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Association between adolescent lifestyle factors and high-energy traumas in early adulthood: A longitudinal study

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ABSTRACT

Introduction: Longitudinal studies investigating lifestyle factors as risk factors for high-energy traumas from adolescence to adulthood are lacking. The aim of this study was to investigate the influence of 14 to 18-year old adolescent health-related behaviours, overweight, chronic disease, family socioeconomic status (SES), and adulthood education level on the risk of high-energy traumas during the average 27-year follow-up in Finland.
Materials and methods: The baseline data were surveys gathered biennially from 1981 to 1997 (the Adolescent Health and Lifestyle Survey) and individually linked with outcome data on high-energy traumas retrieved from the Care Register for Health Care until the year 2018. A logistic regression model was used to analyse the associations between the exposure variables in adolescence (frequent physical activity, overweight, smoking, monthly drunkenness, chronic disease, family SES, adulthood education level) and the overall risk for high-energy traumas. Adjusted odds ratios (aOR) with 95 % confidence intervals (CIs) were computed.
Results: A total of 876 persons (1.8 %) had a high-energy trauma during the follow-up. High-energy trauma diagnoses overall were more common among males than among females (2.8 % vs 1.0 %). Follow-up showed that those who smoked (aOR 1.49, CI 1.40–1.58), were drunk monthly (aOR 1.49, CI 1.39–1.59), had a chronic disease (aOR 1.22, CI 1.12–1.34) in adolescence or had attained only low education level in adulthood (aOR 1.39, CI 1.30–1.48) had higher odds for high-energy traumas. Frequent physical activity or overweight in adolescence were not related to the higher odds for high-energy traumas.
Conclusion: Smoking, monthly drunkenness, self-reported chronic diseases in adolescence, and low educational level in adulthood increased the risk of high-energy traumas during the mean follow-up of 27-years. Frequent physical activity and overweight in adolescence did not predict the occurrence of high-energy traumas. Intervention programs should also focus on the long-term consequences of these risk factors.

Introduction

Certain types of fractures in the younger population are mainly caused by trauma mechanisms requiring high-energy. These include fractures of the spine, pelvis, hip, and shaft of femur or tibia [1,2,3,4]. Furthermore, certain thorax injuries typically result from trauma mechanisms that require high energy [5,6]. The mortality due to these traumas is found to be high and marked at the global level [7]. According to the World Health Organization (WHO), injuries and traumas from all causes kill 5.8 million persons per year globally, accounting for 10 % of the world's deaths [7]. The most common causes of high-energy traumatic injuries were identified as road traffic accidents, conflicts, and falls [8,9,10]. Based on the WHO reports, road traffic injuries are the leading cause of injury-related deaths worldwide, with over one million deaths (3250 per day), and 20–50 million wounded [11]. Currently, road traffic injuries are the leading cause of death among 15–29-year-olds, and 75 % of these deaths occur in men [11]. By contrast, the other significant burden experienced by level 1 trauma centres, namely

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fall-related injuries, occurs across all age groups and in both genders [12].

The risk factors for high-energy trauma injuries are only moderately studied at present. It is known that lower socioeconomic status (SES) is one factor associated with an increased risk of undifferentiated traumas [13], and lower education level is found to be associated with risky behaviours, including criminal behaviour [14]. Excessive alcohol consumption is another strong predictor of risky behaviour and injuries [15, 16], and adolescent drinkers who report problem drinking and peer drinking are more likely to have engaged in physical fighting, to have been injured in fights and to have injured others in fights [17]. Smoking in the early life also increases the risk of other risky behaviours, such as stealing, delinquent behaviors, and use of predatory and relational violence [18].

Only a small number of longitudinal studies have investigated lifestyle choices as risk factors for high-energy traumas from adolescence to adulthood [19,20]. In the present study, we hypothesized that – in addition to the already known risk factors (alcohol use, smoking, lower family SES and educational level) – other health behaviours, such as overweight, physical activity, and chronic diseases, might also influence the risk for high energy traumas (e.g., through related risky behavior, different free-time activities, or sports collisions). Hence, the aim of this is to investigate the influence of adolescent health-related behaviors (physical activity, overweight, drunkenness, smoking), chronic disease, family socioeconomic status (SES), and education level attained in adulthood on the risk for high-energy traumas in adulthood, using a large cohort of Finnish adolescents who were followed up for an average of 27 years.

Materials and methods

Study design

This longitudinal study utilised the survey data from the Adolescent Health and Lifestyle Survey (AHLS) and individually linked these data with sociodemographic data from Statistics Finland and with outcome data retrieved from the Care Register for Health Care (formerly the Hospital Discharge Register) [21]. The endpoint of the follow-up for each participant was either the first occurrence of the first high-energy trauma, or the termination of the follow-up on December 31, 2018.

Baseline data

The baseline data were sourced from AHLS [22]. Commencing in 1977, surveys were mailed biennially to representative samples of Finnish youth. aged 14, 16, or 18 years. The sample covered all children born on selected days in June, July, or August. The surveys took place between February and March, with individual follow-ups commencing from the conclusion of each survey on April 30 of the survey year. Samples were drawn from the Population Register Centre. Two re-inquiries were sent to non-responders. This study utilised data collected between 1981 and 1997. If a responder had been included in more than one survey, the answer from his/her first survey was used. The overall response rate was 77.8 % and the numbers of participants 47 747.

Outcome variable

The outcome was an outpatient emergency department visit or a hospitalisation due to a high-energy fracture. Only the first visit with diagnoses was included. Outcome variables were obtained from the Care Register for Health Care, which includes information on participants discharged from inpatient care, day surgeries, and specialised outpatient care. The coverage and quality of the Care Register for Health Care is good [23]. ICD-10 (International Classification of Diseases 10th revision) diagnoses, were used to identify specific fracture diagnoses starting from the year 1998, as the quality of the register has had higher quality since then. However, the external causes were not included because the reporting in the registry is not reliable enough. In this study, a high-energy trauma was specified as a fracture in cervical, thoracic, or lumbar vertebra, in the pelvis, femur, or shaft of the tibia, or thoracic injuries requiring high force. These diagnoses were chosen based on clinical expertise and the literature on the trauma mechanisms behind these injuries in the younger population [1–6]. Isolated head injuries were excluded despite their possible high-energy nature as these injuries may not always involve high-energy mechanisms and their inclusion would have led to incorporation of patients without high-energy trauma. Table 1 shows the specific ICD-10 codes used in this study and the total number of different high-energy traumas. The flowchart for forming the final study sample is shown in Fig. 1.

Explanatory variables

Variables describing health behaviors and chronic disease were obtained from the AHLS, while data on family SES and education level in adulthood were collected from the national registries of Statistics Finland. A summary of the variables used in the analyses and the original variables is shown in Table 2.

Statistical methods

Continuous variables were presented as means with standard deviations (sd). Categorical variables were presented as absolute numbers and percentages. A binary logistic regression model was used to analyse risk factors for high-energy traumas. The explanatory variables were the

Table 1
The classification of high-energy traumas according to ICD-10-codes, and the total number of different first diagnoses.

High-energy traumas		
ICD-10 code	Definition	n
Fractures		743
S12.0	Fracture of first cervical vertebra	5
S12.1	Fracture of second cervical vertebra	9
S12.2	Fracture of third cervical vertebra	60
S12.7	Multiple fractures of cervical vertebra	9
S12.8	Fracture of other parts of neck	<5*
S12.9	Fracture of neck, unspecified	5
S22.0	Fracture of thoracic vertebra	90
S22.1	Multiple fractures of thoracic vertebra	16
S22.5	Flail chest	5
S32.0	Fracture of lumbar vertebra	106
S32.1	Fracture of sacrum	11
S32.3	Fracture of ilium	17
S32.4	Fracture of acetabulum	15
S32.5	Fracture of pubis	15
S32.7	Multiple fractures of lumbar spine and pelvis	20
S32.8	Fracture of other parts of pelvis	20
S32.9	Fracture of unspecified parts of lumbosacral spine and pelvis	0
S72.0	Fracture of head and neck of femur	37
S72.1	Pertrochanteric fracture	14
S72.2	Subtrochanteric fracture	6
S72.3	Fracture of shaft of femur	48
S72.4	Fracture of lower end of femur	30
S72.7	Multiple fractures of femur	<5*
S72.8	Other fracture of femur	6
S72.9	Unspecified fracture of femur	<5*
S82.2	Fracture of shaft of tibia	190
Thoracic traumas		133
S25	Injury of blood vessels of thorax	5
S26	Injury of heart	6
S27	Injury of other and unspecified intrathoracic organs	122
S28	Crushing injury of thorax, and traumatic amputation of part of thorax	0

* Finnis legislation prevents to report the exact rate if the rate is <5.

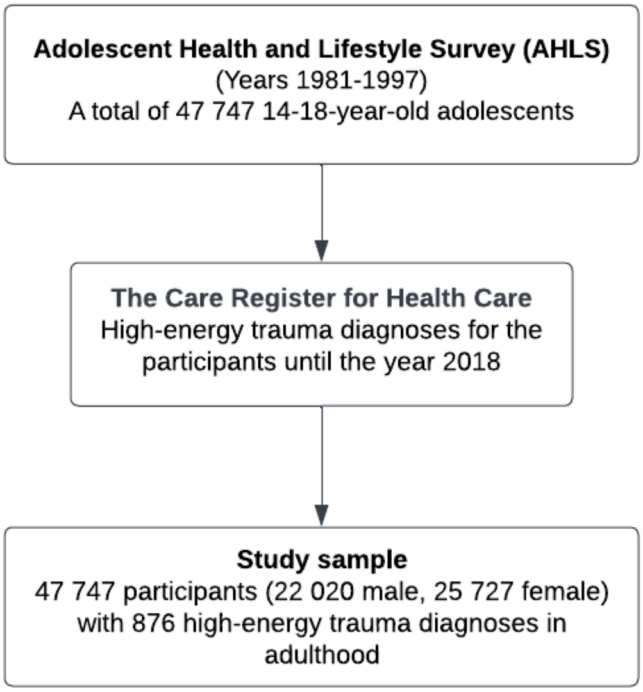

Fig. 1. Flowchart depicting the formation of the study sample. data from the adolescent health and lifestyle survey were linked with the data on high-energy trauma diagnoses found in the care register for health care.

following adolescent health and health behavior variables: frequent physical activity, overweight, smoking, monthly drunkenness, chronic diseases, family SES, and education level in adulthood. In the models for family SES and education level in adulthood, adolescents with a missing SES for both parents and missing education level were excluded from the model. The gender-stratified models were also created. In addition, explanatory variables that showed major differences between the gender-stratified models were further explored using interaction effects models between the outcome, and explanatory variable + gender variables were explored using logistic regression. Adjusted odds ratios (aOR) with 95 % confidence intervals (CIs) for the explanatory variables were compared between groups.

In the logistic regression models, adjustments were made by choosing the variables for a multivariable model based on directed acyclic graphs (DAGs). The variables included in the DAGs were chosen based on known risk factors and hypothesised causal pathways. The models were created using the free online software DAGitty (dagitty.net) (Supplementary figures 1–7) [24]. DAGitty automatically suggests possible adjustment variable sets that can influence the main outcome. DAGitty determines the minimal adjustment set needed to block all non-causal paths, thereby ensuring that no node in the set is a descendant of the explanatory variables and that all backdoor paths are blocked when conditioning on this set. The tool uses algorithms from graph theory and causal inference to automate this process and provides real-time feedback on the sufficiency of specified adjustments to aid researchers in making valid causal inferences [25]. In the DAGs, the exposure variable is placed in the bottom left corner and the outcome in the right corner. The yellow variables are called an ancestors of exposure (affecting the exposure variable), the blue variables as an ancestors of outcome (affecting the outcome variable), and the red variables as an ancestors of outcome and exposure variables. The pathways between different variables can be either green, red, or black. A green pathway means a causal pathway located between the exposure variable and the outcome variable, a red pathway means a biasing pathway, and black a pathway is located between the outcome and the variables that affect only the outcome.

Table 2
Description of explanatory variables used in the analyses.

Variable and its source	Original variable and formation of the variable used in the analyses	Values
Family SES, Statistics Finland	Occupation-based socioeconomic status of the respondent' mother and father from the national registries of Statistics Finland. he registry data on socioeconomic circumstances had been obtained from national censuses conducted every fifth year until 1995 and from on-line registry data on a yearly basis from 2000 onwards. Classification of Statistics Finland [22].	Both parents' unknown = 0 Both parents upper white-collar = 1 Either one upper white-collar = 2 Either one lower white-collar = 3 Either one blue-collar = 4
Attained education level in the end of the follow-up, Statistics Finland	The highest degree	High (lower degree-level tertiary or higher) = 0 Low (upper secondary or lower) = 1
Smoking status, AHLS	Combining questions on tobacco experimentation and frequency of tobacco use	No = 1 Yes = 2
Monthly drunkenness, AHLS	Question on frequency of alcohol use and drunkenness	No = 1 (Abstinence or only occasional drinking) Yes = 2 (Drunk once or more often a month)
Frequency of physical activity, AHLS	Combining questions on frequency of participation in physical exercise in sports clubs and frequency of leisure time physical activity	Low = 1 (Once a week or less) Medium = 2 (2 to 3 times a week or less) High = 3 (4 or more times a week)
Self-reported chronic diseases and disabilities, AHLS	Question on long-term disease or disability that disturbs your everyday life.	No = 1 Yes = 2
High BMI, AHLS	BMI calculated from self-reported height (cm) and weight (kg)	No = 1 (Normal or low weight) Yes = 2 (High BMI according to Cole's criteria)[23]

Based on the DAGs, the models with frequent physical activity, smoking, monthly drunkenness, and chronic diseases as exposure variables were adjusted by the age of the adolescent and family SES in adolescence. The model with overweight as an exposure variable was adjusted by the age of the adolescent, physical activity, and family SES in adolescence. The model with family SES and attained education level as exposure variables was adjusted by the age of the adolescent, and smoking status in adolescence.

Variance inflation factor (VIF) scores were calculated to assess the potential for regression model instability [26]. Statistical analyses were performed with R version 4.0.5 (R Foundation for Statistical Computing, Vienna, Austria) [27]. The results of this study are reported according to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines [28].

Results

Of the participants, 22 020 (46.1 %) were males and 25 727 (53.9 %) females. In this population, a total of 876 persons (1.8 %) had a high-energy trauma during the follow-up. The high-energy traumas were more common among males than among females (2.8 % vs 1.0 %). The mean follow-up time was 26.8 years (sd 4.1 years). The mean age at the time of the first high-energy trauma diagnosis was 31.1 years (sd 8.2

years) for males, and 33.5 years (sd 8.0 years) for females. The mean age at the end of the follow-up was 42.7 years (sd 4.3). (Table 3)

The logistic regression analysis showed that adolescents who smoked had higher odds for high-energy traumas; all (aOR 1.49, CI 1.40–1.58), males (aOR 1.60, CI 1.47–1.72), and females (aOR 1.27, CI 1.15–1.4) when compared to non-smoking adolescents. The interaction effects model showed that smoking + male gender gave the greatest increase in the odds for high-energy traumas (aOR 1.76, CI 1.49–2.09), whereas no difference was found among smoking females. Adolescents with monthly drunkenness also had higher odds for high-energy traumas; all (aOR 1.49, CI 1.39–1.59), males (aOR 1.44, CI 1.32–1.56), and females (aOR 1.37, CI 1.22–1.53) when compared to adolescents who abstained from alcohol or drank only occasionally. The interaction effects model showed that monthly drunkenness + male gender had highest odds for high-energy traumas (aOR 1.51, CI 1.26–1.80), whereas no such increase was evident among females (aOR 1.44, CI 1.04–1.98). The presence of self-reported chronic diseases in adolescence increased the odds for high-energy traumas; all (aOR 1.22, CI 1.12–1.34), males (aOR 1.18, CI 1.04–1.34), and females (aOR 1.35, CI 1.17–1.54) when compared to adolescents without chronic diseases. In addition, low education level in adulthood increased the odds for high-energy traumas; all (aOR 1.39, CI 1.30–1.48), males (aOR 1.44, CI 1.32–1.57), and females (aOR 1.12, CI 1.02–1.23) when compared to participants with high education level. We found no statistically significant association between frequent physical activity and overweight in adolescence and high-energy traumas in adulthood, and the interaction effects model also showed no difference between gender and BMI (Table 4).

Table 3
Descriptive statistics on variables used in the study by gender.

	All		Male		Female	
Total number	47 747		22 020		25 727	
	n	%	n	%	n	%
Background information						
Age during the survey						
14 years	15 880	33.3	7533	34.2	8347	32.5
16 years	15 885	33.3	7320	33.3	8565	33.3
18 years	15 982	33.5	7167	32.6	8815	34.3
Age at the end of the follow-up (years), mean (sd)	42.7 (4.3)		42.7 (4.3)		42.7 (4.3)	
Explanatory variables						
Smoking in adolescence	11 564	24.2	5690	25.9	5874	22.8
Drunk once or more a month	9048	19.0	4892	22.2	4156	16.2
Physical activity in adolescence						
high	11 315	23.7	5588	25.3	5727	22.3
medium	13 467	28.2	6324	28.7	7143	27.8
low	22 280	46.7	9681	44.0	12 599	49.0
unknown	662	1.4	417	1.9	245	1.0
High BMI in adolescence	4839	10.1	2838	12.9	2001	7.8
Chronic diseases in adolescence	4222	8.8	1819	8.2	2403	9.3
Family SES at age 15						
both upper white-collar	7775	16.3	3677	16.7	4098	16.0
either one upper white-collar	11 899	24.9	5456	24.8	6443	25.1
either one lower white-collar	15 184	31.8	7093	32.2	8091	31.5
either on blue-collar	10 423	21.8	4647	21.1	5776	22.5
both unknown	2466	5.2	1147	5.2	1319	5.1
Education level in adulthood						
Low	23 235	48.7	11 639	52.9	11 596	45.1
High	19 080	40.0	7276	33.0	11 804	45.9
Unknown	5432	11.4	3105	14.1	2327	9.0
Outcome variables in adulthood						
High-energy trauma	876	1.8	614	2.8	262	1.0

Discussion

The main finding of this study was that smoking, monthly drunkenness, and a self-reported chronic disease in adolescence as well as low education level in adulthood were associated with a higher risk of high-energy traumas in adulthood during the 27-year of follow-up. The risk of high-energy traumas was high among adolescents who smoked (especially among males), and who were intoxicated monthly. However, we found no evidence of an effect of increased adolescent physical activity or overweight on the occurrence of high-energy traumas.

The risk for high-energy traumas was high among adolescents who were drunk once a month or more often. Alcohol is a known factor to increase the risk of physical injuries, especially in the younger population [16,17,29]. Alcohol also plays a role in a high proportion of the more severe injuries suffered by trauma patients, with falls from stairs and assaults being the most common reasons behind these traumas [30].

Table 4
Odds ratios (aOR) with 95 % confidence intervals (CI) for high-energy traumas. The exposure variables are shown in the first column, and the aORs for the specific exposure variable have been presented separately for all participants, males, and females.

	All		Males		Females	
	aOR	CI	aOR	CI	aOR	CI
Physical activity[a]						
low	1.00		1.00		1.00	
medium	0.99	0.92–1.06	0.98	0.89–1.07	0.95	0.85–1.05
high	1.03	0.99–1.07	1.01	0.97–1.06	1.00	0.97–1.06
BMI[b]						
normal BMI	1.00		1.00		1.00	
high BMI	1.03	0.94–1.13	0.87	0.77–0.97	1.11	0.94–1.30
Tobacco use[a]						
no smoking	1.00		1.00		1.00	
smoking	1.49	1.40–1.58	1.60	1.47–1.73	1.27	1.15–1.40
Monthly drunkenness[a]						
abstinence or occasional	1.00		1.00		1.00	
drunk once or more a month	1.49	1.39–1.59	1.44	1.32–1.56	1.37	1.22–1.53
Chronic disease[a]						
no	1.00		1.00		1.00	
yes	1.22	1.12–1.34	1.18	1.04–1.34	1.35	1.17–1.54
Family SES at age 15[c]						
Both parents upper white-collar	1.00		1.00		1.00	
Either one upper white-collar	1.05	0.96–1.20	1.06	0.94–1.20	1.07	0.92–1.24
Either one lower white-collar	1.06	1.02–1.11	1.09	1.03–1.15	1.04	0.97–1.11
Either one blue-collar	1.05	1.00–1.14	1.07	1.00–1.14	1.04	0.96–1.12
Attained education level[c]						
High	1.00		1.00		1.00	
Low	1.39	1.30–1.48	1.44	1.32–1.57	1.12	1.02–1.23

[a] Adjusted by the adolescent age and family SES in adolescence.
[b] Adjusted by the adolescent age, physical activity, and family SES in adolescence.
[c] Adjusted by the adolescent age, and smoking status in adolescence.

Chronic alcohol consumption is also associated with alterations in bone remodelling due to a general uncoupling of bone formation from bone resorption [31]. Specifically, alcohol seems to impair the bone microarchitecture, with effects on both cortical thickness and trabecular bone volume [32]. However, whether high use of alcohol actually weakens or strengthens the structure of the bone is unknown and remains controversial, suggesting the possibility that the increased fracture risk among young alcohol abusers might be mainly due to their riskier behaviour in general. Future interventions should focus on age-appropriate educational programs in primary and secondary schools.

Along with monthly drunkenness, smoking was a strong risk factor for high-energy traumas. There are several mechanisms through which smoking can increase the risk for traumatic events; smoking is related to the abuse of narcotics and alcohol[33,34,35], smokers adopt more often risk-taking and delinquent behaviors, such as use of predatory and relational violence[18], smoking in adolescence is associated with suicide mortality[36], and finally, smoking can influence negatively bone health and metabolism[37,38], lower bone density and increase the risk for fractures [19,20,39,40]. The traumas included in the study required high-energy, but because the trauma mechanisms were not coded in the registry, it is not possible to conclude if the adverse effects of smoking on bone health had played a role here. Consequently, no conclusion can be drawn regarding whether the adverse effects of smoking on bone health had played a role in these traumas or whether a person with a healthier musculoskeletal system would have survived the traumatic events with lesser injuries.

The presence of chronic diseases also slightly increased the odds for high-energy traumas. The exact reason for this is unclear and cannot be fully explained by associations between chronic diseases and other behavioral factors that increase the risk for high-energy traumas. A previous study investigating the association between chronic diseases and educational level using the same dataset found that these diseases predicted a lower academic path [41]. The exact information on the precise chronic diseases is not taken into account in our study; however, in the younger population, these chronic conditions most commonly include diseases like asthma, type 1 diabetes mellitus, epilepsy, inflammatory bowel diseases, and attention-deficit hyperactivity disorder (ADHD), and are mainly hereditary and occurring in a heterogenic population from the background [42]. This could indicate, that chronic diseases might decrease the quality of life, thereby leading to a more challenging adulthood and increased risk for traumatic events through various routes. The long-term medications, such as corticosteroids for asthma and rheumatoid arthritis can also lower the bone mineral density and further increase vulnerability to fractures requiring higher energy [43,44]. Similarly, disorders of the thyroid gland can cause disturbances in bone metabolism and increase the risk for osteoporosis and fractures [45]. However, the increased risk for fractures is most likely multifactorial, and psychological reasons that lead to behavioural differences among adolescents can play a role in explaining the increased risk of adolescents with chronic diseases. Furthermore, self-reported variables are always prone to bias, and this should be taken into account when interpreting the results and drawing conclusions. A previous study investigating the chronic diseases variable has reported a small number of inconsistencies [41].

Participants who had attained only a low education level in adulthood had a high risk for high-energy traumas, as expected. Based on previous literature, the benefits of higher education are not only restricted to monetary outcomes (i.e., higher employment, lower unemployment, and higher earnings) [46,47], as they also apply to the nonmonetary domains of human well-being and health [48]. These include paying greater attention to healthy behaviour, reducing abusive alcohol use, decreasing levels of tobacco consumption, and increasing consumption of fruit and vegetables [48]. The previous literature shows that educational attainment plays a significant role in mediating health inequalities in adulthood [49], in line with the results of this study. Interestingly, low family SES in adolescence was only a minor risk factor for high-energy traumas, and only for males. Compared to the risk caused by low education in adulthood, the risk caused by low family SES in adolescence is small. Compared to the risk of adulthood low education, the risk caused by low family SES in adolescence was small in future adulthood. A study performed in New Zealand indicated a higher likelihood for adverse health behavioural habits and poorer health status among adolescents with low family SES in adolescence [50]. In that study, these risks were notably higher than in our study [50].

Physical activity at any intensity or overweight in adolescence were not associated with high-energy traumas in adulthood. This was somewhat unexpected because frequent physical activity might increase the number of high-energy contacts, especially in contact sports. Conversely, physical activity can be a protective factor against high-energy traumatic injuries due to its health effects, as increased bone mineral density, and higher muscle mass protecting the body [51]. However, we studied here only the frequency, not the intensity of the physical activity; therefore, any conclusions should be made with caution. Correspondingly, overweight adolescents had no increased risk for high-energy traumas but for males, overweight was a minor protective factor. Overweight might be associated with more passive lifestyle [52], which could explain also males' lower risk. In previous studies the increased energy and more severe high-energy traumas have been more common among overweight people [53].

A strength of this study lies in its long follow-up period of 27 years on average, which could show how adolescent risk factors can influence high-energy traumas in mid-adulthood. The study does possess some limitations. Our nationwide sample was large representing Finnish adolescents but males, particularly 18-year-olds, were slightly underrepresented among the respondents. This unlikely affects significantly the generalizability of the results.

Our register-based data on the outcomes had no information on trauma mechanisms. These may have given more insight of the external and behavioral mechanisms. All health behaviors and chronic diseases were self-reported which may have caused inaccuracy and bias in results (e.g., younger adolescents might underreport smoking or alcohol because they may have been afraid that parents might see their answers). Conversely, the reliability and validity of self-reported smoking status are generally good among young adults [54]. A further limitation is that non-responsive adolescents (22.2 %) were not included in this study, although information is now available for the exposure variables among these persons. Notably, a previous study has found that these nonresponsive adolescents had a higher mortality in adulthood when compared to responsive adolescents [55]. Moreover, we do not know how health and health behaviours have changed over time, although many of these (especially smoking) are clearly related from adolescence to adulthood [56]. In addition, chronic diseases were reported only as the presence of the chronic disease (yes/no); therefore, no breakdown of different chronic diseases was performed. However, the most common chronic diseases among adolescents are diseases such as asthma, type 1 diabetes mellitus, and epilepsy [42].

Conclusion

Smoking, monthly drunkenness, and chronic diseases in adolescence increased the risk of high-energy traumas during the follow-up of mean 27-years. The risk based on smoking and monthly drunkenness was higher among males. Lower family SES in adolescence slightly increased the risk among males while the risk was higher for both genders when low education level in adulthood was low. Frequent physical activity and overweight in adolescence did not predict the occurrence of high-energy traumas Our study shows several risk factors for high-energy traumas. This knowledge can be valuable when in health education programs for adolescents as well as for adults, particularly those with low education level. Intervention programs should also focus on the long-term consequences of these risk factors, not only for health in general but because they can impair decision-making in later life.

Ethical standard statement

For this type of study formal consent is not required.

Human and animal rights

This study does not contain any studies with human participants or animals performed by ny of the authors.

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CRediT authorship contribution statement

Matias Vaajala: Writing – original draft, Methodology, Formal analysis. **Alisa Teuho:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Rasmus Liukkonen:** Writing – review & editing, Methodology. **Ville Ponkilainen:** Writing – review & editing, Methodology. **Arja Rimpelä:** Writing – review & editing, Supervision, Resources, Methodology. **Leena K. Koivusilta:** Writing – review & editing, Supervision, Resources, Methodology. **Ville M. Mattila:** Writing – review & editing, Supervision, Resources, Methodology.

Declaration of competing interest

The authors declare no conflict of interest.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2024.112008.

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