Paper II

The relationship between multisite musculoskeletal pain in adolescence and mental health disorders in young adulthood – The NAAHS cohort study.

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ABSTRACT

Background

Musculoskeletal pain is a widespread problem, not least in adolescence, and is related to mental health problems. The prediction of later mental health disorders from adolescent musculoskeletal pain has been sparsely investigated. This study explores the association between adolescent multisite musculoskeletal pain and mental health disorders in young adulthood.

Methods

Data were obtained from a linkage between the Norwegian Patient Registry (2008–12) and the Norwegian Arctic Adolescent Health Study, a school-based survey responded by 3,987 (70%) out of all 5,877 10th grade students in North Norway (2003–05). Musculoskeletal pain was measured by the number of musculoskeletal pain sites. Multivariable logistic regression was used to explore the association with later mental healthcare use and disorders.

Results

Multisite adolescent musculoskeletal pain was significantly associated with an increase in mental healthcare use and mental health disorders in young adulthood. The relationship was stronger for anxiety and mood disorders, in both genders. Overall, the association between musculoskeletal pain and later mental health problems was mediated by adolescent psychosocial and mental health problems, not by physical or sedentary activity. However, when examining the different mental health disorders we found musculoskeletal pain to be significantly associated with anxiety disorders, and showing a strong trend in mood disorders, when adjusted for the adolescent factors.

Conclusion

Physicians should be aware that multisite adolescent pain is associated with mental health problems in adolescence, and that these adolescents are at increased risk of mental health disorders in young adulthood. As youth troubled by mental health problems commonly present physical complaints it is important to examine for psychosocial problems in order to offer early interventions.

Strengths and limitations of this study

- The main strength of this study is the linkage of a large population-based study in adolescents (2003–05) to the Norwegian Patient Registry (2008–12).
- This study linkage was used to explore the association between multisite musculoskeletal pain in adolescence and mental health disorders in young adulthood.
- Psychosomatic problems are complex, and with only one cross-sectional study linked to the patient registry there might be other factors influencing the associations found in this study.
- The adolescent population study relied on self-reports with the risk of information bias.
- The Norwegian Patient Registry had few logical errors, but it was not possible to differentiate between primary and secondary diagnoses of mental health disorders.

INTRODUCTION

Musculoskeletal pains are prevalent in adolescents,[1–3] with an increasing trend in recent decades[4,5]. Pain complaints in youth tend to persist into adulthood,[6,7] and multisite pain is more associated with psychosocial problems than single-site pain is[2,3,8,9]. Pain in adolescents has been shown to be associated with psychosocial and mental health problems in both cross-sectional[3,10,11] and longitudinal[12–17] studies. Longitudinal studies in adolescents have shown overall a bidirectional relationship between pain and mental health problems[12–17]. Except for the recent findings presented by Shanahan et al.[16] most of the studies are of a shorter timeframe[18] and do not examine this relationship beyond adolescence.

Multiple physical complaints are strongly associated with mental health disorders, especially mood and anxiety disorders, influencing the clinical picture of these disorders[11,19–22]. Comorbid physical complaints are a common way of presenting mental health problems in a clinical setting,[20–22] and is an important sign in the early detection of mental health problems[19,22,23]. Shanahan et. al. found pain in children and adolescents to be predictive of mood and anxiety disorder in young adulthood, and youth with persistent pain were at increased risk of later mental health problems[16]. Adolescents are generally a physically healthy group, and the influence of potential adolescent mediators on the relationship between adolescent pain and adult mental health problems needs to be examined further[16].

Adolescence and young adulthood can be a challenging period and the age of mental illness onset[24,25]. Chronic pain and mental health disorders are two major public health issues. They are costly to young people's[2,26,27] and their families' quality of life,[27,28] and to society[24,26,29,30]. Therefore early detection and interventions are of major importance. In order to investigate the relationship between adolescent musculoskeletal pain and mental health problems in young adulthood we linked the Norwegian Patient Registry[31] section on specialized mental healthcare with a population-based study, the Norwegian Arctic Adolescents Health Study[32].

The aim of this study was to investigate whether multisite musculoskeletal pain in adolescents was associated with mental health problems in young adulthood in an unselected community sample. Secondly, to determine the importance of musculoskeletal pain in relation to later mental healthcare use and mental health disorders, when adjusting for adolescent psychosocial factors. Thirdly, we wanted to explore differences in the prediction of different mental health disorders.

METHODS

Study design

The Norwegian Arctic Adolescent Health Study (NAAHS)[32] was conducted among 10th graders (15–16-year-olds) in nearly all junior high schools (292 out of 293) in the three northernmost counties in Norway, in 2003–05. The questionnaires were administered in classroom settings by project staff, and completed during two school hours. Students who

were absent completed the questionnaire at a later date. There were no specific exclusion criteria in this study.

The participants from the NAAHS were linked to the Norwegian Patient Registry (NPR),[31] a detailed registry from 2008 that includes personal identification of specialized healthcare utilization and diagnosis. We used available data from specialized mental healthcare from 2008 through 2012 when the participants were 18–20 to 23–25 years of age.

Ethics

The students and their parents were given written information about the study, and the students provided written consent.

The Norwegian Data Inspectorate and the school authorities approved the NAAHS. The Regional Medical Ethical Committee approved the NAAHS and the registry linkage. The Norwegian Institute of Public Health and Statistics Norway carried out the linkage.

Sample

In total, 4,881 out of 5,877 (83%) invited students responded to the NAAHS, and 3,987 (82%) consented to a future registry linkage, resulting in a 70% sample of all 10th grade students in Northern Norway. The registry sample consisted of 49.9% females and 9.2% indigenous Sami.

In order to explore the representativeness of the proportion of mental healthcare users in our sample (30% nonresponders), the NPR calculated the total number of mental healthcare users in Northern Norway with the same age and registration period as the study sample. The total number of patients (n=850) was compared to the total population data from Statistics Norway public database (n=5,715) to give and approximate cumulative prevalence of mental health care users in the total population, which we compared our sample to.

The Norwegian Arctic Adolescent Health Study

Physical factors

Musculoskeletal pain was measured by "yes/no" answers to the question: "*During the last 12 months have you often been troubled by pain in the head, neck/shoulder, arms/legs/knees, abdomen or back?*" Abdominal pain was excluded due to the potential confusion with menstrual pain[3], resulting in 0–4 musculoskeletal pain sites.

Pain-related functional impairment was present if the participants reported reduced activity during leisure time due to pain (yes/no).

Physical activity was measured by the question: *"How many hours per week do you spend on physical activity, to an extent that makes you sweat and/or out of breath?"* Possible answers: 0, 1–4, 5–7 and ≥8 hours per week[33].

Sedentary activity was measured by the question: "After school hours: How many hours per school day (Monday to Friday) do you spend in front of a TV, video and/or PC?" Possible answers: <1 hour, 1–2, 3–5 or >5 hours.

Psychosocial supportive factors

Adolescent pain and mental health problems

Resilience was measured by a five-item version (α=0.77) of the *General perceived self-efficacy scale*[34] with higher scores indicating higher resilience. Responses were scored on a four-point Likert scale from "completely wrong" to "completely right."

Parental involvement was measured by a four-item version of the *Parental Involvement Scale* (α=0.78)[3,35].

Parental support (α=0.88) was measured by five statements on family attachment, being valued and taken seriously, and receiving help when needed[3].

Peer support (α=0.84) was measured by four statements on peer attachment and support, being valued, and receiving help when needed[3].

Parental involvement, *parental* and *peer support* were scored on a four-point Likert scale from "completely agree" to "completely disagree."

Psychosocial life stressor factors

School-related stress (α=0.66) was measured by the following four experiences: work pressure, pressure to succeed, concentration difficulties, and understanding the teacher[3]. Responses were scored on a three-point Likert scale from "no" to "yes, often."

Negative life events (α=0.55) such as parental drug problems, bullying and assault were measured by 12 dichotomized questions previously described by Eckhoff and Kvernmo[3].

Psychosocial mental health factors

Mental health was examined by *anxiety/depression* symptoms measured by the Hopkins Symptom Checklist 10-item version (HSCL-10)[36]. The HSCL-10 (α=0.87) measures symptoms in the previous week. Psychometrics has been validated among subjects aged 16–24 years[37] with a cutoff of 1.85 indicating a presence of emotional distress.

Help seeking

The *use of a psychiatrist/psychologist* during the previous year was dichotomized (yes/no) from the responses "no," "1–3 times", and "4 or more times".

Sociodemographic factors

Parental education: Parents' highest education was obtained from Statistics Norway's education registry, registered when the participants were 15–16 years old. Parental education was categorized from "lower secondary" (≤10th grade), "upper secondary" (≤13th grade), "lower university degree" (up to 5 years) to "higher university degree" (more than 4 years)[38].

Family income: Adolescents reported their family's economic situation compared to other families on a four-point scale from "not well off" to "very well off."

Sami ethnicity was measured by participants having one or more of the following factors: Sami parentage and Sami language competence in parents, grandparents and the participants, and Sami ethnic self-labeling.

Mental healthcare registry

Mental healthcare users consisted of participants found in the specialized psychiatric patient registry, including use of *public psychiatric healthcare* and *private specialists*. We constructed an ordinal variable of "not a patient," "outpatient only" and "inpatient."

The number of *outpatient contacts* and *inpatient admissions*, and the sum of all *outpatient treatment hours* and *inpatient treatment days* were calculated.

Mental health disorders: Each participant's primary and secondary diagnoses were organized according to the main chapters in the ICD-10[39]. We used a classical model for psychiatric diagnoses to achieve theoretically constructed groups of reasonable size. We recorded whether the participants had received a diagnosis from any of the five diagnostic groups: substance use disorders (F10–19), psychotic (F20–29), mood (F30–39), anxiety (F40–49), developmental and behavioral disorders (F50–98), and undiagnosed. We included both primary and secondary diagnoses due to an evident difference in diagnostic coding practice, making it difficult to pick out the primary disorder in patients with several diagnoses. Patients with two or more diagnoses from the ICD-10 main chapters were: two=102, three=42, four=32 and five diagnostic chapters=22.

Data analysis

The means of the explanatory factors were examined in the registry sample, the original NAAHS sample[3] and in the missing sample. We found no significant difference between the registry sample and the missing sample except for a slightly lower mean of negative life events in the missing sample (Supplement Table S1). The missing sample was not worse off. Chi-square tests and one-way ANOVA were used for the univariate analyses. Anxiety/depression (HSCL-10) was handled continuously in the multivariable analyses.

Initially we examined the prediction of later mental healthcare by ordinal and multinomial regression. However, we found no linearity between the constructed ordinal groups. The main statistical difference was between the users and nonusers of mental healthcare, and not between the user groups (outpatient only vs. inpatients). We therefore present multivariable logistic regression results on mental healthcare users vs. no mental healthcare users.

Hierarchical logistic regression was used for the multivariable analysis for later mental health care use (Table 3). In Step 1 the sociodemographic (Model 1), physical factors (Model 2: musculoskeletal pain, adjusted for sedentary and physical activity) and psychosocial factors (Model 3, 4 and 5) were analyzed grouped together in models based on their respective characteristic groups. Insignificant factors were not included in the next steps in order to simplify the models. In Step 2, the significant sociodemographic factors from Model 1 were added as adjustments for musculoskeletal pain alongside physical activity (Model 6). The significant psychosocial factors from Step 1 were analyzed together in Model 7. In the final model, the significant psychosocial factors from the second step (Model 7) were added to the adjustment of adolescent musculoskeletal pain.

Hierarchical logistic regression was used for the multivariable analyses on the diagnostic groups of mental health disorders (Table 4), following the same model building approach as described above. However, only the significant factors from Step 1 in the mental healthcare use model were examined in order to simplify the models. In addition, musculoskeletal pain, physical activity and the sociodemographic factors were included in the

final model regardless of if they were found insignificant in Step 1 and 2 (Model 1, 2 and 6), while insignificant psychosocial factors from Model 7 were excluded.

All analyses were conducted with SPSS 21 (IBM software). The statistical significance level was set at .05.

RESULTS

In our sample, 21.3% reported two, 13.3% three and 8.9% four musculoskeletal pain sites (Table 2). The proportion of mental healthcare users was 13.6% (59.5% females) (Table 1), in comparison to 14.9% (850 out of 5,715) in the total population age cohort.

Table 1 Adult mental healthcare use, mental health disorders and treatment in a cohort of adolescents, registry-based data[‡]

Factors (%/mean)	Females	Males	Total	χ2 / F-ratio
Total sample (%):	n=1991	n=1996	n=3987	
Mental healthcare users	16.2	11.0	13.6	$22.48^{p<.001}$
Inpatient	3.0	3.4	3.2	$0.28^{p=.598}$
Mental health disorders (%):				
Substance use	0.9	2.3	1.6	$11.51^{p=.001}$
Psychotic	0.7	0.8	0.7	$0.03^{p=.855}$
Mood	5.5	2.8	4.1	$17.23^{p<.001}$
Anxiety	6.7	3.4	5.0	$23.00^{p<.001}$
Developmental and behavioral	4.2	2.4	3.3	$9.83^{p=.002}$
Undiagnosed	3.5	3.0	3.2	$0.53^{p=.465}$
Mental healthcare users (%/mean):	n=323	n=220	n=543	
Public mental healthcare (%)	93.8	95.5	94.5	$0.40^{p=.527}$
Private specialist (%)	16.7	9.5	13.8	$5.07^{p=.024}$
Inpatient (%)	18.6	30.5	23.4	$9.65^{p=.002}$
Total outpatient contacts (M)	27.54 (60.83)	22.03 (54.56)	25.31 (58.38)	$1.17^{p=.281}$
Total outpatient hours (M)	31.53 (83.79)	21.31 (63.59)	27.39 (76.35)	$2.35^{p=.126}$
Total inpatient admissions (M)	0.61 (2.25)	0.74 (1.59)	0.66 (2.01)	$0.54^{p=.461}$
Total inpatient days (M)	17.00 (70.36)	32.82 (100.98)	23.41 (84.39)	$4.63^{p=.032}$

Note: Statistical analyses: Chi-square analysis and one-way ANOVA.
[‡]Patient data from the Norwegian Patient Registry.

A calculated approximation of mental healthcare users in our missing sample was 17.8% (307 out of 1,728).

Females reported more musculoskeletal pain (Table 2), had more mental healthcare outpatient contacts and total treatment hours, while males had more inpatient admissions and almost double the number of inpatient days (Table 1). Anxiety and mood disorders were more prevalent, while 23.8% were undiagnosed. Few of the undiagnosed (n=9) were at risk of remaining undiagnosed due to contact at the end of the registration period. This group had less outpatient treatment (mean=5.25 hours) than the other diagnostic groups (mean=36.46–149.26 hours).

There was a significantly higher proportion of adult mental healthcare users (Figure 1) and increased mental healthcare treatment in participants reporting two or more musculoskeletal pain sites in adolescence, even stratified by adolescent anxiety/depression

and regardless of pain-related functional impairment (Table 2). A higher proportion of mental healthcare users were found in the participants reporting pain-related functional impairment, 17.7% compared to 12.2% in the nonimpaired (χ^2 (1, n=2900)=16.22, p<.001). The association with adolescent musculoskeletal pain was stronger in anxiety and mood disorders (Figure 1 and Table 2).

Table 2 The number of adolescent musculoskeletal pain sites, by gender, and the association with mental healthcare use[‡], mental healthcare treatment and mental health disorders in young adulthood

Factors (n/%/mean)	n	0	1	2	3	4	χ^2 / F-ratio
				Number of adolescent musculoskeletal pain sites			
Pain by gender:							$121.42^{p<.001}$
Females (n)	1843	n=395	n=494	n=433	n=314	n=207	
Females (%)		(21.4)	(26.8)	(23.5)	(17.0)	(11.2)	
Males (n)	1877	n=638	n=576	N=359	n=181	n=123	
Males (%)		(34.0)	(30.7)	(19.1)	(9.6)	(6.6)	
Mental healthcare users (%):							
Females	1843	11.1	11.3	17.3	19.7	24.2	$27.28^{p<.001}$
Males	1877	9.2	9.5	9.2	18.8	17.9	$13.32^{p<.001}$
Mental healthcare treatment (%/M):							
Total outpatient hours (M)	3720	2.84	2.23	4.03	4.69	8.66	$3.19^{p=.013}$
Inpatients (%)	3720	2.0	2.8	2.8	4.0	7.3	$18.71^{p<.001}$
Total inpatient days (M)	3720	3.08	3.11	1.36	3.71	5.97	$1.36^{p=.247}$
Mental health disorders (%):							
Substance use	3720	1.3	1.4	1.3	1.8	3.3	$4.77^{p=.029}$
Psychotic	3720	0.7	0.7	0.4	0.8	0.9	$0.43^{p=.835}$
Mood	3720	2.5	2.7	4.8	6.5	7.9	$29.96^{p<.001}$
Females	1843	3.3	2.8	7.2	8.0	8.7	$16.77^{p<.001}$
Males	1877	2.0	2.6	1.9	3.9	6.5	$5.65^{p=.017}$
Anxiety	3720	2.6	3.6	5.3	8.3	10.0	$44.95^{p<.001}$
Females	1843	3.3	4.5	7.2	8.3	11.6	$20.68^{p<.001}$
Males	1877	2.2	2.8	3.1	8.3	7.3	$16.17^{p<.001}$
Developmental and behavioral	3720	3.0	1.9	3.0	4.6	6.7	$12.85^{p<.001}$
Females	1843	3.8	2.4	3.7	5.7	7.2	$6.94^{p=.008}$
Males	1877	2.5	1.4	2.2	2.8	5.7	$2.47^{p=.116}$
Undiagnosed	3720	2.8	2.5	2.7	4.8	3.6	$3.06^{p=.080}$
Females	1843	2.3	2.6	3.2	4.8	4.3	$4.21^{p=.040}$
Males	1877	3.1	2.4	1.9	5.0	2.4	$0.02^{p=.886}$
Adolescent anxiety/depression symptoms (%):							
Yes:	679						
Mental healthcare users	156	17.6	16.4	20.7	25.3	30.3	$8.84^{p=.003}$
Inpatients	37	2.7	4.5	5.2	5.4	7.7	$2.54^{p=.111}$
No:	2967						
Mental healthcare users	325	9.6	9.6	11.4	16.1	14.6	$11.06^{p=.001}$
Inpatients	78	2.0	2.5	2.1	3.4	6.7	$7.36^{p=.007}$
Adolescent pain-related functional impairment (%):							
Yes:	1059						
Mental healthcare users	178	0	11.2	15.9	18.8	25.4	$12.78^{p<.001}$
Inpatients	36	0	1.6	3.5	3.2	6.5	$4.04^{p=.044}$
No:	1650						
Mental healthcare users	200	7.2	10.3	12.4	20.1	14.6	$15.08^{p<.001}$
Inpatients	55	1.4	3.3	2.6	4.5	7.3	$6.55^{p=.010}$

Adolescent pain and mental health problems

Note: Statistical analyses: Chi-square analysis (Linear-by-Linear Association) and one-way ANOVA test for trend. Stratified analyses on gender, adolescent anxiety/depression symptoms and adolescent pain-related functional impairment.
‡Patient data from the Norwegian Patient Registry.

Table 3 shows the multivariable analysis for the prediction of mental healthcare use in young adulthood, with an 8.1% explained variance for the final model.

Table 3 The association between adolescent musculoskeletal pain and mental healthcare use[‡] in young adulthood, adjusted for adolescent sociodemographic, physical and psychosocial factors

Adolescent factors	n	Mental healthcare use in young adulthood Odds ratio (95% CI) / R^2
Step 1:		
Model 1 – Sociodemographic:	3583	$R^2 = .026$
Female gender		$1.47\ (1.21–1.79)^{p<.001}$
Sami		$0.86\ (0.61–1.20)^{p=.372}$
Higher parental education		$0.89\ (0.78–1.00)^{p=.051}$
Family income		$0.68\ (0.59–0.78)^{p<.001}$
Model 2 – Physical:	3602	$R^2 = .041$
Musculoskeletal pain		$1.27\ (1.18–1.37)^{p<.001}$
Sedentary activity		$0.99\ (0.89–1.11)^{p=.909}$
Physical activity		$0.72\ (0.64–0.80)^{p<.001}$
Psychosocial factors:		
Model 3 – Supportive:	3790	$R^2 = .037$
Resilience		$0.91\ (0.88–0.94)^{p<.001}$
Parental involvement		$1.02\ (0.98–1.07)^{p=.320}$
Parental support		$1.07\ (1.04–1.11)^{p<.001}$
Peer support		$1.05\ (0.99–1.09)^{p=.053}$
Model 4 – Life stressors:	3703	$R^2 = .046$
School-related stress		$1.18\ (1.12–1.24)^{p<.001}$
Negative life events		$1.14\ (1.08–1.20)^{p<.001}$
Model 5 – Mental health:	3876	$R^2 = .060$
Anxiety/depression		$2.51\ (2.15–2.93)^{p<.001}$
Step 2:		
Model 6 (1+2) –	3572	$R^2 = .058$
Sociodemographic and physical:		
Female gender		$1.25\ (1.02–1.53)^{p=.036}$
Family income		$0.68\ (0.59–0.79)^{p<.001}$
Musculoskeletal pain		$1.24\ (1.15–1.34)^{p<.001}$
Physical activity		$0.75\ (0.67–0.84)^{p<.001}$
Model 7 (3+4+5) – Psychosocial:	3578	$R^2 = .066$
Resilience		$0.96\ (0.92–0.99)^{p=.026}$
Parental support		$1.02\ (0.99–1.06)^{p=.182}$
School-related stress		$1.10\ (1.04–1.17)^{p=.001}$
Negative life events		$1.07\ (1.01–1.13)^{p=.029}$
Anxiety/depression		$1.64\ (1.33–2.02)^{p<.001}$
Step 3/Final model[§] **(Model 6+7):**	3302	$R^2 = .081$
Female gender		$1.01\ (0.80–1.27)^{p=.965}$
Family income		$0.76\ (0.65–0.90)^{p=.001}$
Musculoskeletal pain		$1.05\ (0.96–1.15)^{p=.329}$
Physical activity		$0.79\ (0.69–0.89)^{p<.001}$
Resilience		$0.98\ (0.94–1.02)^{p=.326}$
School-related stress		$1.07\ (1.01–1.14)^{p=.024}$
Negative life events		$1.06\ (0.99–1.13)^{p=.055}$
Anxiety/depression		$1.63\ (1.29–2.07)^{p<.001}$

Note: Statistical analyses: Hierarchical logistic regression.
[‡]Patient data from the Norwegian Patient Registry.
[§]Bonferroni adjusted significance level .0063 for the final model.

Adolescent anxiety/depression symptoms was the strongest predictor followed by low family income, low physical activity and school-related stress. Musculoskeletal pain remained significant in the second step when adjusted for physical activity, gender and family income. However, when we adjusted for psychosocial factors in the final model, then musculoskeletal pain was no longer significantly associated with mental health care use in young adulthood. Sami ethnicity was not significant (Table 3).

Table 4 presents the multivariable analyses for the included mental health disorders.

Table 4 The association between adolescent musculoskeletal pain and mental health disorders[‡] in young adulthood, adjusted for adolescent sociodemographic, physical and psychosocial factors

Adolescent factors	n	Mood n=165	Anxiety n=201	Developmental and behavioral n=130	Undiagnosed n=129
		Odds ratio (95% CI) / R^2			
Step 1:					
Model 1 – Sociodemographic:	3918	$R^2 = .032$	$R^2 = .034$	$R^2 = .024$	$R^2 = .002$
Female gender		1.88 (1.35–2.61)[p<.001]	2.04 (1.50–2.77)[p<.001]	1.74 (1.20–2.53)[p=.003]	1.12 (0.78–1.60)[p=.546]
Family income		0.60 (0.47–0.75)[p<.001]	0.63 (0.51–0.78)[p<.001]	0.62 (0.48–0.80)[p<.001]	0.84 (0.64–1.09)[p=.190]
Model 2 – Physical:	3618	$R^2 = .062$	$R^2 = .043$	$R^2 = .022$	$R^2 = .008$
Musculoskeletal pain		1.36 (1.20–1.54)[p<.001]	1.43 (1.28–1.61)[p<.001]	1.29 (1.12–1.49)[p<.001]	1.14 (0.98–1.31)[p=.084]
Physical activity		0.54 (0.44–0.67)[p<.001]	0.75 (0.63–0.90)[p=.001]	0.78 (0.63–0.97)[p=.022]	0.81 (0.65–1.00)[p=.051]
Psychosocial factors: Model 3 – Supportive:	3892	$R^2 = .016$	$R^2 = .029$	$R^2 = .024$	$R^2 = .003$
Resilience		0.88 (0.83–0.93)[p<.001]	0.85 (0.81–0.89)[p<.001]	0.85 (0.80–0.91)[p<.001]	0.95 (0.89–1.01)[p=.111]
Model 4 – Life stressors:	3703	$R^2 = .033$	$R^2 = .032$	$R^2 = .025$	$R^2 = .025$
School-related stress		1.24 (1.14–1.35)[p<.001]	1.22 (1.13–1.31)[p<.001]	1.18 (1.07–1.31)[p=.001]	1.14 (1.04–1.25)[p=.008]
Negative life events		1.07 (0.97–1.17)[p=.169]	1.08 (0.99–1.17)[p=.066]	1.11 (1.00–1.23)[p=.044]	1.15 (1.04–1.27)[p=.005]
Model 5 – Mental health:	3876	$R^2 = .050$	$R^2 = .062$	$R^2 = .033$	$R^2 = .010$
Anxiety/depression		2.62 (2.07–3.31)[p<.001]	2.81 (2.28–3.48)[p<.001]	2.27 (1.75–2.95)[p<.001]	1.64 (1.23–2.20)[p=.001]
Step 2:					
Model 6 (1+2) – Sociodemographic and physical:	3572	$R^2 = .082$	$R^2 = .058$	$R^2 = .038$	$R^2 = .011$
Female gender		1.63 (1.13–2.36)[p=.009]	1.51 (1.09–2.11)[p=.015]	1.66 (1.10–2.15)[p=.015]	1.01 (0.68–1.51)[p=.954]
Family income		0.64 (0.50–0.82)[p<.001]	0.68 (0.54–0.85)[p=.001]	0.63 (0.48–0.83)[p=.001]	0.83 (0.62–1.10)[p=198]
Musculoskeletal pain		1.29 (1.14–1.47)[p<.001]	1.36 (1.21–1.53)[p<.001]	1.19 (1.03–1.38)[p=.018]	1.12 (0.97–1.30)[p=.135]
Physical activity		0.58 (0.47–0.72)[p<.001]	0.80 (0.67–0.96)[p=.016]	0.86 (0.69–1.07)[p=.184]	0.81 (0.65–1.02)[p=.068]
Model 7 (3+4+5) – Psychosocial:	3803	$R^2 = .061$	$R^2 = .071$	$R^2 = .046$	$R^2 = .025$
Resilience		0.96 (0.90–1.02)[p=.175]	0.92 (0.87–0.97)[p=.003]	0.88 (0.82–0.95)[p=.001]	–
School-related stress		1.16 (1.06–1.27)[p=.001]	1.13 (1.04–1.22)[p=.005]	1.09 (0.98–1.22)[p=.121]	1.12 (1.01–1.25)[p=.030]
Negative life events		–	–	1.05 (0.94–1.18)[p=.370]	1.13 (1.02–1.26)[p=.018]
Anxiety/depression		1.95 (1.46–2.60)[p<.001]	2.00 (1.54–2.60)[p<.001]	1.47 (1.00–2.15)[p=.049]	1.15 (0.79–1.69)[p=.464]
Step3/Final model[§] (Model 6+7):	3464	$R^2 = .100$	$R^2 = .079$	$R^2 = .054$	$R^2 = .030$
Female gender		1.39 (0.93–2.07)[p=.109]	1.23 (0.86–1.75)[p=.267]	1.35 (0.87–2.10)[p=.179]	0.97 (0.64–1.47)[p=.892]
Family income		0.68 (0.53–0.87)[p=.002]	0.74 (0.59–0.94)[p=.012]	0.72 (0.54–0.96)[p=.025]	0.86 (0.64–1.16)[p=.333]
Musculoskeletal pain		1.13 (0.98–1.31)[p=.102]	1.21 (1.06–1.38)[p=.006]	1.06 (0.91–1.25)[p=.450]	0.98 (0.83–1.16)[p=.811]
Physical activity		0.62 (0.49–0.77)[p<.001]	0.86 (0.72–1.04)[p=.112]	0.93 (0.74–1.17)[p=.535]	0.84 (0.67–1.05)[p=.131]
Resilience		–	0.95 (0.89–1.01)[p=.077]	0.92 (0.85–0.99)[p=.026]	–
School-related stress		1.08 (0.98–1.20)[p=.138]	1.04 (0.95–1.14)[p=.380]	–	1.15 (1.04–1.28)[p=.010]
Negative life events		–	–	–	1.13 (1.01–1.26)[p=.036]
Anxiety/depression		1.69 (1.20–2.37)[p=.002]	1.70 (1.24–2.34)[p=.001]	1.68 (1.17–2.39)[p=.005]	–

Note: Statistical analyses: Hierarchical logistic regression.
[‡]Patient data from the Norwegian Patient Registry.

The final model explained 10.0% of the variance for mood disorders, 7.9% for anxiety disorders, and lower explained variance for developmental and behavioral disorders and the undiagnosed. We found some differences in predictors in the final models for the different diagnostic groups, with musculoskeletal pain predicting anxiety disorders adjusted for gender, family income, physical activity and adolescent psychosocial factors (Table 4).

In the year prior to the NAAHS, 6.1% of the participants had seen a psychiatrist/psychologist. Of these, 41.7% were registered as mental healthcare users in young adulthood, compared to 11.9% in those who had not seen a psychiatrist/psychologist in adolescence (χ^2 (1, n=3936)=166.70, p<.001).

DISCUSSION

Main findings
We found multisite adolescent musculoskeletal pain to be associated with an increase in mental healthcare use and mental health disorders in young adulthood, in both genders. Overall, this association was mediated by adolescent psychosocial problems, not by physical or sedentary activity. However, adolescent musculoskeletal pain was associated with later anxiety disorder, when adjusted for adolescent psychosocial problems.

Interpretation of the results and comparison to previous findings
A high proportion of adolescents were found to be mental healthcare users in young adulthood, comparable to national data and with a representative distribution of disorders[40].

The significant univariate associations between the number of adolescent musculoskeletal pains and later mental health disorders, mental healthcare use and the amount of treatment, support earlier research in which pain, and other physical complaints, have been found to be predictive of mental health problems[14,16,41–43]. However, the relationship between adolescent musculoskeletal pain and later mental health problems was mediated by adolescent psychosocial problems, indicating an intertwined relationship between adolescent psychosocial problems and musculoskeletal pain in predicting mental health problems.

The higher proportion of later mental healthcare users in the pain-related functional impairment group support that daily function, in relation to symptoms, is an important predictor of mental health outcome. However, the relationship between adolescent musculoskeletal pain and later mental health problems was evident regardless of functional impairment.

Physical problems, such as pain, are part of the clinical picture of mental health disorders, especially anxiety and mood disorders[20–22,39]. Our findings support this and show the relevance of adolescent physical and psychosocial problems in predicting later mental health disorders. The physical aspects were further highlighted in the final regression models where adolescent musculoskeletal pain was significantly associated with anxiety disorders, and low physical activity with mood disorders. This is in line with the clinical picture of these disorders[39].

Adolescent pain and mental health problems

Shanahan et al. found pain in youth to be predictive of anxiety and mood disorders in young adulthood adjusted for psychosocial mediators[16]. In our results, this was the case just for anxiety disorders, but the relationship between adolescent musculoskeletal pain and mental health disorders was stronger for anxiety and mood disorders in both genders, supporting the findings of Shanahan et al.[16]. The differences in our findings may be due to the different methodology and adolescent mediators. Interestingly, Shanahan et al. found that pain persisting across developmental periods increased the risk of mental health problems in young adulthood[16]. We could not examine this in our study, but we did find a significant positive relationship between the number of adolescent pain sites and mental healthcare outpatient treatment and the proportion of inpatients in young adulthood. This indicates that adolescents with multisite pain and psychosocial problems may have an increased risk of being worse off later on.

The dominant predictors for the undiagnosed group were different from those diagnosed with a mental health disorder. The impact of school-related stress and negative life events may indicate that this group struggles with everyday stressors and life experiences, and are not in need of long-term treatment. However, a potential bias in the undiagnosed group is dropout from treatment. This group's low treatment hours could indicate that they were evaluated and not satisfying a diagnosis, or it might indicate patient dropouts. It was impossible to differentiate this in the registry data.

The strongest predictor of mental health disorders was adolescent anxiety/depression problems. Low family income and low physical activity were also highly associated with later mental health disorders in the final model. Low family income might result in or be a result of social inequalities and thereby increase the risk of mental health problems[24,44]. Sagatun et al. found adolescent physical activity to be weakly associated with later mental health problems at three-year follow-up, however only in males[33]. School-related stress was significant and negative life events a strong trend in the final model. Pressure to succeed and the risk of academic failure can be a stressor in all social classes and educational levels, as it is often associated with personal expectations and limited employment opportunities for young people[24]. The negative life events measure, although crude, included known risk factors of mental illness such as bullying and sexual abuse[24].

Almost half of those who had consulted a psychiatrist/psychologist in adolescence were registered as later mental healthcare users, indicating that a considerable proportion of adolescents with mental health problems have a long-term need for specialized services. A low recognition of adolescent mental health disorders in primary care has been shown[19]. With short consultations, discovering underlying mental health problems might be challenging for clinicians in patients presenting with physical complaints. Therefore, physical complaints, such as pain, should not be ignored in the early detection of mental health problems. Most patients with mental health problems presenting physical complaints acknowledge their emotional problems when asked about them[20]. Early detection might reduce the duration of illness and the splitting of physical and psychosocial problems.

Methodological strengths and limitations
The main strength of this study is the linkage of a large unselected population-based study to a patient registry, making it possible to study a wide range of predictors of mental healthcare

use and disorders. The study had equal gender distribution and a high participation rate. We had a representative sample of mental healthcare users in our sample compared to the total population estimation.

The NPR is a national patient registry for specialist care of high quality, and we found few logical errors. Ideally, it would have been preferable to differentiate between primary and secondary diagnoses, but from a close inspection of the NPR data it was clear that attempting this would not be trustworthy due to the evident difference in the specialists diagnostic coding practice. However, most of the primary and secondary diagnoses were within their respective main chapters of the ICD-10.

This study has several weaknesses. The specification of a 12-month period for the pain questions may have increased the risk of recall bias compared to shorter time periods. The expression "several times" is objectively vague and is open to interpretation, but it indicates some regularity and seriousness of pain. However, the importance of multisite pain is still emphasized.

Psychosomatic problems are complex, and with only one cross-sectional study linked to the patient registry there might be other factors influencing the associations found in this study. The population study relied on self-reports with the risk of information bias. Some scales did not have a defined time period and the HSCL-10 measured only anxiety/depressive symptoms during the previous week. Some of the scales from the population study are not frequently used by other studies, making it hard to exactly replicate the findings, though their internal consistency was high. The lack of linearity between the ordinal groups in the type of mental healthcare users could be caused by the fact that we only had a single study from adolescence. At first glance the explained variance of the multivariable models might be considered to be low, however explained variance is a relative value, dependent on the nature of the associations examined. In outcomes with multiple determinants the size of the explained variance is limited by nature[45].

CONCLUSIONS

Multisite adolescent pain and can be part of the clinical picture and serve as an early clinical marker of mental health problems in youth. Adolescents with multisite musculoskeletal pain and psychosocial problems are at increased risk of mental health disorders in young adulthood, especially mood and anxiety disorders. Since it is common for youth troubled by mental health problems to present physical complaints in a primary care setting it is therefore important to examine for psychosocial problems in such cases, in order to offer early interventions.

Adolescent pain and mental health problems

Data from the Norwegian Patient Register (NPR) has been used in this publication. The interpretation and reporting of these data are the sole responsibility of the authors, and no endorsement by the Norwegian Patient Register is intended nor should be inferred.

Figure legends
Fig 1 Chi-squared test for trend. The relationship between the number of adolescent musculoskeletal pain sites and (A) mental healthcare users and (B) mental health disorders (data in Table 2).

Table legends
Table 1 Adult mental healthcare use, mental health disorders and treatment in a cohort of adolescents, registry-based data[‡]

Table 2 The number of adolescent musculoskeletal pain sites, by gender, and the association with mental healthcare use[‡], mental healthcare treatment and mental health disorders in young adulthood

Table 3 The association between adolescent musculoskeletal pain and mental healthcare use[‡] in young adulthood, adjusted for adolescent sociodemographic, physical and psychosocial factors

Table 4 The association between adolescent musculoskeletal pain and mental health disorders[‡] in young adulthood, adjusted for adolescent sociodemographic, physical and psychosocial factors

Supplementary Table S1 Descriptive analyses of the adolescent factors in the Norwegian Arctic Adolescent Health Study (NAAHS) in the total sample, the registry sample and the non-registry sample.

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Fig 1 Chi-squared test for trend. The relationship between the number of adolescent musculoskeltal pain sites and (A) mental healthcare users and (B) mental health disorders (data in Table 2).
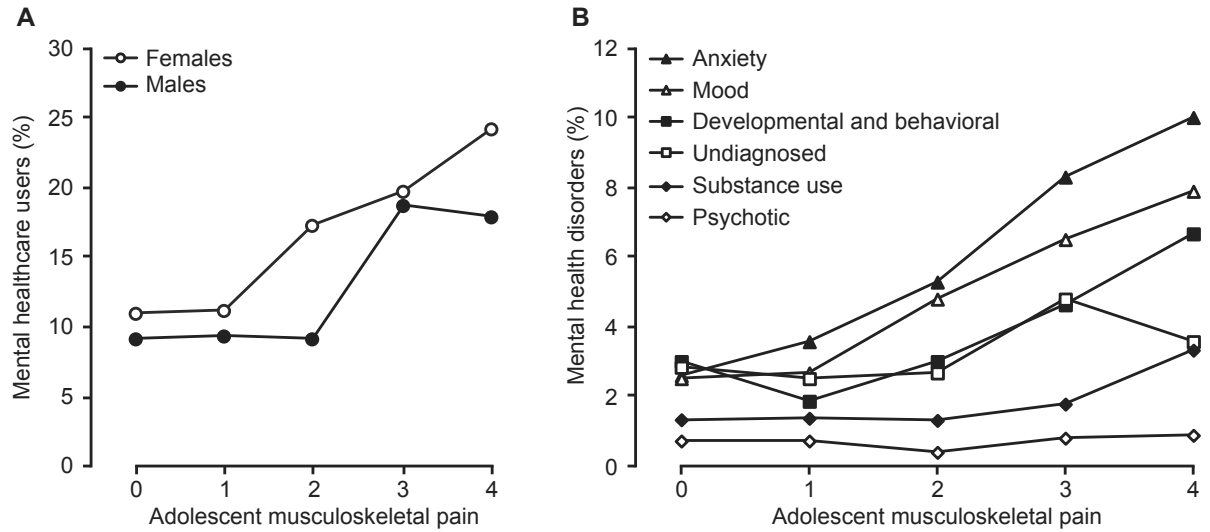
Supplementary Table S1 Descriptive analyses of the explanatory adolescent factors in the Norwegian Arctic Adolescent Health Study (NAAHS) in the total sample, the registry sample and the non-registry sample.

Factors (Mean/SD)	Total sample n=4881	Registry sample n=3987	Non-registry sample (missing) n=894	Registry vs. missing sample (F-ratio)
Family income (1–4)	2.66 (0.67)	2.66 (0.67)	2.68 (0.69)	$0.84^{p=.36}$
Musculoskeletal pain (0–4)	1.47 (1.27)	1.47 (1.27)	1.47 (1.29)	$0.01^{p=.92}$
Sedentary activity (1–4)	2.80 (0.90)	2.78 (0.90)	2.85 (0.86)	$3.32^{p=.07}$
Physical activity (0–3)	1.46 (0.93)	1.46 (0.93)	1.41 (0.93)	$1.75^{p=.19}$
Resilience (5–20)	14.74 (2.62)	14.75 (2.61)	14.76 (2.63)	$0.03^{p=.87}$
Parental involvement (4–16)	6.45 (2.26)	6.45 (2.26)	6.41 (2.22)	$0.02^{p=.90}$
Parental support (5–20)	7.21 (2.83)	7.21 (2.84)	7.22 (2.81)	$0.01^{p=.93}$
Peer support (4–16)	5.62 (1.99)	5.62 (2.00)	5.63 (1.97)	$0.21^{p=.64}$
School-related stress (4–12)	7.22 (1.96)	7.23 (1.98)	7.18 (1.87)	$0.36^{p=.55}$
Negative life events (0–12)	2.73 (1.96)	2.76 (1.79)	2.58 (1.71)	$6.08^{p=.014}$
Anxiety/depression (1–4)	1.48 (0.52)	1.47 (0.51)	1.46 (0.51)	$0.80^{p=.37}$

Note: The analyses were carried out to explore potential differences between the total NAAHS sample and the registry sub-sample used in this current paper.