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Associations of leisure-time physical activity and active school transport with mental health outcomes: A population-based study

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Promoting physical activity can improve population health. This study aimed to examine associations of leisure-time moderate-to-vigorous physical activity and active school transport with mental health, that is, symptoms of depression and anxiety, among 15- to 16-year-old adolescents. We also assessed the relationships with less-studied outcomes, such as chronic stress and visits to school psychologist. A nationwide Finnish cohort of eighth and ninth graders from the School Health Promotion study (32 829 participants; mean age 15.4 years; 53% girls) was studied. We used logistic regression to estimate odds ratios (OR), with models adjusted for major sociodemographic, health behavior, and physical activity variables. Key findings suggest that leisure-time moderate-to-vigorous physical activity is associated with better mental health in a dose–response manner. Even the smallest dose, 30 weekly minutes, was linked to 17% lower odds of chronic stress symptoms compared to inactivity (OR 0.83, 95% CI 0.71–0.96). Compared to non-active transportation, more than 30 min of daily active school transport yielded 19% (OR 1.19, 95% CI 1.07–1.31) and 33% (OR 1.33, 95% CI 1.12–1.58) higher odds of depression symptoms and school psychologist visits, respectively. However, no associations were found for low-to-moderate daily active school transport levels (<30 min). This large-scale study further highlights a positive association between leisure-time physical activity and mental health among youth. Future research should explore what factors might explain the potential adverse mental health outcomes of active school transport.

KEYWORDS
active school transport, adolescent health, cross-sectional study, mental health, physical activity, population-based study

1 | BACKGROUND

Mental disorders affect 13% of adolescents globally.[1] In Finland, self-reported mental health problem prevalence among youth has either remained stable or decreased for the last two decades.[2] Moreover, prevalence of suicidal thoughts, a symptom of severe depression, is decreasing among Finnish 18-year-old males.[3] Despite the encouraging trends, mental health service use for depression and anxiety disorders has increased drastically among young people, placing a burden on the healthcare system.[4] Consequently, finding cost-effective solutions to protect the mental health of adolescents is needed.

Engaging in regular physical activity (PA) during adolescence is a key modifiable protective factor for various mental disorders.[5,6] Although protective mechanisms of PA are not completely understood, effects are suggested to occur via multiple biological, psychosocial, and behavioral pathways.[7] For example, regular PA reduces physiological risk factors of depression, such as low-grade inflammation[8] and oxidative stress.[9] Neurobiologically, PA can enhance mental health by changing the structural and functional composition of the brain.[10–12] Furthermore, exercise may increase self-esteem,[13] improve social well-being,[14] and enhance sleep quality.[15] Despite the benefits, most adolescents do not meet PA recommendations.[16]

Promoting active travel, such as active school transport (AST), has emerged as one of the main solutions for tackling the global problem of insufficient PA.[17] At the same time, the increased use of sustainable travel modes is considered as an essential factor in climate change mitigation.[17] Previous findings have suggested that AST is associated with healthier body composition as well as higher PA and cardiorespiratory fitness levels.[18–20] Only few studies have explored the association between AST and mental health, however.

A study comprising nine upper-middle- or high-income countries found that adolescents who cycled to school were less likely to report mental health complaints than passive commuters.[21] In contrast, similar findings of an Irish study attenuated to null after adjusting for sociodemographic confounders.[22] In low- and middle-income countries, AST has been associated with lower odds of depression symptoms[23,24] and fewer suicide attempts.[25] Nevertheless, all previous studies have lacked essential covariate adjustments, such as leisure-time PA or socioeconomic status, the latter being a major determinant of mental health.[26] Additionally, none of the European studies have used a cohort that comprises a substantial population proportion of their countries.[21,22]

To strengthen the previous PA and mental health literature, we examine associations of weekly leisure-time moderate-to-vigorous physical activity (MVPA) and AST with mental health outcomes using data from the nationwide School Health Promotion (SHP) study in Finland. We hypothesize, based on existing evidence, that both higher levels of leisure-time MVPA and AST are positively associated with mental health among 15- to 16-year-old adolescents.

2 | MATERIALS AND METHODS

2.1 | School health promotion study

The SHP study monitors the well-being and health of Finnish children and adolescents every second spring. The data are collected by an anonymous and voluntary classroom-administered questionnaire, which is offered to every comprehensive school pupil in Finland. The questionnaire comprises various health-related topics, such as living conditions, health behaviors, and use of school health services. The results are used to strengthen the planning and evaluation of health promotion activities at school, regional, and national levels. The study is conducted by the Finnish Institute for Health and Welfare (THL). The data collection has been approved by the ethical committee of the THL (THL/1407/6.02.01/2014). An extensive description of the study can be found on the THL's website.[27]

2.2 | Study design

In this population-based cross-sectional study, we used SHP study data from 2015 to investigate associations of leisure-time MVPA and AST with mental health outcomes. The data from 2015 were chosen as the questionnaires of the other survey rounds did not comprise AST-related questions. We treated various sociodemographic factors, health behaviors, and other PA types as confounders.

2.3 | Participants

In 2015, 43% (N = 50 404) of all eighth and ninth graders from Finnish comprehensive schools responded to the SHP study. We excluded participants with over 10 kilometers one-way distance to school (N = 9006), as the share of active transport was minimal at longer distances. Additionally, we excluded those with implausible (N = 1694; reported by the THL) or missing answers in exposure, outcome, or confounding variables (N = 6875). Exclusions resulted in a total analytical sample of 32 829.

2.4 | Leisure-time moderate-to-vigorous physical activity

Weekly leisure-time MVPA was self-reported and requested by a question: "During your leisure-time, how many hours per week do you spend doing exercises that increase sweating and breathing rate?" We derived six categories from the answers: non-active, 30 min, 1 h, 2–3 h, 4–6 h, and 7 h or more.

2.5 | Active school transport

Daily time spent in AST was self-reported and requested by a question "How much time do you typically spend walking or cycling to school? Consider traveling to bus stops as well." We derived four categories from the answers: non-active (school transport by a motorized vehicle), <10 min, 10–30 min, and more than 30 min.

2.6 | Mental health outcomes

We used four different mental health outcomes: chronic stress symptoms (for the past 6 months), depression symptoms (for the past month), moderate-to-severe anxiety symptoms (for the past 2 weeks), and visits to school psychologist (for the past school year).

The questionnaire included three items on stress symptoms with a response scale from "rarely or never" to "almost every day." We categorized almost daily feelings of "tension and nervousness," "irritability and anger," and "sleep problems" (difficulties to fall asleep or waking up several times during the night)—in any combination—as indicators of chronic stress symptoms.

Depression symptoms were measured with two dichotomous items (yes/no). We used the occurrence of "feeling down, depressed or hopeless" and/or "little interest or pleasure in doing things" as depression symptoms indicators. The items were Finnish translations of the validated Patient Health Questionnaire-2 (PHQ-2).[28]

The moderate-to-severe anxiety indicator was based on a question: "How often have you experienced the following problems during the past two weeks?" The indicator comprised seven sub-questions: (1) feelings of nervousness, anxiety, or being on edge, (2) not being able to stop or control worrying, (3) worrying too much about different things, (4) trouble relaxing, (5) being restless, (6) becoming easily annoyed or irritable, and (7) feeling afraid as if something awful might happen. The response options were as follows: (1) not at all, (2) on some days, (3) on most days, and (4) almost daily. The options were scored as follows: 1 = 0, 2 = 1, 3 = 2, and 4 = 3. The total score, varying from 0 to 21, indicated the following: 0–4 (no anxiety), 5–9 (mild anxiety), 10–15 (moderate anxiety), and 16–21 (severe anxiety). The sub-questions were Finnish translations of the validated Generalized Anxiety Disorder 7-Item Scale (GAD-7).[29]

Visits to school psychologist were self-reported and included all occurred meetings from the past school year as well as counseling that the participants had a need for but were not organized.

2.7 | Covariates

Based on previous literature[26] and data availability,[27] we identified key determinants and risk factors of mental disorders that could plausibly affect PA behaviors as well. As a result, we treated school grade, sex, country of birth, household financial situation, education level of parents, distance to school, smoking, snus use, electric cigarette (comprising nicotine) use, cannabis use, alcohol consumption, and either AST or leisure-time MVPA (depending on exposure) as confounders. Different health status indicators (subjective health, weight, and sleep quality), which can both confound and mediate the studied association, were controlled for in sensitivity analyses. All covariates were categorical and self-reported.

2.8 | Statistical analyses

The distribution of sociodemographic, health behavior, health status, and PA characteristics were examined across leisure-time MVPA, AST, and mental health outcome groups. We assessed differences across groups by chi-square test (χ^2). We also compared characteristics of the participants in the analytical sample with those of the excluded due to implausible or missing answers ($N = 8569$).

The associations of leisure-time MVPA and AST with mental health outcomes were investigated by logistic regression models. We adjusted the models initially for school grade and sex, then additionally for country of birth, household financial situation, parents' education level, distance to school, and health behaviors, and finally for other PA types. For leisure-time MVPA, the models were adjusted for AST and vice versa. Orthogonal polynomial coding was used to test for linear trend across PA levels. The absence of multicollinearity was confirmed using variance inflation factors.

In sensitivity analyses, we added subjective health status, weight status, and adequate sleep individually to the model that included all confounder variables. We also excluded participants who were bullied once a week or more often ($N = 1725$).

We performed all statistical analyses using R (version 4.1.2) and RStudio (version 2022.02.1) software. Results are presented as odds ratios (OR) with 95% confidence intervals (CI).

3 | RESULTS

3.1 | Descriptive characteristics

Of all 32 829 participants (mean age 15.4 years; 53% girls), 53% ($N = 17466$) engaged in leisure-time MVPA for at least 4 to 6 h a week, 26% for 2–3 h (N = 8523), 10% for 1 h ($N = 3330$), and 6% for 30 min ($N = 1864$). Approximately 5% ($N = 1646$) reported complete lack of participation in MVPA at their leisure-time. Adolescents with greater leisure-time MVPA had generally higher socioeconomic status, healthier weight, less detrimental health behaviors, and better sleep quality. Comprehensive characteristics by leisure-time MVPA groups are reported in Table 1.

Of the participants, 31% ($N = 10109$) reported spending <10 min a day on AST, 45% ($N = 14824$) 10–30 min, and 9% ($N = 2901$) more than 30 min. Compared to adolescents exclusively using non-active transportation modes (15%; $N = 4995$), girls and eighth graders were more likely to engage in AST. Differences in socioeconomic attributes, health behaviors, and health status indicators were prominent and mostly nonlinear among the AST groups. Comprehensive characteristics by daily AST are reported in Table 2.

Depression symptoms (40%; $N = 13254$) were the most prevalent mental health outcome among the cohort, followed by chronic stress symptoms (19%; $N = 6382$), moderate-to-severe anxiety (11%; $N = 3621$), and visits to school psychologist (7%; $N = 2435$). Mental health symptom occurrence was more frequent among girls than boys, ninth than eighth graders, and participants with lower socioeconomic status or more negative health behaviors, such as smoking, alcohol consumption, and cannabis use. Comprehensive characteristics by mental health outcomes are reported in Tables S1 and S2.

Compared with the analytical sample, the excluded participants (mean age 15.4 years; 58% boys) were somewhat more physically inactive. For example, 9% did not engage in leisure-time MVPA at all and 18% used only non-active transportation modes. Excluded participants also reported more depression (43%), chronic stress (21%), and anxiety symptoms (13%), as well as more visits to school psychologist (12%).

3.2 | Associations between leisure-time MVPA and mental health

We observed dose–response associations between leisure-time MVPA and mental health outcomes (Table 3). Compared to the non-active group, even 30 min of leisure MVPA was linked to 17% (OR 0.83, 95% CI 0.71–0.96) lower odds of chronic stress symptoms after multivariable adjustments. The odds were even lower for the most physically active adolescents (OR 0.49, 95% CI 0.43–0.56). Likewise, starting from 1 h to at least 7 h of weekly leisure-time MVPA, linear reductions in the odds of depression (from 22% to 48%) and moderate-to-severe anxiety (from 32% to 44%) symptoms were observed. For participants with at least 2–3 h of weekly leisure-time MVPA, the odds of school psychologist visits were 27% (OR 0.73, 95% CI 0.61–0.87) lower than for non-active participants. Similar to the other outcomes, the odds were the lowest among the most active group (OR 0.58, 95% CI 0.48–0.70).

Adjusting for subjective health status and sleep quality attenuated the associations, although majority of them remained significant. Weight status adjustments and excluding frequently bullied participants did not affect the findings (see Table S3).

3.3 | Associations between AST and mental health

After adjustments for sociodemographic and health behavior variables (see Table 4), we did not observe associations between low-to-moderate AST levels and mental health outcomes. Compared to the non-active transport group, high AST levels (more than 30 min a day) were associated with 19% (OR 1.19, 95% CI 1.07–1.31) and 33% (OR 1.33, 95% CI 1.12–1.58) higher odds of depression

TABLE 1 Characteristics of the analytical sample by weekly leisure-time moderate-to-vigorous physical activity.

Characteristics	Non-active N = 1646	30 min N = 1864	1 h N = 3330	2–3 h N = 8523	4–6 h N = 8932	7 h or more N = 8534
Sociodemographic						
School grade						
8	713 (43.3)	846 (45.4)	1615 (48.5)	4209 (48.5)	4460 (49.9)	4445 (52.1)
9	933 (56.7)	1018 (54.6)	1715 (51.5)	4314 (51.5)	4472 (50.1)	4089 (47.9)
Sex						
Boy	863 (52.4)	865 (46.4)	1553 (46.6)	3676 (43.1)	3929 (44.0)	4589 (53.8)
Girl	783 (47.6)	999 (53.6)	1777 (53.4)	4847 (56.9)	5003 (56.0)	3945 (46.2)
Household financial situation						
Very good	254 (15.4)	239 (12.8)	476 (14.3)	1360 (16.0)	1596 (17.9)	2059 (24.1)
Good	655 (39.8)	818 (43.9)	1567 (47.1)	4234 (49.7)	4483 (50.2)	4184 (49.0)
Fair	549 (33.4)	606 (32.5)	999 (30.0)	2329 (27.3)	2277 (25.5)	1866 (21.9)
Poor or very poor	188 (11.4)	201 (10.8)	288 (8.6)	600 (7.0)	576 (6.4)	425 (5.0)
Level of education (mother)						
Higher education	481 (29.2)	497 (26.7)	979 (29.4)	2951 (34.6)	3492 (39.1)	4116 (48.2)
Secondary education	974 (59.2)	1182 (63.4)	2048 (61.5)	5062 (59.4)	5018 (56.2)	4097 (48.0)
Primary education	191 (11.6)	185 (9.9)	303 (9.1)	510 (6.0)	422 (4.7)	321 (3.8)
Level of education (father)						
Higher education	422 (25.6)	409 (21.9)	858 (25.8)	2503 (29.4)	3042 (34.0)	3627 (42.5)
Secondary education	962 (58.5)	1179 (63.3)	2048 (61.5)	5212 (61.1)	5170 (57.9)	4349 (51.0)
Primary education	262 (15.9)	276 (14.8)	424 (12.7)	808 (9.5)	720 (8.1)	558 (6.5)
Health behavior						
Alcohol consumption						
Yes, once a week or more often	94 (5.7)	74 (4.0)	103 (3.1)	215 (2.5)	227 (2.6)	204 (2.4)
Yes, once or twice a month	261 (15.9)	339 (18.2)	526 (15.8)	1462 (17.2)	1502 (16.8)	1378 (16.1)
No, never or rarely	1291 (78.4)	1451 (77.8)	2701 (81.1)	6846 (80.3)	7203 (80.6)	6952 (81.5)
Smoking						
Yes, daily	245 (14.9)	262 (14.1)	338 (10.2)	689 (8.1)	474 (5.3)	324 (3.8)
Yes, occasionally	118 (7.2)	151 (8.1)	268 (8.0)	727 (8.5)	835 (9.4)	639 (7.5)
No	1283 (77.9)	1451 (77.8)	2724 (81.8)	7107 (83.4)	7623 (85.3)	7571 (88.7)
Snus use						
Yes, daily	66 (4.0)	34 (1.8)	71 (2.1)	159 (1.9)	215 (2.4)	359 (4.2)
Yes, occasionally	119 (7.2)	142 (7.6)	202 (6.1)	519 (6.1)	534 (6.0)	640 (7.5)
No	1461 (88.8)	1688 (90.6)	3057 (91.8)	7845 (92.0)	8183 (91.6)	7535 (88.3)
Electric cigarette use						
Yes, daily	58 (3.5)	49 (2.6)	65 (2.0)	108 (1.3)	109 (1.2)	111 (1.3)
Yes, occasionally	120 (7.3)	125 (6.7)	197 (5.9)	516 (6.0)	466 (5.2)	406 (4.8)
No	1468 (89.2)	1690 (90.7)	3068 (92.1)	7899 (92.7)	8357 (93.6)	8017 (93.9)
Cannabis use						
Yes, at least five times	80 (4.8)	66 (3.5)	82 (2.5)	165 (1.9)	148 (1.7)	148 (1.7)
Yes, one to four times	113 (6.9)	117 (6.3)	158 (4.7)	396 (4.7)	349 (3.9)	300 (3.5)
No, never	1453 (88.3)	1681 (90.2)	3090 (92.8)	7962 (93.4)	8435 (94.4)	8086 (94.8)

(Continues)

TABLE 1 (Continued)

Characteristics	Non-active N = 1646	30 min N = 1864	1 h N = 3330	2–3 h N = 8523	4–6 h N = 8932	7 h or more N = 8534
Adequate sleep						
Yes, almost always	318 (19.4)	308 (16.7)	582 (17.6)	1584 (18.7)	1718 (19.4)	1894 (22.5)
Yes, often	660 (40.3)	883 (48.0)	1707 (51.5)	4486 (53.0)	4725 (53.3)	4503 (53.3)
Rarely, never, or cannot tell	659 (40.3)	649 (35.3)	1024 (30.9)	2392 (28.3)	2422 (27.3)	2037 (24.2)
Health status						
Subjective health status						
Excellent	333 (20.3)	369 (19.9)	740 (22.4)	2334 (27.6)	3257 (36.7)	4488 (53.1)
Above average	740 (45.2)	959 (51.7)	1843 (55.7)	4666 (55.1)	4547 (51.2)	3303 (39.1)
Average	445 (27.2)	441 (23.7)	622 (18.8)	1285 (15.2)	950 (10.7)	547 (6.5)
Poor or very poor	120 (7.3)	87 (4.7)	104 (3.1)	176 (2.1)	122 (1.4)	106 (1.3)
Weight status						
Normal weight or underweight	1162 (80.3)	1333 (80.4)	2411 (81.0)	6439 (82.4)	7137 (85.8)	7215 (89.7)
Overweight or obese	285 (19.7)	324 (19.6)	565 (19.0)	1375 (17.6)	1183 (14.2)	830 (10.3)
Physical activity						
Active school transport (daily)						
Non-active	351 (21.3)	305 (16.4)	549 (16.5)	1276 (15.0)	1307 (14.6)	1207 (14.1)
<10 min	524 (31.9)	627 (33.6)	1036 (31.1)	2535 (29.7)	2748 (30.8)	2639 (30.9)
10–30 min	629 (38.2)	784 (42.1)	1457 (43.8)	3926 (46.1)	4081 (45.7)	3947 (46.3)
>30 min	142 (8.6)	148 (7.9)	288 (8.6)	786 (9.2)	796 (8.9)	741 (8.7)

Note: Values are numbers (percentages). All variables globally significantly different between leisure-time activity groups at $p < 0.001$.

symptoms and school psychologist visits, respectively. Adjusting for health status indicators and excluding frequently bullied adolescents did not affect the effect estimates (see Table S4). Overall, trend analyses indicated a negative relationship between AST and mental health.

4 | DISCUSSION

We studied the associations of leisure-time moderate-to-vigorous physical activity and active school transport with mental health outcomes among Finnish adolescents using nationwide data from the School Health Promotion study. Leisure-time MVPA was related to better mental health in a dose–response manner. No associations between low-to-moderate AST levels and mental health were observed. However, the most active commuters had more depression symptoms and school psychologist visits.

Our results for leisure-time MVPA are generally in line with the literature. For example, two recent umbrella reviews have suggested that there is, at a minimum, partial evidence for a causal association between PA and depression.[5,6] However, the number of high-quality studies using stress and anxiety as outcomes is limited, preventing comprehensive analyses of causality.[5,6] We found similar effect sizes of leisure-time MVPA on all mental health outcomes with various time frames. Therefore, our findings may imply that leisure-time MVPA does not only protect against depression but also against other negative mental health symptoms and problems.

Only few studies have evaluated associations between AST and mental health. Our results are inconsistent with the previous findings from a study conducted in upper-middle- and high-income countries,[23] but consistent, to some extent, with a study conducted in Ireland.[24] However, both studies lacked essential covariate adjustments, including leisure-time PA. Other two contradicting observations from middle- and low-income countries might be explained by inadequate control for sociodemographic and cultural factors.[23,24] For example, these studies did not control for socioeconomic indicators, although a safe active transport infrastructure in lower-income countries may only be accessible to adolescents with higher social status and wellbeing. Furthermore, these studies did not adjust for health behaviors, such as substance use, which attenuated the association in our study.

Intensity difference between leisure-time MVPA and AST could be one explanatory factor for our findings.

TABLE 2 Characteristics of the analytical sample by daily active school transport.

Characteristics	Non-active N = 4995	<10 min N = 10109	10–30 min N = 14824	>30 min N = 2901
Sociodemographic				
School grade				
8	1342 (26.9)	5199 (51.4)	8139 (54.9)	1608 (55.4)
9	3653 (73.1)	4910 (48.6)	6685 (45.1)	1293 (44.6)
Sex				
Boy	2806 (56.2)	4961 (49.1)	6492 (43.8)	1216 (41.9)
Girl	2189 (43.8)	5148 (50.9)	8332 (56.2)	1685 (58.1)
Household financial situation				
Very good	1026 (20.5)	1859 (18.4)	2589 (17.5)	510 (17.6)
Good	2418 (48.4)	4890 (48.4)	7294 (49.2)	1339 (46.1)
Fair	1239 (24.8)	2662 (26.3)	3948 (26.5)	777 (26.8)
Poor or very poor	312 (6.3)	698 (6.9)	993 (6.7)	275 (9.5)
Level of education (mother)				
Higher education	1733 (34.7)	3650 (36.1)	5976 (40.3)	1157 (39.9)
Secondary education	2969 (59.4)	5751 (56.9)	8103 (54.7)	1558 (53.7)
Primary education	293 (5.9)	708 (7.0)	745 (5.0)	186 (6.4)
Level of education (father)				
Higher education	1388 (27.8)	3177 (31.4)	5283 (35.6)	1013 (34.9)
Secondary education	3090 (61.9)	5867 (58.1)	8328 (56.2)	1635 (56.4)
Primary education	517 (10.3)	1065 (10.5)	1213 (8.2)	253 (8.7)
Health behavior				
Alcohol consumption				
Yes, once a week or more often	241 (4.8)	284 (2.8)	312 (2.1)	80 (2.7)
Yes, once or twice a month	1306 (26.2)	1721 (17.0)	2056 (13.9)	385 (13.3)
No, never or rarely	3448 (69.0)	8104 (80.2)	12456 (84.0)	2436 (84.0)
Smoking				
Yes, daily	579 (11.6)	734 (7.2)	800 (5.4)	219 (7.6)
Yes, occasionally	617 (12.3)	836 (8.3)	1107 (7.5)	178 (6.1)
No	3799 (76.1)	8539 (84.5)	12917 (87.1)	2504 (86.3)
Snus use				
Yes, daily	267 (5.4)	290 (2.9)	294 (2.0)	53 (1.8)
Yes, occasionally	560 (11.2)	696 (6.9)	747 (5.0)	153 (5.3)
No	4168 (83.4)	9123 (90.2)	13783 (93.0)	2695 (92.9)
Electric cigarette use				
Yes, daily	149 (3.0)	142 (1.4)	160 (1.1)	49 (1.7)
Yes, occasionally	473 (9.5)	522 (5.5)	663 (4.5)	142 (4.9)
No	4373 (87.5)	9415 (93.1)	14001 (94.4)	2710 (93.4)
Cannabis use				
Yes, at least five times	139 (2.8)	222 (2.2)	260 (1.7)	68 (2.3)
Yes, one to four times	303 (6.1)	472 (4.7)	543 (3.7)	115 (4.0)
No, never	4553 (91.1)	9415 (93.1)	14021 (94.6)	2718 (93.7)

(Continues)

TABLE 2 (Continued)

Characteristics	Non-active N = 4995	<10 min N = 10 109	10–30 min N = 14 824	>30 min N = 2901
Adequate sleep				
Yes, almost always	939 (19.0)	2092 (20.9)	2801 (19.1)	572 (20.0)
Yes, often	2563 (51.7)	5195 (51.8)	7810 (53.1)	1396 (48.7)
Rarely, never, or cannot tell	1453 (29.3)	2740 (27.3)	4094 (27.8)	896 (31.3)
Health status				
Subjective health status				
Excellent	1722 (34.7)	3645 (36.4)	5205 (35.3)	949 (33.0)
Above average	2466 (49.6)	4878 (48.7)	7285 (49.5)	1429 (49.7)
Average	656 (13.2)	1277 (12.7)	1950 (13.2)	407 (14.2)
Poor or very poor	122 (2.5)	218 (2.2)	285 (2.0)	90 (3.1)
Weight status				
Normal weight or underweight	3803 (82.8)	7932 (85.1)	11 724 (85.7)	2238 (84.0)
Overweight or obese	791 (17.2)	1384 (14.9)	1962 (14.3)	425 (16.0)
Physical activity				
Leisure-time MVPA (weekly)				
Non-active	351 (7.0)	524 (5.2)	629 (4.3)	142 (4.9)
30 min	305 (6.1)	627 (6.2)	784 (5.3)	148 (5.1)
1 h	548 (11.0)	1036 (10.2)	1457 (9.8)	288 (9.9)
2–3 h	1276 (25.5)	2535 (25.1)	3926 (26.5)	786 (27.1)
4–6 h	1307 (26.2)	2748 (27.2)	4081 (27.5)	796 (27.4)
7 h or more	1207 (24.2)	2639 (26.1)	3947 (26.6)	741 (25.6)

Note: Values are numbers (percentages). All variables globally significantly different between active school transport groups at $p < 0.001$.
Abbreviation: MVPA, moderate-to-vigorous physical activity.

Previous limited research suggests that light-intensity PA, such as walking to school, may not affect mental health outcomes in children and adolescents.[30] Moreover, specifically high-intensity exercise has been reported to enhance serotonin (5-HT) system functioning[11] and elevate plasma endorphin,[12] which are both considered as "feel-good" hormones. On the contrary, intensity should not impact anti-inflammatory effects of PA,[31] which are significant predictors of depression incidence even among youth.[32]

Psychosocial and motivational determinants also differ between leisure-time MVPA and AST. For example, leisure PA can enhance self-efficacy by exposing adolescents to mastery experiences.[33] AST, however, can be considered as a simple, unchallenging activity, which may not offer similar opportunities for able-bodied young people. Furthermore, individuals choose to engage in leisure-time PA, often because of enjoyment,[34] when AST can be a mandatory task for most youth. Therefore, behavior under controlled motivation, such as AST, may not yield positive mental health outcomes of the same magnitude as intrinsically motivated engagement in leisure PA.[35]

We also observed that high AST levels were associated with a greater occurrence of depression symptoms and school psychologist visits compared to non-active commuting. Similarly, longer commuting distances by any travel mode have been associated with detrimental health outcomes, such as overweight and disturbed sleep.[36] This does not explain our results that remained unchanged after adjustments for distance to school, weight status, and sleep quality. Although observational designs, such as ours, are susceptible to residual confounding, contextual factors may also explain this unexpected finding. As mentioned, adolescents may not have a variety of choices in terms of travel modes. If walking to school is the only applicable option, especially for longer distances, AST may become an everyday mental burden for an individual.[37]

The main strengths of our study are the population-based design and a large, nationwide cohort. We were also able to perform extensive adjustments for various sociodemographic, health, and behavioral covariates. Yet, as in any cross-sectional study, the observed associations could have been biased by reverse causality. Our findings for leisure-time MVPA are supported by a considerable body of experimental evidence, nonetheless.[5,6]

Self-reported AST and leisure-time MVPA can also lead to overestimated PA frequencies.[38] However, the

TABLE 3 Adjusted odds ratios with 95% confidence intervals (CI) for mental health outcomes by weekly leisure-time moderate-to-vigorous physical activity (MVPA).

Mental health outcome by weekly leisure-time MVPA	Number of cases (%)	Adjusted odds ratio[a] (95% CI)	*p* for trend
Chronic stress symptoms (past 6 months)			
Non-active	513 (31.2)	1 (reference)	<0.01
30 min	522 (28.0)	0.83 (0.71–0.96)	
1 h	719 (21.6)	0.62 (0.54–0.72)	
2–3 h	1750 (20.5)	0.59 (0.52–0.67)	
4–6 h	1584 (17.7)	0.51 (0.45–0.58)	
7 h or more	1294 (15.2)	0.49 (0.43–0.56)	
Depression symptoms (past month)			
Non-active	867 (52.7)	1 (reference)	<0.01
30 min	1004 (53.9)	1.01 (0.88–1.17)	
1 h	1540 (46.3)	0.78 (0.69–0.89)	
2–3 h	3591 (42.1)	0.66 (0.59–0.74)	
4–6 h	3457 (38.7)	0.59 (0.53–0.66)	
7 h or more	2795 (32.8)	0.52 (0.46–0.58)	
Moderate-to-severe anxiety symptoms (past 2 weeks)			
Non-active	293 (17.8)	1 (reference)	<0.01
30 min	314 (16.9)	0.89 (0.74–1.07)	
1 h	418 (12.6)	0.68 (0.57–0.81)	
2–3 h	973 (11.4)	0.61 (0.52–0.71)	
4–6 h	894 (10.0)	0.55 (0.47–0.65)	
7 h or more	729 (8.5)	0.56 (0.48–0.66)	
Visit to school psychologist (past school year)			
Non-active	198 (12.0)	1 (reference)	<0.01
30 min	210 (11.3)	0.92 (0.75–1.14)	
1 h	305 (9.2)	0.83 (0.68–1.01)	
2–3 h	673 (7.9)	0.73 (0.61–0.87)	
4–6 h	585 (6.6)	0.64 (0.53–0.76)	
7 h or more	464 (5.4)	0.58 (0.48–0.70)	

[a]Adjusted for school grade, sex, country of birth, household financial situation, parents' education level, school distance, smoking, snus use, electric cigarette use, cannabis use, alcohol consumption, and daily active school transport.

nature of AST, that is, typically consistent behavior over days and weeks, is likely to decrease misclassification bias. Furthermore, non-differential misclassification for leisure-time MVPA would be expected to bias results toward the null, rather than indicate stronger associations.[39] Moreover, we were unable to distinguish AST modes between walking and cycling. As bicycle commuting seems to be associated with greater health benefits than other travel modes,[40] our findings may not imply null effects for higher-intensity active transport modes.

Further limitations include non-validated measures for leisure-time MVPA, AST, and stress. All SHP study questions face preliminary tests in pilot schools,[27] however, reducing the risk of measurement error. In addition, 17% of the participants from the original sample were excluded due to implausible answers and complete-case approach to missing data. The excluded adolescents were slightly more often boys and, to some extent, more physically inactive and more likely to report negative mental health symptoms than those in the analytical sample. Therefore, girls might be overrepresented in our study and "healthy volunteer" selection bias cannot be completely ruled out.

5 | PERSPECTIVE

This study provides further evidence of a positive association between leisure-time MVPA and mental health. The findings emphasize the importance of providing

TABLE 4 Adjusted odds ratios with 95% confidence intervals (CI) for mental health outcomes by daily active school transport.

Mental health outcome by daily AST	Number of cases (%)	Adjusted odds ratio[a] (95% CI)	p for trend
Chronic stress symptoms (past 6 months)			
Non-active	997 (20.0)	1 (reference)	0.0477
<10 min	1906 (18.9)	0.93 (0.84–1.02)	
10–30 min	2850 (19.2)	1.00 (0.91–1.09)	
>30 min	629 (21.7)	1.11 (0.98–1.25)	
Depression symptoms (past month)			
Non-active	2014 (40.3)	1 (reference)	<0.01
<10 min	4031 (39.9)	1.01 (0.94–1.10)	
10–30 min	5920 (39.9)	1.03 (0.96–1.11)	
>30 min	1289 (44.4)	1.19 (1.07–1.31)	
Moderate-to-severe anxiety symptoms (past 2 weeks)			
Non-active	557 (11.2)	1 (reference)	0.0516
<10 min	1084 (10.7)	1.00 (0.88–1.13)	
10–30 min	1605 (10.8)	1.02 (0.91–1.14)	
>30 min	375 (12.9)	1.16 (0.99–1.35)	
Visit to school psychologist (past school year)			
Non-active	375 (7.5)	1 (reference)	<0.01
<10 min	751 (7.4)	1.03 (0.89–1.18)	
10–30 min	1043 (7.0)	1.05 (0.92–1.20)	
>30 min	266 (9.2)	1.33 (1.12–1.58)	

Abbreviation: AST, active school transport.

[a]Adjusted for school grade, sex, country of birth, household financial situation, parents' education level, school distance, smoking, snus use, electric cigarette use, cannabis use, alcohol consumption, and weekly leisure-time moderate-to-vigorous physical activity.

high-quality, enjoyable leisure PA opportunities for all youth—even the small doses can make a difference. In contrast, evidence for mental health outcomes of AST remain inconclusive. Despite this, successfully promoted walking or cycling to school can improve physical fitness and cardiometabolic health among adolescents.[18–20]

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from Findata - Finnish Social and Health Data Permit Authority. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from https://findata.fi/en/ with the permission of Findata - Finnish Social and Health Data Permit Authority.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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