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Association between physical activity changes and risky behaviors among adolescents and young adults in Switzerland—a longitudinal study

Marine Dumas[1] A,C-G, Stéphane Tercier[2] A,D,G,
Joan-Carles Suris[3] A-D,G, Yara Barrense-Dias[3] A-D,G

[1] University of Lausanne, Lausanne, Switzerland
[2] Centre SportAdo, Department of Women-Mother-Child, Lausanne University Hospital, Lausanne, Switzerland
[3] Centre for Primary Care and Public Health (Unisanté), Lausanne, Switzerland

Abstract

Purpose: Recent global studies on physical activity patterns among adolescents indicate that a significant majority fail to meet recommended activity levels, with higher amounts of sedentary behavior in this age group associated with poorer behavioral outcomes. The aim of this longitudinal study is to examine physical activity (PA) changes in a cohort of 1386 15–24-year-olds youth and to evaluate their association with risky behaviours.

Material and methods: Data were retrieved from the first (T1-2015-2016) and third (T3-2017–2018) waves of the GenerationFree study in Switzerland. Respondents were divided into four groups according to PA changes between T1–T3: Actives (16.2%), Increasers (11.3%), Decreasers (15.1%) and Inactives (57.4%). Results are given as relative risk ratios (RRR) using Actives as reference.

Results: One in six was physically active during the studied period. Compared to Actives, Increasers (RRR 2.154) and Decreasers (RRR 1.900) were more at-risk of smoking at T3, and Inactives at T1 (RRR 1.952) and T3 (RRR 2.218). While Decreasers (RRR 0.522) and Inactives (RRR 0.507) had lower odds for alcohol misuse at T1, Decreasers had higher odds at T3 (RRR 2.092). At T3, Inactives were more at-risk of an eating disorder (RRR 1.675). No relationship was found for cannabis use or problematic Internet use.

Conclusions: As PA guidelines are not met by most participants, PA should be promoted actively in adolescents by public health authorities and schools, and risk-taking should be prevent in active young people.

Approval of ethics committee

The Ethics Committee of the Canton of Vaud approved the study protocol (#292/10).

Original article

Keywords

- exercice
- risk-taking
- health promotion
- substance-related disorders
- feeding and eating disorders
- Internet addiction disorder

Contribution

A – Preparation of the research project
B – Assembly of data
C – Conducting of statistical analysis
D – Interpretation of results
E – Manuscript preparation
F – Literature review
G – Revising the manuscript

Corresponding author

Yara Barrense-Dias
e-mail: yara.barrense-dias@unisante.ch
Center for Primary Care and Public Health (Unisanté); Department of Epidemiology and Health Systems; Research Group on Adolescent Health
Route de la Corniche 10
CH-1010 Lausanne, Switzerland

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Introduction

Physical activity (PA) is defined by the World Health Organization (WHO) as any movement produced by skeletal muscle contraction that results in energy expenditure. It includes all movements in the context of leisure activities, transportation to and from places, or work.[1] Physical activity is thus not equivalent to exercise, which is a subclass of structured and repetitive PA aiming at improving or maintaining physical fitness.[2] For adolescents, the WHO recommends at least 60 minutes a day of moderate- to vigorous-intensity PA, as the latter is known to have beneficial health outcomes on cardiometabolic and bone health, physical fitness, mental health and cognitive functioning. However, recent global studies on PA patterns in adolescents revealed that more than four in five adolescents (81.0%) aged 11 to 17 years did not meet these recommendations in 2016, with 77.6% of boys and 84.7% of girls not achieving this guideline.[3] Yet, the true prevalence of insufficient PA in adolescents could be even higher as self-reported PA levels are typically overestimated by participants in comparison to PA levels measured by tracking devices.

According to the WHO, "in children and adolescents, higher amounts of sedentary behaviour are associated with [...] poorer behavioural conduct" (page 1).[1] In this line, risky behaviours such as substance misuse or eating disorders can threaten adolescents' physical and mental health. They are influenced on the one hand by neuronal reorganisation during adolescence and on the other hand by individual and environmental factors such as biological predisposition, peer influence, reward or PA. The study of PA levels during adolescence is of great interest because this transition period contributes to the establishment of lifelong habits in a critical way, and it seems that young people become less active throughout the maturation process of puberty.[4]

Evidence regarding associations between PA and risk-taking in adolescence is limited and findings are often inconsistent. Whilst it is assumed that PA in general acts as a protective factor against several risky behaviours, this is not always true. Organised exercise within the framework of sports clubs, for instance, has repeatedly been found to be associated with increased alcohol use.[5,6] As a matter of fact, the term "physical activity" includes many different types of movement. Therefore, the association between PA and engagement in risky behaviours may vary according to the type of physical activity performed.

Although it is has been shown that PA levels start to decrease well before adolescence, this diminution in physical activity is accelerated during puberty due not only to changes in hormonal balance and body composition, but also to changes in life priorities and lifestyle, such as an increased focus on school and other sedentary occupations for example.[4,7] Despite its importance, little is known about the correlation between changes in physical activity (PA) levels and engagement in risky behaviors. This study aims to analyze the amount and evolution of PA among adolescents and young adults (AYAs) in Switzerland. It will also assess their involvement in risky behaviors—tobacco use, cannabis consumption, alcohol misuse, disordered eating patterns, and problematic Internet use—and their evolution over time. Finally, the study will explore the relationship between changes in PA levels and these risky behaviors. To our knowledge, this is the first longitudinal study to examine the association between changes in PA levels and risk-taking behaviors in AYAs in Switzerland.

Materials and methods

Study design and sampling method

To analyse the relationship between PA and the engagement in risky behaviours in AYAs, we used data from the first (T1, 2015–2016) and third (T3, 2017–2018) waves of the GenerationFRee study. GenerationFRee is a longitudinal in-school survey carried out amongst post-mandatory students aged 15 to 24 at T1 between 2015–2016 and 2018–2019 in the canton of Fribourg, Switzerland. It included the 5 high schools and the 6 vocational schools of the canton and looked at lifestyle, health and risk-taking. In Switzerland, the two options after mandatory school are indeed high school or vocational school (apprenticeship and one-day class). During the academic year 2015–2016 (T1), 3538 adolescents in their first year of post-mandatory education in the canton of Fribourg (mean age 16.6 years) were invited to take part in an online self-reported questionnaire in class. (13) Overall, 3115 questionnaires were completed (response rate 88%), of which 2627 were assessed as being useable. The students were then followed as 3rd-year students in 2017–2018 (T3). At T3, 2419 questionnaires were completed, of which 449 had to be excluded. In total, 1332 participants completed the questionnaires both at T1 and T3 (response rate 39%) and 1311 answered questions on physical activity at both waves. Participants flow diagram in figure 1. For this paper, we did not include the last wave (2018–2019), as the 4th year is particular for vocational schools, most apprenticeships being completed in 3 years instead of 4. Although we did try to follow young people after they had accomplished their 3 years of training at

school, our analysable sample would have been greatly reduced if we had included the last wave.

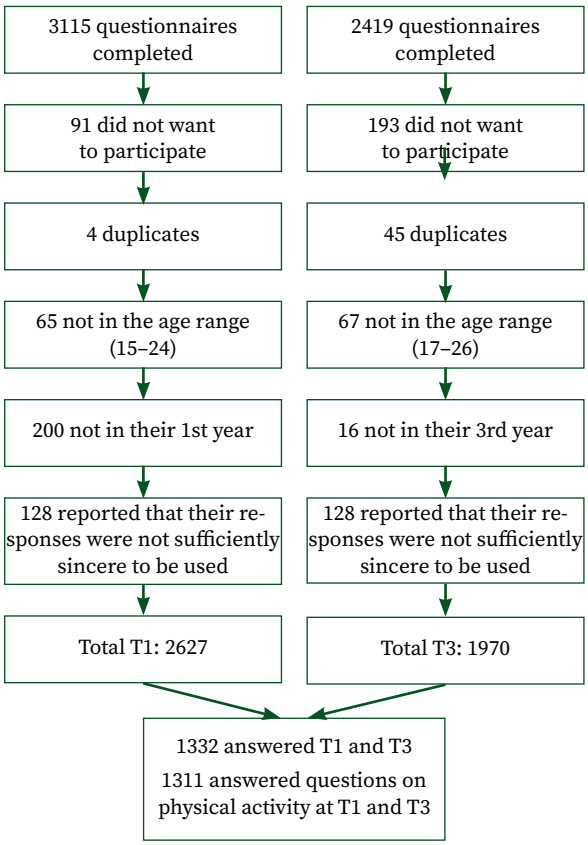

Figure 1. Participants flow diagram at T1 and T3

Dependent variable

PA was assessed through the following question: "In the past 7 days, on how many days were you physically active for at least 60 minutes?". Possible answers ranged from 0 to 7 days.

Based on Olds et al. study on the operationalisation of activity guidelines for young people,[8] we chose to set the cut-off between high and low PA at four days a week. With this premise, we created four groups:

1. Actives: AYAs who were physically active on four days a week or more at T1 and at T3 (n = 237; 18.1%).
2. Increasers: AYAs who increased their PA from less than four days in the past week to four days or more in the past week between T1 and T3 (n = 147; 11.2%).
3. Decreasers: AYAs who decreased their PA from four days or more in the past week to less than four days in the past week between T1 and T3 (n = 201; 15.4%).
4. Inactives: AYAs who were physically active on less than four days in the past week at T1 and at T3 (n = 726; 53.4%).

Independent variables

The risky behaviours selected in the study included current smoking, E-cigarette use in the last 30 days, drunkenness episodes in the past 30 days, cannabis use in the past 30 days, problematic Internet use and the risk of developing an eating disorder.

Smoking was assessed with the question "Do you smoke cigarettes?". Participants were dichotomised as "Non-smokers" and "Smokers".

E-cigarette use was measured with the question "Have you tried smoking an E-cigarette in the last 30 days?". The variable was dichotomised as "No" and "At least once".

Alcohol misuse was measured with the question "Have you experienced a drunkenness episode in the last 30 days?" and dichotomised as "Never" and "At least once".

Cannabis use was measured with the question "Have you used cannabis in the last 30 days?" and dichotomised as "Never" and "At least once".

We investigated problematic Internet use using the short version of the Internet Addiction Test.[9] A score higher than 36/72 indicated excessive Internet use.

The risk of developing an eating disorder was assessed using the questions from the SCOFF-score.[10] A score of ≥ 2 positive answers suggested an increased risk of developing an eating disorder.

In addition to these variables, various confounding factors were controlled for, including: age, sex assigned at birth, self-reported weight and height used to calculate the body-mass index (BMI), academic track (high school or vocational school), family structure (parents together/ other), subjective perception of the socioeconomic status of the family (average or higher/ lower than average compared to other Swiss families)[11] and mental well-being (using the WHO-5 Well-Being Index[12]). Note that instead of creating three different BMI groups (underweight/normal weight/overweight and obese), we chose to include normal weight and underweight participants in the same group because of the small number of underweight adolescents in our study, thus only forming two groups (underweight and normal weight/ overweight and obese). Table 1 describes the sample at T1.

Table 1. General characteristics of the participants at T1

Category		Mean	
		n	%
Biological sex	Male	698	53.5
	Female	613	46.7
Financial situation	Average or higher	1211	92.4
	Low	99	7.6
Family structure	Parents together	938	71.5
	Other	373	28.5
Academic track	Highschool	515	39.3
	Vocational school	795	60.7
BMI (n = 1296)	Normal or underweight	1133	87.4
	Overweight or obese	163	12.6
Emotional well-being	Good	1064	18.8
	Poor	247	81.2
Mean age (years ± standard error)	–	1311	16.6 ± 0.05

Statistical analysis

Statistical analyses were conducted using STATA 17.0. We first ran bivariate analyses using chi-square tests for categorical variables and ANOVA for continuous ones. We set the significance threshold at $p < 0.05$. All statistically significant variables were then included in a multinomial logistic regression using Actives as the reference category. The results are given as relative risk ratios (RRR) and confidence intervals (95% CI).

The Ethics Committee of the canton of Vaud approved the study protocol (#292/10).

Results

At the bivariate level (Table 2), statistically significant associations were found between changes in physical activity and various variables, including smoking, risk of disordered eating, episodes of drunkenness in the past 30 days, poor emotional well-being, body mass index, gender, and age. Detailed results are presented in Table 2, which shows these associations at both T1 and T3, with Inactives primarily comprising females and older students.

Table 2. Bivariate analyses comparing the 4 groups

Variable	Actives n = 237		Increasers n = 147		Decreasers n = 201		Inactives n = 726		p-value
	n	%	n	%	n	%	n	%	
Smoking T1	57	25.68	48	33.92	56	29.82	254	36.45	0.0499
Smoking T3	54	23.8	57	40.31	63	32.33	281	40.36	0.0006
Cannabis consumption (last 30 days) T1	35	15.1	23	16.48	33	17.04	126	17.81	0.865
Cannabis consumption (last 30 days) T3	49	20.95	35	24.24	46	23.34	166	23.45	0.901
E-cigarette use (last 30 days) T1	27	11.29	12	8.58	17	8.56	79	10.94	0.727
E-cigarette use (last 30 days) T3	24	9.98	21	14.56	28	14.04	96	13.41	0.585
Risk of eating disorder (SCOFF) T1	32	13.61	33	22.26	34	16.70	170	23.44	0.010
Risk of eating disorder (SCOFF) T3	24	10.26	21	14.09	36	17.99	195	26.81	<.01
Drunkenness (last 30 days) T1	102	43.18	59	41.29	61	31.06	216	30.63	0.004

Variable	Actives n = 237		Increasers n = 147		Decreasers n = 201		Inactives n = 726		p-value
	n	%	n	%	n	%	n	%	
Drunkenness (last 30 days) T3	102	43.90	63	44.11	96	48.29	261	36.78	0.032
Internet misuse (IAT) T1	8	3.55	7	4.68	13	6.57	39	5.35	0.636
Internet misuse (IAT) T3	4	1.85	6	3.75	7	3.73	28	3.88	0.588
Poor emotional well-being (WHO-5) T1	26	11.13	22	14.95	31	15.28	168	23.16	0.0004
Poor emotional well-being (WHO-5) T3	33	13.72	28	19.24	44	21.80	205	28.25	0.0002
Biological sex (females)	53	22.20	60	40.77	87	43.00	413	57.01	<.01
BMI T1 (overweight/ obese)	19	8.32	20	13.69	16	8.00	107	15.01	0.024
BMI T3 (overweight/ obese)	19	8.06	24	16.33	15	7.47	104	14.37	0.009
Mean age T1	16.28 years		16.29 years		16.58 years		16.82 years		<.01
Financial situation below average	11	4.52	9	5.83	19	9.44	61	8.42	0.177
Family structure (other)	58	24.67	41	28.15	55	27.20	218	30.10	0.520
Academic track (vocational school)	127	53.61	92	62.70	116	57.38	461	63.49	0.086

Multivariate analyses were conducted for statistically significant variables at T1 (Table 3), T3 (Table 4), and both time points simultaneously (Table 5). Key findings include:

1. At T1: Females were more likely to be Increasers, Decreasers, and Inactives. Additionally, Inactives were older, smokers, overweight/ obese, and less likely to feel emotionally well.
2. At T3: Increasers and Decreasers were more likely to be females. Increasers were also more likely to be smokers and overweight/ obese. Inactives were more likely to be females, older, smokers, overweight/ obese, and at risk of disordered eating, but less likely to feel emotionally well.
3. At T1 and T3 simultaneously: Increasers were more likely to be females, smokers, and overweight/ obese. Decreasers were more likely to be females, smokers, and to have experienced drunkenness recently, but less likely to report such experiences at T1. Inactives were more likely to be females, smokers, and older, but less likely to feel emotionally well or have experienced drunkenness at T1.

For precise values and comparisons, refer to Tables 3, 4, and 5.

Table 3. Multivariate analyses at T1 controlling for age, sex, emotional well-being and BMI using Actives as the reference category

Variable	Increasers RRR [95% confidence interval]	Decreasers RRR [95% confidence interval]	Inactives RRR [95% confidence interval]
Smoking T1	1.657 [0.95–2.88]	1.494 [0.89–2.52]	**1.952 [1.25–3.05]**
Risk of ED (SCOFF) T1	1.038 [0.54–2.00]	0.814 [0.43–1.54]	0.826 [0.50–1.38]
Drunkenness (last 30 days) T1	0.848 [0.50–1.43]	**0.522 [0.32–0.84]**	**0.507 [0.34–0.76]**

Variable	Increasers RRR [95% confidence interval]	Decreasers RRR [95% confidence interval]	Inactives RRR [95% confidence interval]
Emotional well-being T1	0.899 [0.46–1.77]	0.813 [0.42–1.59]	**0.559 [0.33–0.96]**
BMI T1 (overweight/ obese)	1.800 [0.80–4.04]	0.917 [0.41–2.05]	**2.328 [1.25–4.33]**
Biological sex (female)	**2.355 [1.37–4.05]**	**2.742 [1.66–4.52]**	**4.522 [3.01–6.80]**
Age T1	0.958 [0.78–1.17]	1.157 [0.99–1.36]	**1.221 [1.06–1.40]**

NB—bold font indicates statistically significant values; RRR—relative risk ratio

Table 4. Multivariate analyses at T3 controlling for age, sex, emotional well-being and BMI using Actives as the reference category

Variable	Increasers RRR [95% confidence interval]	Decreasers RRR [95% confidence interval]	Inactives RRR [95% confidence interval]
Smoking T3	**2.154 [1.18–3.95]**	1.423 [0.86–2.35]	**2.218 [1.47–3.35]**
Risk of ED (SCOFF) T3	0.891 [0.46–1.72]	1.211 [0.65–2.27]	**1.675 [1.02–2.76]**
Drunkenness (last 30 days) T3	1.044 [0.60–1.82]	1.397 [0.88–2.20]	0.869 [0.60–1.26]
Emotional well-being T3	0.792 [0.44–1.44]	0.697 [0.38–1.29]	**0.542 [0.35–0.85]**
BMI T1 (overweight/ obese)	**2.703 [1.24–5.88]**	0.978 [0.42–2.24]	**2.219 [1.16–4.25]**
Biological sex (female)	**2.648 [1.61–4.35]**	**2.659 [1.67–4.24]**	**4.046 [2.77–5.91]**
Age T3	1.040 [0.85–1.27]	1.126 [0.96–1.32]	**1.260 [1.09–1.45]**

NB—bold font indicates statistically significant values; RRR—relative risk ratio.

Table 5. Multivariate analyses at T1 and T3 controlling for age, sex, emotional well-being and BMI using Actives as the reference category

Variable	Increasers RRR [95% confidence interval]	Decreasers RRR [95% confidence interval]	Inactives RRR [95% confidence interval]
Smoking T1	1.030 [0.50–2.11]	0.946 [0.50–1.78]	1.202 [0.70–2.05]
Smoking T3	**2.523 [1.14–5.56]**	**1.900 [1.02–3.55]**	**2.367 [1.41–3.96]**
Risk of ED (SCOFF) T1	1.115 [0.56–2.22]	0.823 [0.41–1.63]	0.770 [0.45–1.32]
Risk of ED (SCOFF) T3	0.722 [0.35–1.50]	0.958 [0.48–1.91]	1.413 [0.81–2.46]
Drunkenness (last 30 days) T1	0.731 [0.40–1.33]	**0.385 [0.23–0.65]**	**0.469 [0.30–0.74]**
Drunkenness (last 30 days) T3	1.307 [0.72–2.38]	**2.092 [1.26–3.46]**	1.203 [0.79–1.82]
BMI T1 (overweight/obese)	1.137 [0.46–2.80]	1.064 [0.45–2.52]	1.633 [0.88–3.05]
BMI T3 (overweight/obese)	**2.378 [1.04–5.43]**	0.772 [0.30–2.01]	1.621 [0.82–3.20]
Emotional well-being T1	1.044 [0.49–2.21]	1.028 [0.49–2.14]	0.764 [0.43–1.37]
Emotional well-being T3	0.636 [0.33–1.22]	0.566 [0.29–1.09]	**0.511 [0.31–0.84]**
Gender (female)	**2.617 [1.50–4.56]**	**2.995 [1.77–5.04]**	**4.289 [2.78–6.61]**
Age T1	0.985 [0.80–1.22]	1.166 [0.99–1.38]	**1.240 [1.07–1.44]**

NB—bold font indicates statistically significant values; RRR—relative risk ratio.

Discussion

A significant majority of AYAs in our study were inactive during the study period, with only one in six meeting PA recommendations. Additionally, a greater proportion of participants decreased their PA levels (15.1%) compared to those who increased it (11.3%). These findings align with the global trend of declining PA levels during adolescence, as noted by Dumith et al.,[7] who reported a consistent annual decline of approximately 7% during adolescence, resulting in a 60–70% decrease in PA by the end of this period.

Physical activity and smoking

The negative association between PA and smoking observed in adults[13,14] appears to be less pronounced in adolescents and young adults.[15] The current study revealed a persistent association between physical inactivity and smoking at T1 and at T3, alongside an association with decreased PA a T3. The link between physical inactivity and smoking has been well described in literature, which offers several reliable explanations for this phenomenon. First, it is known that negative health behaviours tend to cluster together.[16] It is thus possible that some adolescents, by decreasing their physical activity or by staying inactive, moved towards other unhealthy behaviours such as smoking or drinking, as discussed later. Second, lower levels of PA have repeatedly been found to be associated with lower self-esteem, anxiety, stress and even depression.[17] Depression is in turn associated with smoking, the latter being a source of reward which decreases subjective stress levels and transiently elevates mood.[18] Our study supports this hypothesis as our analyses consistently reveal poorer emotional well-being in inactive adolescents.

Interestingly, AYAs who increased their PA levels between T1 and T3 were more likely to smoke at T3. This seemingly contradictory finding may be explained by specific subgroup characteristics. First, when looking at the populational characteristics of the Increasers, we notice that most of them are females and more at risk of being overweight or obese at T3. As both smoking and physical activity could be used to control weight,[18] we could imagine that some overweight adolescents would increase their PA levels and start smoking in order to lose weight. The gender effect observed in our analyses supports this hypothesis as it has indeed been described in several studies that girls tend to be more preoccupied with their weight and tend to engage more in weight-control practices than boys.[19] Second, the association between increased PA levels and smoking at T3 could be the effect of socialisation in the context of organised sports, which represent a major part of physical activity during adolescence. As a matter of fact, the presence of peers and peer pressure are two risk factors for smoking initiation in adolescents.

Physical activity and drinking

In our study, we found a negative correlation between decreased PA or inactivity and drunkenness episodes in the past 30 days at T1. This finding, which probably results from the sports participation of adolescents with higher PA levels, suggests that PA would be a risk factor for experiencing drunkenness. This is in line with the literature, where it has been described that especially team sports can act as a risk factor for heavy drinking in adolescents and young adults.[5,6,17] Team sports seem in fact to favour drinking amongst adolescents due to peer pressure, socialising processes and adaptation to the perceived consumption norm of other players, but also due to the competitive nature of the young athletes and the role of alcohol consumption as a stress-coping mechanism.[20]

On the contrary, our analyses revealed an increased risk of experiencing drunkenness in the past 30 days for Decreasers at T3. This result could be explained, as mentioned earlier, by the clustering of negative health behaviours16, meaning that AYAs with lower levels of PA might take fewer health-oriented decisions. The association between low PA levels and drunkenness episodes, which has already been described in literature,[5,6] could also be explained by the fact that inactive adolescents have more free time to socialise than their active peers and may drink more alcohol in this context. After school attendance, extracurricular activities are in fact the most important occupations in an adolescent's time schedule, leading to the development of social networks and offering the possibility for social drinking.[21] It is also noteworthy that, between T1 and T3, most of the participants reached the legal age for purchasing hard liquors, which may also have contributed to the increased likelihood of drunkenness experiences at T3.

Physical activity and cannabis use

Based on various articles exploring the relationship between sports participation and cannabis consumption,[6,22] we were expecting to find a negative association between high levels of PA and cannabis consumption. However, our analyses did not reveal any significant correlation between these two behaviours neither at T1, nor at T3. This discrepancy may be due to variations in the age groups studied or differences in cultural and societal norms regarding cannabis use. Further research should examine the interplay between PA types, intensity, and cannabis use to clarify these findings.

Physical activity, disordered eating risk and BMI

PA is known to improve body image and self-esteem, whereas a sedentary lifestyle is rather correlated with

poorer body image.[23] Inversely, it has also been reported that people with lower self-esteem and higher body dissatisfaction are more at risk of disordered eating and substance abuse and tend to engage less in PA.[23]

We found a positive association between physical inactivity and overweight or obesity at T1 and at T3. This is not surprising, as PA is one of the main determinants of weight control.[18] Our findings corroborate the results of a systematic review in which clear evidence that obese adolescents spent less time exercising than their non-obese counterparts was found.[24] Previous research has also shown that overweight and obese adolescents tend to participate less in PA, probably partly due to weight-based stigma.[25]

We also found that inactive AYAs were more at risk of developing an eating disorder at T3. As discussed earlier, this result could be explained by the higher proportion of girls in the inactive group, who tend to be more preoccupied with their weight and could thus tend to pursue unhealthy eating and diet patterns more easily than boys.[19] The correlation between physical inactivity and the increased risk of developing eating disorders could also be explained in the light of the positive association between physical inactivity and overweight or obesity, as several types of eating disorders are correlated to a higher BMI.[26]

Physical activity and problematic Internet use

According to literature, sports participation supposedly increases self-control and thus decreases the risk of Internet addiction.[27] Although we were expecting to find a negative relationship between PA and problematic Internet use, we could not find any significant association between these two behaviours at T1 and at T3. This absence of correlation could be explained on the one hand by the age of our respondents as in Tsitsika et al. study on online social networking in adolescence,[28] the negative association between PA and Internet overuse seemed to be more pronounced in younger adolescents (aged 14 to 16) than in older ones (aged 17–18). The authors explained this observation by the increased self-regulation capacity of older adolescents, who might use networking platforms to organise outdoor activities with their peers, rather than as an alternative to outside occupations.[28] The fact that the mean age of the participants in our study was above 16 may explain this lack of association. On the other hand, problematic Internet use might have been underestimated in the current study by the employment of the short version of the Internet Addiction Test.[9] Indeed, this test may not be ideal for the assessment of excessive Internet use in AYAs, as they might have a different understanding of the word "Internet". Despite their importance amongst young people, social media are, for example, not mentioned explicitly in the questions of the Internet Addiction Test and might not be part of the intuitive meaning of the word "Internet" for some adolescents.

Physical activity and emotional well-being

Consistent with existing literature suggesting that PA has a protective effect on mental health in young people, reducing symptoms of depression and anxiety and increasing cognitive functioning 29, inactive participants in our study exhibited poorer mental health outcomes at both T1 and T3.

Physical activity and gender

In line with previous studies4, males remained more active than females between T1 and T3. As a matter of fact, females tend to reduce their PA levels before males (9–12 years vs 13–16 years) during adolescence, possibly due to the timing of the onset of puberty, which usually starts earlier in girls than in boys.[7] The hormonal changes, the modifications in body composition and in self-consciousness as well as the lifestyle modifications resulting from puberty all seem to be related to the engagement in PA.[4] Puberty is indeed characterized by endocrinological, morphological and cognitive changes with high energetic demands, resulting in higher resting and total energy expenditure. From an evolutionary point of view, PA might therefore be reduced naturally during puberty and sedentary time increased in order to save enough energy to meet these new requirements.[30] According to several authors, PA levels actually start declining well before adolescence, from the age of 5–7 onwards.[31] However, the most noticeable age-related decline in PA still occurs during adolescence.[7,30] At the same time, time spent in sedentary activities increases during late childhood and adolescence at the expense of light PA.[4]

In addition to these factors, it is possible that females' earlier morphological changes are accompanied by increased self-consciousness and lower self-esteem, potentially causing drop-out of sporting activities. Body changes may indeed lead to more body dissatisfaction in females than in males, contributing, in turn, to lower physical activity levels in order to avoid situations in

which they might be judged based on their appearance.[32] Males, on the contrary, are more likely than females to engage in organised sporting activities during adolescence and maintain higher levels of physical activity.[7]

Limitations

Several limitations must be acknowledged. The GenerationFRee questionnaire, while providing valuable insights, was not specifically designed to assess PA comprehensively. It excluded PA below 60 minutes per day (which is the amount of PA recommended by the WHO for adolescents and young adults), potentially underestimating correlations with risky behaviors. Additionally, the questionnaire did not capture information on PA type, intensity, or context (e.g., individual vs. team sports), which could offer nuanced insights into our findings. The information on PA type could have been interesting because some types of sports have been shown to be associated with a higher probability of engaging in risky behaviours, and exercise makes up an important part of PA during adolescence. For example, females practising appearance-oriented sports, in which leanness is desirable, have been found to be at higher risk for disordered eating6, whereas adolescents taking part in high-contact sports such as rugby seem to be at greater risk for smoking and engaging in other risky behaviours than those participating in low-contact sports such as running.[13] It would also have been interesting to investigate whether the AYAs carried out PA individually or in a sports club, as a membership in a sports club is likely to increase socialisation and to be associated with peer pressure and higher levels of drinking and smoking. Another limitation to mention is that the study relies on self-reported height and weight and previous studies highlighted some discrepancies with actual values.[33,34] This limitation may affect the accuracy of BMI-related findings. Finally, recall bias and social desirability bias cannot be excluded in a self-reported questionnaire.

Conclusions

This study provides valuable insights into physical activity (PA) patterns and their associations with health-related behaviors over time, offering several important implications for public health. The longitudinal approach enabled us to identify trends and associations that highlight critical periods for intervention. Given that most adolescents and young adults (AYAs) do not meet recommended PA guidelines, there is a pressing need for public health authorities, schools, and sports organizations to collaborate in fostering environments that promote PA during the transition from adolescence to adulthood. This period is crucial for establishing lifelong habits, and targeted programs should encourage the integration of PA into daily routines as a foundation for a healthier lifestyle.

The observed associations between PA and risky behaviors underline the necessity of addressing these behaviors in tandem with PA promotion. Educational initiatives should focus on mitigating risk-taking tendencies in active youth, emphasizing the importance of balanced and health-conscious behaviors alongside physical activity. Collaborative efforts between schools, sports clubs, and public health authorities can play a pivotal role in this endeavor.

Moreover, as the decline in PA is known to begin in early childhood, preventive efforts should not be confined to AYAs but extend to children as young as those in primary school. Early interventions that promote PA and educate children about its benefits can help build resilience against risky behaviors later in life. Future research should further investigate the underlying causes and mechanisms of this early decline to inform more precise and effective interventions.

Finally, gender disparities in PA participation highlight the importance of inclusive policies that address systemic barriers. Ensuring equitable access to PA opportunities and resources for all genders is essential for maximizing public health outcomes.

By addressing these critical areas, public health strategies can more effectively combat the decline in PA and its associated risks, fostering healthier behaviors across the lifespan.

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