance (Williams, 2000). All analyses were conducted using Stata statistical package, version 9 (StataCorp., 2005) and adjusted for sex and follow-up age. Where possible, we reported the results by sex. For the continuous alcohol outcomes (maximum number of drinks, number of drinking days, the RAPI), we used regression analyses.

Table 1

Descriptive Information on Persistent Physical Activity/Inactivity at Baseline (Ages 16–18.5) and Selected Characteristics at Follow-Up (Mean Age 24.4)

	Baseline physical activity					
	Men (n = 1871)			Women (n = 2369)		
	Persistently active	Occasionally active	Persistently inactive	Persistently active	Occasionally active	Persistently inactive
Row % (n) distribution of men and women	20.6 (385)	72.6 (1358)	6.8 (128)	12.7 (302)	81.4 (1929)	5.8 (138)
Age, mean at follow-up	24.4	24.3	24.4	24.3	24.3	24.4
% completed upper secondary school or higher education	71.2	50.5	34.4	82.5	64.9	41.3
% living with partner at follow-up	62.4	58.5	57.0	68.4	69.2	71.7
% having children at follow-up	6.2	10.0	13.3	6.3	15.2	23.2
Completed military service	94.5	90.2	86.7	2.0	1.3	0.0
Lives in Helsinki metropolitan area	28.1	23.8	26.2	26.5	24.6	27.7
Subjectively well-off financially	36.9	37.8	30.5	34.3	32.0	17.4

Because these variables were not normally distributed, we used the log(x + 1) transformation in order to approximate normal distribution and to include zero values. When reporting the results, the regression coefficients were back transformed.

Twin pairs discordant for physical activity and substance use were analyzed to investigate whether physical activity predicts use of alcohol and drugs after controlling for shared genes and shared family environments. Based on the two different combinations of discordance, ORs at follow-up with their 95% CIs according to different leisure physical activity categories at baseline were calculated using conditional logistic regressions. In the absence of significant activity by zygosity — interactions, comparisons were pooled across zygosity.

Of all twin pairs, 1,434 were concordant, and 436 discordant, for baseline physical activity. Of the discordant pairs, 41 were male monozygotic, 56 female monozygotic, 74 male dizygotic, 71 female dizygotic, 181 opposite sex (dizygotic), and 13 same-sex pairs of unknown zygosity. There were 270 twin pairs whose discordance was such that one twin had persistent activity and the other occasional activity, and 157 pairs whose discordance was between occasional activity in one twin and persistent inactivity in the co-twin. Not surprisingly, extreme discordance was rare: there were only nine pairs in which one twin was persistently passive but the co-twin persistently active.

Results

Baseline Characteristics by Level of Physical Activity

Concerning baseline characteristics, persistently inactive adolescents were only half as likely as active adolescents to complete education beyond that required. Inactive adolescents were 2 to 4 times more likely to have children already in early adulthood. Personal financial situation was worse among inactive than active women (Table 1).

Physical Activity Level as a Predictor of Alcohol Use

Prevalence of alcohol use and problems of excess alcohol use among men and women at follow-up by three levels of baseline physical activity are shown in Table 2. Persistently inactive men and women tended to report several forms of alcohol-related outcomes more commonly than those who were active. The individual level logistic regressions shown in Table 3 suggested no clear association between baseline physical activity and weekly alcohol use. However, weekly intoxication (p = .002) and problems due to alcohol (p < .001) at follow-up were more common among those persistently physically inactive compared to those active at baseline, more prominently so in women (Table 3). Further, the incidence of weekly intoxication associated with activity levels (not shown in tables). Among women, after excluding those reporting baseline weekly intoxication (11.6%), frequent intoxication at follow-up remained more common among those occasionally active (OR = 2.40, 95% CI 1.17–4.95, p = .017) or persistently inactive (OR = 5.79, 95% CI 2.39–14.0, p < .001) compared to those persistently active at baseline. Further, within the analyses among the pairs discordant for baseline physical activity and alcohol outcome, those individual based results were not replicated (Table 5).

For continuous outcomes (maximum number of drinks, number of drinking days, the RAPI) the regression coefficients according to persistent physical activity frequency at baseline are shown in Table 4. The only significant outcome predicted by baseline physical inactivity was the RAPI: persistently inactive persons had higher alcohol problem index scores than did more active ones. An almost significant sex interaction (p = .08) was seen, such that the association was significant only among women.

Physical Activity Level as a Predictor of Illicit Drug Use

Use of illicit drugs regularly (> 20 times) at follow-up by three levels of baseline physical activity among men

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Table 2

Persistent Physical Activity at Baseline (Ages 16–18.5) and Substance Use at the Follow-Up (Mean Age 24.4)

	Baseline physical activity					
	Men			Women		
Substance use at follow-up	Persistently active	Occasionally active	Persistently inactive	Persistently active	Occasionally active	Persistently inactive
Use of alcohol at follow-up			%*			
Weekly	55.6	59.9	60.9	35.9	41.8	39.9
Intoxicated weekly	19.7	20.8	25.8	3.6	8.0	13.8
MmMAST† score ≥6	31.8	36.6	42.1	11.2	17.6	28.5
Maximum # of drinks during 24 hours	21.6	21.0	22.6	11.3	11.7	13.3
# of drinking days during past month	5.1	5.3	5.9	3.5	4.0	3.7
Rutgers Alcohol Problem Index (RAPI)	6.4	7.2	8.6	3.3	4.5	6.1
Use of drugs at follow-up						
Use of drugs regularly or lifetime use > 20 times	3.9	5.5	10.2	0.7	1.8	5.8

Note: *Of those who answered the specific question.
    †Malmö-Modified Michigan alcoholism screening test.

Table 3

Odds Ratios of Forms of Substance Use at Follow-up (mean age 24.4) According to Persistent Physical Activity Frequency at Baseline (Ages 16–18.5)*

		Occasionally active			Persistently inactive			
Substance use at follow-up		Odds ratio	95% CI	p	Odds ratio	95% CI	p	p for activity level by sex interaction†
Use of alcohol at follow-up								
Weekly		**1.23**	1.03–1.48	.025	**1.20**	0.89–1.63	.23	.83
Intoxicated weekly		**1.25**	0.96–1.62	.092	**1.87**	1.27–2.77	.002	.028
	Men	**1.07**	0.79–1.44	.67	**1.41**	0.88–2.26	.15	
	Women	**2.32**	1.26–4.30	.007	**4.38**	2.03–9.42	< .001	
MmMast‡ score ≥ 6		**1.35**	1.09–1.68	.006	**2.04**	1.46–2.83	< .001	.11
	Men	**1.24**	0.96–1.60	.11	**1.56**	1.01–2.39	.043	
	Women	**1.70**	1.12–2.58	.012	**3.18**	1.85–5.46	< .001	
Use of drugs at follow-up								
Use of drugs regularly or lifetime use > 20 times		**1.59**	0.91–2.77	.11	**3.75**	1.86–7.55	< .001	.32
	Men	**1.44**	0.77–2.68	.25	**2.79**	1.23–6.32	.014	
	Women	**2.73**	0.67–11.1	.16	**9.62**	2.00–46.2	.005	

Note: *Persistently active group at baseline is the reference group. OR denotes odds ratio; adjusted for sex and follow-up age. CI denotes confidence interval.
    †p values for activity group by sex interaction are from global test over different activity levels.
    ‡ Malmö-Modified Michigan alcoholism screening test.

and women is shown in Table 2. Persistently inactive men and women reported regular drugs use more commonly than the more active ones. Logistic regressions (Table 3) suggested that the risk of drug abuse was significantly higher among the persistently physically inactive individuals at baseline (OR = 3.75, $p <$ .001) in comparison to those active ones. The risk of drugs use was particularly high among persistently inactive women (OR = 9.62, p = .005), although the activity by sex interaction was not significant (p = .32). After excluding those with baseline desire or experience of cannabis use (n = 637) we approximated the incidence of drug use in the remaining sample (n = 3699). Those occasionally active (OR = 1.35, 95% CI 1.01–1.82, p = .044) or persistently inactive (OR = 1.87, 95% CI 1.18–2.96, p = .007) had elevated risk for incident use of drugs compared to the persistently active participants (not shown in tables). Finally, the finding of sedentary lifestyle predicting drug use was replicated in the pair-wise analyses (p = .007) (Table 5). In 20 of the 25 pairs discordant for physical activity and drug use, it was the less active co-twin who used drugs. Too few discordant pairs existed for sex-specific analyses.

Table 4

Regression Coefficients for Alcohol Use at Follow-Up (Mean Age 24.4) According to Persistent Physical Activity Frequency at Baseline (Ages 16–18.5)*

		Occasionally active			Persistently inactive			
		β†	95% CI	p	β†	95% CI	p	p for activity level by sex interaction
Maximum number of drinks during 24 hours		0.97	0.92–1.03	.308	1.07	0.97, 1.18	.148	.24
	Men	0.93	0.86–1.00	.060	1.00	0.90, 1.17	.686	
	Women	1.02	0.94–1.10	.589	1.13	0.98, 1.30	.084	
Number of drinking days during the past month		1.05	1.00–1.11	.069	1.04	0.94, 1.14	.460	.35
	Men	1.05	0.97–1.13	.251	1.09	0.95, 1.26	.207	
	Women	1.06	0.98–1.13	.134	0.98	0.87, 1.11	.797	
Rutgers Alcohol Problem Index (RAPI)		1.09	1.01–1.19	.036	1.33	1.14, 1.55	< .001	.08
	Men	1.02	0.91–1.15	.760	1.16	0.92, 1.45	.209	
	Women	1.19	1.06–1.34	.003	1.54	1.25, 1.90	< .001	

Note: *Persistently active group at baseline is the reference group.

† β denotes regression coefficient and CI denotes confidence interval; based on the natural log transformed estimates which have been transformed back to normal distribution.

Table 5

Odds Ratios of Forms of Substance Use at Follow-Up (Mean Age 24.4) Among Twin Pairs Discordant for Leisure Physical Activity Frequency at Baseline (Ages 16–18.5)*

		Number of discordant pairs†	Occasionally active			Persistently inactive		
			Odds ratio	95% CI	p	Odds ratio	95% CI	p
Use of alcohol at follow-up								
Weekly		165	0.86	0.59–1.24	.42	1.06	0.57–1.96	.85
Intoxicated weekly		91	0.79	0.46–1.34	.38	1.48	0.64–3.41	.36
	Men	31	1.33	0.56–3.16	.51	2.00	0.43–9.26	.38
	Women	18	1.00	0.25–4.00	1.00	1.00	0.16–6.42	1.00
MmMAST‡ score ≥6		132	0.85	0.54–1.33	.47	1.21	0.61–2.38	.59
	Men	36	0.83	0.36–1.93	.67	1.53	0.42–5.61	.52
	Women	23	1.50	0.42–5.32	.53	1.31	0.26–6.64	.74
Use of drugs at follow-up								
Use of drugs regularly or lifetime use > 20 times		25	3.81	0.81–18.00	.091	14.74	2.11–103.0	.007

Note: *Persistently active group at baseline is the reference group.

†Number of twin pairs who were discordant for baseline physical activity and also discordant for the specific form of substance use at follow-up. When results of men and women are combined including opposite sex pairs, they are adjusted for sex. When there was an interaction, results are given separately for same-sex pairs of men and women.

‡Malmö-Modified Michigan alcoholism screening test.

Discussion

We used Finnish longitudinal twin data to explore whether physical activity during adolescence predicts use of alcohol and drugs during young adulthood. Persistent physical inactivity during adolescence, compared to persistent physical activity, predicted alcohol related problems and illicit drug use during young adulthood. The association of physical inactivity and drug use was replicated in the incidence analysis and in the analysis of activity-discordant twin pairs. In this analysis, we did not use our twin data to explore shared genetic or environmental influences on the association between physical inactivity and subsequent use of alcohol and drugs. Rather, we used twins as individuals but controlled for the statistical effects of sampling on twin pairs. And we then used a discordant twin pair design to further explore the causal nature of that association.

In agreement with earlier data (Sallis et al., 2000) the association between baseline physical activity and weekly use of alcohol was not consistent. Another Finnish longitudinal investigation from adolescence to young adulthood (Paavola et al., 2004) found little

evidence of association between physical activity and alcohol use per se. Perhaps when young team sports athletes travel together away from home that they have more opportunities to try alcohol. This may, to some extent, compensate the idea that total abstinence associates with active sports. Our finding regarding physical inactivity and alcohol problems, such as weekly intoxication, may be novel. In contrast to earlier evidence, where physical activity and excessive alcohol use were unrelated (Schuit et al., 2002), our findings suggest that sedentary lifestyle predicts weekly intoxications and alcohol related problems. Even after excluding those reporting weekly intoxication at baseline, persistently inactive women had almost six-fold likelihood for incidence of alcohol abuse compared to the active ones. We are not aware of other studies reporting longitudinal association between persistent sedentary lifestyle and problems due to alcohol consumption. However, in the within-pair analyses sedentary life style did not predict alcohol use in a fashion similar to its effect on drug use, as demonstrated now, and on smoking, as reported earlier (Kujala et al., 2007). Thus, also some other factors within the living environments of young people may influence those relationships (de Bourdeaudhuij & van Oost, 1999).

Our finding on persistent physical inactivity predicting illicit drugs use supports the results of earlier cross-sectional studies among adolescents, showing association between low activity and marijuana use (Pate et al., 1996), as well as reporting more cannabis use among the adolescents never engaging in endurance sports (Kirkcaldy et al., 2002). Our study additionally approximated drug use incidence. When we excluded those with drug experience at age 18, physical inactivity continued to be a predictor of future ever use. This incidence finding strengthens the sedentary lifestyle to drug use pathway. Moreover, because our finding remained significant among the discordant twin pairs, the association is not likely confounded by between-family differences in environments encouraging physical activity and discouraging drug use. Thus, persistent physical activity may actually be involved in the pathway of developing drug-free behavior. We consider this a novel finding, yet this applies now only to late-onset users. It is possible that the late-onset users have different reasons for their drug-seeking behavior than the early-onset users have. Early-onset users may try drugs because of novelty seeking and trying unconventional and proscribed experiences. Late-onset users may start using drugs for different reasons. Among them sedentary lifestyle may be a more robust predictor, being associated with other harmful health habits and risk factors, not to forget poor peer models and negative environments.

To summarize, the association between physical activity and alcohol use is less prominent than that between physical inactivity and drug use. There are possible mechanisms by which physical activity relates to illicit drug use although not so consistently to alcohol consumption. First, physically active subjects usually aim to improve their fitness and health; they know that drug use mitigates achieving that goal. In public health recommendations, use of small doses of alcohol is not unambiguously linked to poor health and fitness, which may explain why differences in alcohol use per se by physical activity are small. Adolescents may perceive that occasional alcohol intoxication does not impair sports activity, and drinking socially with team mates may even be encouraged through peers to promote bonding and friendships. Further, adolescents interested in physically active lifestyles seek friends with similar interests (Rose, 2002). Further mechanisms may be related to mediating factors in the associations between physical activity and substance use. For example, in an adolescent sample where regular endurance exercise was related to substance use — yet more clearly to tobacco and cannabis than to alcohol use — exercise was also associated to better body image and self-esteem, lower anxiety and depression scores (Kirkcaldy et al., 2002).

We observed some sex differences and sex-specific associations. Being physically inactive was more common among women; some 13% of women, whereas some 20% of men were active. Concerning alcohol use, the incidence of weekly intoxication was significantly predicted by persistent sedentary lifestyle only among women. Sex-specific association between sedentary lifestyle and alcohol use has been earlier reported cross-sectionally (Pate et al., 1996). However, this observation concerned alcohol use in general and sedentary lifestyle being negatively correlated among female but not among male students. Although the risk of drug use was elevated among persistently inactive men and women without significant sex interaction, this risk was nine-fold among women while three-fold in men. Several predictive factors in drug use have been reported to differ by sex (Guxens et al., 2007), such as girls spending time in bars and discos having a four-fold whereas boys have a two-fold risk for subsequent cannabis use. Young women, in general, may nowadays be more vulnerable than young men to experiment with illegal drugs. According to our national statistics, girls experiment with illicit drugs earlier than boys, although adult men use drugs regularly more than women (Virtanen & Sjöberg, 2006). In summary, sedentary lifestyle might be a stronger predictor of substance use among young women than men.

Strengths of this study include population-based cohort with high response rates, longitudinal data, and twin design controlling for family background. We recognize limitations, as well. First, our follow-up started from age 16, so the basis for physical activity and substance use may have been partially formed before the baseline assessment. However, we observed significant associations between adolescent physical inactivity and incidence of drug use and excess alcohol use at follow-up. Among women, adolescent physical

inactivity predicted later incidence of weekly intoxications. Nonetheless, it would be relevant to repeat similar analyses using a younger cohort. Follow-up studies starting from childhood would be valuable to confirm our results, as the participation rates in organized sports and other physical activity forms are already high in early teens, while drug use is more rare. Second, we did not measure use of illicit drugs identically at baseline and follow-up. Thus, we only approximated the incidence of drug use. We refer to our study in the younger twin sample investigating drug use at age 17 where 13% had tried illicit drugs, while 1.6% reported using 20 times or more (Korhonen et al., 2008). Given that this drug use frequency was the measure of regular drug use in the current study, use of illicit drugs at age of 17 — the middle point of our baseline measurements — was rare among Finnish adolescents. Thus, we assume that most of regular drug use had initiated after our baseline survey.

This study enriches understanding of how physical inactivity influences the development of other health habits. Independently of between-family environmental differences, persistent physical inactivity in adolescence predicts drug use in adulthood. Although not replicated independently of familial background, adolescence sedentary lifestyle may predict problems due to alcohol use in young adulthood, particularly among women. Future studies should investigate whether exercise interventions targeted at adolescents reduce the risk of later substance use.

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