Soc Psychiatry Psychiatr Epidemiol (2013) 48:745–756
DOI 10.1007/s00127-012-0594-6

ORIGINAL PAPER

Personality, physical activity, and symptoms of anxiety and depression: the HUNT study

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Received: 8 December 2011 / Accepted: 16 September 2012 / Published online: 2 October 2012
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Abstract
Purpose To analyze the association between physical activity (PA), symptoms of depression and anxiety, and personality traits.
Methods Cross-sectional study from a Norwegian population-based survey conducted in the period 2006–2008. The sample consisted of a total of 38,743 subjects aged ≥19 years, 56.1 % women and 43.9 % men. Demographic variables, PA, depression and anxiety (The Hospital Anxiety and Depression Scale), and personality (Eysenck Personality Questionnaire) were assessed by self-reporting measurements.
Results Individuals who reported moderate and high PA had significantly lower scores on depression and anxiety compared with less physically active individuals ($p < 0.05$). Significantly lower risk of HADS-defined depression and anxiety was associated with frequency, duration, and intensity of activity among women ($p < 0.05$), and significantly lower risk of HADS-defined depression was associated with frequency, duration, and intensity of activity among men ($p < 0.05$). There was a significant linear trend between extroversion and levels of PA ($p < 0.01$) and between neuroticism and PA ($p < 0.01$).
Conclusions Subjects reporting regular leisure-time PA were less likely to report symptoms of HADS-defined depression and anxiety. Personality may be an underlying factor in explaining this association.

Keywords Physical activity · Depression · Anxiety · Personality · Cross-sectional study

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Background

Depression and anxiety are the two most common mental health problems in Norway [1]. The World Health Organization (WHO) predicts that by 2020 depression will be the second most common cause of mortality and the most incapacitating problem in the world [2]. Depending on the degree of severity of symptoms, depression and anxiety may affect quality of life, interpersonal relationships, education, and work opportunities [1, 3]. Approximately half of the adult Norwegian population will suffer from a mental health problem at some point in time. Studies of Norwegian populations have found varying 12-month prevalence of major depression (3.7–7.3 %), general anxiety disorders (1.1–1.9 %), and panic disorders (5.0–11.1 %) [1, 4]. In comparison, the 12-month prevalence of depression and anxiety has been reported to be 9.5 and 18.1 %, respectively, in a US population [5] and 4.5 and 12.7 %, respectively, in a cross-European population [6].

Meta-analyses of intervention studies have found that aerobic fitness training and other exercise programs may have a significant moderate to high antidepressive effect [7–9] and a small to moderate anxiolytic effect in non-clinical samples [7–11]. However, the mental health benefits of physically active behavior might differ in the

"real world" compared with laboratory settings. Previous results from observational studies show that leisure-time physical activity (PA) has a small to moderate effect in reducing the risk of depression [12–21], whereas observational studies relating to anxiety are very few and their results are equivocal [12, 14–16, 19–21].

In addition to lifestyle-related factors, personality traits may directly or indirectly influence somatic and mental health outcomes [22]. Extroversion and neuroticism have previously been found to be highly correlated with symptoms of depression and anxiety [23, 24] and also physical activity [25]. Only a few studies have investigated how personality traits relate to the association between PA and mental health problems in the general population [12, 14, 26]. In a large ($N = 19{,}288$) Netherlands twin population aged 18–50 years, De Moor et al. [12] detected that irrespective of gender and age, regular exercisers scored significantly lower on symptoms of mental health problems, lower on neuroticism, and higher on extroversion than irregular exercisers. However, more research is needed to establish how personality traits are associated with physically active behavior and the development of depression and anxiety.

Research question

The purpose of the study was to investigate the cross-sectional association between leisure-time PA, mental health, and personality in a population-based observational survey in Norway.

Methods

Design and sample

During the period 2006–2008, all adults aged 19 years or older living in the county of Nord-Trøndelag in Norway received an invitation to participate in a health survey. The study included a comprehensive questionnaire designed to assess demographics, health, lifestyle, and personality. Of the 94,149 eligible individuals invited to participate, 50,839 (54.0 %) returned the questionnaire. Of those, 27,779 (58.5 %) were women and 23,060 (49.3 %) men.

A total of 12,096 (23.8 %) subjects were excluded from the analysis due to missing information relating to PA, the Hospital Anxiety and Depression Scale (HADS), or the Eysenck personality questionnaire (EPQ). The final sample consisted of 38,743 subjects: 21,722 women (56.1 %) and 17,021 men (43.9 %). The mean age for women was 51.2 years and for men it was 55.1 years.

Measures

Physical activity

The participants reported average weekly frequency (0, <1, 1, 2–3, >3 times), duration (<15, 15–30, 30–60, >60 min.), and intensity (light, moderate, vigorous) of leisure-time PA during the last 12 months before participation. For subjects who reported 0 frequency, but had missing answers on duration and intensity, a 0 score on duration and intensity was assigned. The questions regarding PA have been validated with a good internal consistency in men [27]. Among subjects with registered frequency, duration, and intensity, a summary index of PA was calculated. In 2006, detailed information about the PA index was published by Augestad et al. [28]. The frequency scale was recoded to indicate approximate times per week (0, 0.5, 1, 2.5, 5), the duration scale was estimated by approximate hours per session of PA (0, 0.12, 0.38, 0.75, 1.5), and the intensity scale was scored as in the questionnaire (1 for light, 2 for moderate, and 3 for vigorous) [28]. Furthermore, the PA index was divided into three categories based upon the 33rd and 66th percentiles of the score, indicating low, moderate, and high PA, separately for women and men.

Hospital anxiety and depression scale

The HADS was designed for use in health surveys aiming to estimate the frequency of mental health problems in populations. The HADS consists of two subscales, seven items for depression (HADS-D) and seven items for anxiety (HADS-A) [29]. The subjects were asked to report the feelings they had experienced during the last week. A 4-point Likert scale was used on each question, ranging from 0 (not present) to 3 (maximally present). The classification of scores on the HADS-D and HADS-A subscales is as follows: 0–7 = normal, 8–10 = mild disorder, 11–14 = moderate disorder, and 15–21 = severe disorder. For the present analysis, a cutoff point of 8 was used on each subscale [29]. Validation studies indicate a sensitivity of and specificity of a score >8 for both HADS-D (sensitivity 0.83 and specificity 0.73) and HADS-A (sensitivity 0.90 and specificity 0.78) [30].

Eysenck personality questionnaire

The Revised Eysenck Personality Questionnaire (EPQ-R) was developed from the EPQ by Eysenck, Eysenck and Barrett [31], and is widely used for examining personality traits [32]. The EPQ operates with three basic personality traits: extroversion (i.e., a tendency to be impulsive, sociable, assertive, energetic, seek excitement, and experience positive affect), neuroticism (i.e., a tendency to be emotionally unstable, angry, hostile, anxious, self-conscious,

and vulnerable), and psychoticism (i.e., a tendency to be tough-minded, non-conformist, hostile, aggressive, and impulsive) [33]. The study included an 18-item short version of the EPQ modified for the HUNT study by multivariate analysis of the data from the original Norwegian translation of the EPQ [34]. The items on the scale are dichotomous with a yes (1)/no (0) response to each item and the trait scores are the sum score calculations ranging from 0 to 6 on each scale. The extroversion and neuroticism subscales were found to have good internal reliability with a Cronbach's alpha (α) of 0.62 and 0.65, respectively [34]. The psychoticism scale was excluded from the analyses due to poor internal reliability ($\alpha = 0.38$). In the present study, a higher score indicates higher distribution of the trait [33]. For the purpose of analyses with dichotomous outcome, EPQ extroversion and neuroticism scores were grouped into a lower/upper median score.

Confounding variables

Owing to the large number of potential confounding factors, a series of univariate linear regression analyses was performed, where each potential covariate was tested against a model fitting only an intercept term for men and women separately, and for HADS-defined depression and anxiety as dependent variables separately. Suspected confounders showing an association with a significance level of <0.2 in univariable analysis for either gender were further investigated in all analyses for that particular gender. The following variables were found to influence the associations under study and were included in the final adjusted analyses: age (19–40, 41–60, and >60 years), body mass index (<18.5, 18.5–24.9, 25–29.9, 30–34.9, and >35 kg/m^2), marital status (unmarried, married, widowed, and previously married), living with other people (yes or no), occupational activity level (mostly passive, frequently walking, frequently lifting and walking, and heavy manual labor), current smoking status (yes, former, or no), frequency of alcohol consumption during the last 12 months before the study (No recent drinking, 2–3 times per month, 1 time per week, 2–3 times per week, 4–7 times per week), mental health problems in the family (yes, no, or uncertain), and chronic somatic diseases (yes or no), including angina pectoris, myocardial infarction, asthma, diabetes, epilepsy, arthritis, osteoporosis, stroke, pulmonary arterial obstructive disease, sarcoidosis, Bechterew's disease, and fibromyalgia. Two-way interactions between age and BMI and other statistically significant ($p < 0.20$) covariates were examined.

Analytic strategy

Descriptive statistical analyses included means, standard deviations (SDs), and percentages of categorical baseline characteristics of the sample in relation to HADS-D or HADS-A scores above 8. The mean HADS-D and HADS-A scores across the subgroups of baseline characteristics were examined by one-way ANOVA analysis.

We modeled the probability of being either depressed or anxious by unadjusted and adjusted logistic regression. For HADS-defined depression and HADS-defined anxiety, odds ratios (ORs) estimates were obtained by maximum likelihood with associated 95 % confidence intervals (CIs).

Analyses of the association between PA and personality were carried out using general linear models (GLMs). The mean score (95 % CI) of EPQ extroversion and EPQ neuroticism for each PA category was estimated by maximum likelihood. We tested for trend over levels of PA by assigning a value of 0, 1, 2, etc., for none and up to the highest category of each variable, and then treated this score as continuous. We were interested in investigating whether the association between the PA index and depression and anxiety differed according to lower/higher median EPQ score. Therefore, we conducted additional adjusted logistic regression analyses with HADS-D >8 and with HADS-A >8 as dependent variables with PA index as an independent variable and stratified by the lower/upper median of the EPQ extroversion and EPQ neuroticism scores.

Bivariate correlation analyses were performed to assess the strength of the linear association between mental health problems and personality. For each correlation analysis, a Pearson's correlation coefficient (r) was estimated from the mean scores of the HADS scales and the EPQ scales.

All analyses were run separately for women and men and separately for each of the PA variables (PA index, frequency, duration, and intensity). Furthermore, all adjusted analyses were either simple (adjusted for age only) or multivariate. Probabilities below $p = 0.05$ were regarded as statistically significant although $p = 0.01$ was chosen in the GLM analysis for trend. Statistical analyses were carried out by SPSS Version 18.

Results

Table 1 shows the sample characteristics and the mean scores on the HADS depression scale among women and men. The mean HADS-D score was 3.15 among women and 3.55 among men. When the classification of the HADS-D subscale [29] was applied, 1,910 (8.8 %) women and 1,774 (10.4 %) men scored >8 on the HADS-D scale. Of those, 1,454 (6.7 %) women and 1,359 (8.0 %) men had "mild depression," 361 (1.7 %) women and 333 (2.0 %) men had "moderate depression," and 95 (0.4 %) women and 82 (0.5 %) men had "severe depression."

Table 1 Demographical characteristics and HADS-scored depression in the study sample

Characteristics	Women ($N = 21,722$)				Men ($N = 17,021$)			
	HADS-D				HADS-D			
	N	Mean	Std	% (>8)[e]	*N*	Mean	Std	% (>8)[e]
Age				*				*
19–40	4,842	2.44	2.58	5.8	2,887	2.77	2.68	6.8
41–60	9,188	3.01	2.88	8.5	7,491	3.43	2.93	9.7
>60	7,692	3.73	2.90	11.1	6,643	4.02	2.94	12.8
Marital status				*				*
Married/partnership	12,586	3.02	2.76	7.8	11,058	3.50	2.83	6.2
Unmarried	4,258	2.81	2.81	7.6	3,739	3.46	3.02	2.5
Divorced/separated	2,294	3.48	3.20	12.1	1,557	3.82	3.22	13.1
Widowed	2,563	3.98	3.00	12.8	591	4.32	3.17	15.7
Occupational activity level				*				*
Sedentary	4,589	2.84	2.76	7.5	4,787	3.25	2.83	8.9
Frequent walking	5,734	2.77	2.71	6.6	3,209	3.15	2.73	8.0
Frequent walking and lifting	4,511	2.77	2.64	6.3	2,744	3.38	2.81	8.4
Heavy manual labor	320	3.62	3.11	11.6	2,199	3.68	2.91	10.6
BMI				*				*
<18.5	182	3.85	3.59	17.6	45	5.22	4.41	28.9
18.5–24.9	8,149	2.83	2.75	7.2	4,107	3.38	2.92	10.0
25–29.9	8,260	3.16	2.83	8.5	9,016	3.48	2.85	9.6
30–34.9	3,635	3.49	2.99	10.7	3,168	3.80	3.02	12.1
>35	1,421	3.73	3.07	13.0	636	4.15	3.19	14.3
Current smoking status				*				*
Yes	9,860	3.41	2.86	10.6	3,675	3.74	3.01	12.2
Former	6,039	3.20	2.99	8.9	6,103	3.73	2.92	11.3
No	5,418	2.93	2.78	7.7	7,002	3.26	2.84	8.5
Alcohol (past 12 months)								
No recent drinking[a]	9,062	3.39	3.00	10.5	4,932	3.95	3.13	13.5
2–3 times per month	4,524	2.85	2.67	6.9	3,901	3.37	2.78	9.2
1 time per week	3,975	2.86	2.72	6.9	4,342	3.32	2.78	8.5
2–3 times per week	2,278	2.89	2.72	7.5	2,728	3.35	2.83	8.7
4–7 times per week	392	2.98	2.84	6.9	581	3.71	3.00	11.0
Median EPQ-E score[c]				*				*
Lower half	10,938	3.80	3.09	12.9	9,233	4.18	3.09	14.7
Upper half	10,847	2.47	2.46	4.7	7,788	2.80	2.51	5.4
Median EPQ-N score[d]				*				*
Lower half	10,938	2.01	2.06	2.1	11,101	2.72	2.37	4.3
Upper half	10,784	4.28	3.11	15.6	5,920	5.11	3.21	21.8
Chronic somatic diseases				*				*
Yes	8,691	3.73	3.07	12.2	6,133	4.12	3.07	14.3
No	13,031	2.74	2.66	6.5	10,888	3.23	2.78	8.2
Mental health problems in the family				*				*
Yes	4,788	3.66	3.19	13.1	2,741	4.03	3.20	15.2
No	14,768	2.84	2.64	6.6	12,414	3.32	2.78	8.6
Uncertain	1,315	3.98	3.29	14.7	1,422	4.38	3.18	15.0
Frequency of weekly PA				*				*
<1 time per week	3,647	3.94	3.26	14.4	4,315	4.02	3.14	13.9
1 time per week	4,474	3.27	2.87	9.2	3,743	3.54	2.84	9.7

Table 1 continued

Characteristics	Women ($N = 21,722$)				Men ($N = 17,021$)			
	HADS-D				HADS-D			
	N	Mean	Std	% (>8)[e]	*N*	Mean	Std	% (>8)[e]
2–3 times per week	9,244	2.88	2.68	7.0	6,119	3.28	2.79	8.5
Almost every day	4,357	2.88	2.78	7.4	2,844	3.41	2.89	10.2
Duration of PA				*				*
<15 min	725	4.58	3.43	18.6	755	4.46	3.23	17.6
15–30 min	3,260	3.47	2.91	10.3	2,477	3.89	2.96	12.4
30–60 min	12,331	2.94	2.75	7.6	7,880	3.35	2.79	8.7
>60 min	3,269	2.68	2.64	6.3	3,618	3.23	2.84	8.8
Intensity of PA				*				*
Take it easy	8,805	3.51	2.94	10.6	5,626	3.97	3.01	13.1
I push until I lose my breath	10,054	2.65	2.62	6.1	8,044	3.20	2.74	7.8
I practically exhaust myself	381	2.24	2.63	5.5	679	2.46	2.59	5.2
PA index[b]				*				*
Low	6,151	3.65	3.05	12.1	5,537	3.87	2.98	12.3
Moderate	9,160	2.93	2.71	7.2	6,167	3.34	2.78	8.4
High	5,209	2.64	2.64	6.1	4,134	3.15	2.80	8.5

PA physical activity, *HADS-D* hospital anxiety and depression scale depression subscale, *BMI* body mass index, *EPQ-E* Eysenck personality questionnaire subscale extroversion, *EPQ-N* Eysenck personality questionnaire subscale neuroticism

* Significant *p* values (<0.05) indicate results of the Pearson's Chi-square test

[a] No drinking in the past 2 weeks, but not a teetotaler

[b] Physical activity index: sum score of frequency, duration, and intensity

[c] Median extroversion score of 4.0

[d] Median neuroticism score of 1.0

[e] >8 = sum score of 8 or higher of HADS-D

Table 2 shows the sample characteristics and the scores on the HADS anxiety scale among women and men. The mean HADS-A score was 4.37 among women and 3.53 among men. When the classification of the HADS-A subscale [29] was applied, 3,776 (17.4 %) women and 1,742 (10.2 %) men scored >8 on the HADS-A scale. Among those, 2,435 (11.2 %) women and 1,215 (7.1 %) men had "mild anxiety," 951 (4.4 %) women and 384 (2.3 %) men had "moderate anxiety," and 390 (1.8 %) women and 143 (0.8 %) men had "severe anxiety."

In adjusted analyses, symptoms of depression and anxiety were somewhat lower among women with a high PA index score compared with women with moderate and low scores ($p < 0.05$). Among men, the scores for HADS-defined depression were lower for those with moderate and high PA index scores compared with those with lower scores ($p < 0.05$), but less than for HADS-defined anxiety (Fig. 1). Among women, ORs for HADS-defined depression decreased with increasing levels of frequency, intensity, and duration of activity although the OR for women with the highest frequency and intensity score did not differ much from those with moderate scores. Among men, there was a u-shaped relationship between the ORs for HADS-defined depression and frequency and duration of activity; but, for intensity, OR decreased with higher levels. Further, there was tendency toward a u-shaped relationship between frequency, duration, and intensity of activity and HADS-defined anxiety in men (Fig. 1). None of the two-way interactions reached statistical significance.

There was a significant trend for lower scores on extroversion with lower PA index levels ($p < 0.01$) and a statistically significant trend for higher neuroticism scores for lower PA index levels ($p < 0.01$) (Tables 3, 4). Trends for EPQ extroversion scores across the categories of frequency and intensity of activity were significant for both women and men ($p < 0.01$), but only for women with regard to duration of activity ($p < 0.01$) (Table 3). EPQ neuroticism scores had a significant trend across categories of frequency and duration of activity for women and men ($p < 0.01$). Although intensity of activity had a significant trend with EPQ neuroticism scores ($p < 0.01$), only light

Table 2 Demographical characteristics and HADS-scored anxiety in the study sample

Characteristics	Women ($N = 21,722$)				Men ($N = 17,021$)			
	HADS-A				HADS-A			
	N	Mean	Std	% (>8)[e]	*N*	Mean	Std	% (>8)[e]
Age				*				*
19–40	4,842	4.56	3.40	18.3	2,887	3.92	2.98	11.7
41–60	9,188	4.36	3.55	17.6	7,491	3.72	3.15	11.9
>60	7,692	4.27	3.40	16.5	6,643	3.16	2.78	7.7
Marital status				*				*
Married/partnership	12,586	4.22	3.36	15.9	11,058	3.34	2.85	8.6
Unmarried	4,258	4.63	3.48	19.2	3,739	3.96	3.16	13.1
Divorced/separated	2,294	4.90	3.87	22.7	1,557	4.00	3.48	15.3
Widowed	2,563	4.21	3.50	16.9	591	3.27	2.85	8.8
Occupational activity level				*				
Sedentary	4,589	4.17	3.38	15.8	4,787	3.58	3.05	10.5
Frequent walking	5,734	4.24	3.34	15.8	3,209	3.50	2.91	9.7
Frequent walking and lifting	4,511	4.39	3.41	17.3	2,744	3.58	2.91	10.3
Heavy manual labor	320	4.92	3.65	22.8	2199	3.66	3.04	10.7
BMI				*				
<18.5	182	5.27	4.13	24.7	45	4.60	3.32	20.0
18.5–24.9	8,149	4.42	3.45	17.4	4,107	3.60	2.94	10.0
25–29.9	8,260	4.32	3.41	16.7	9,016	3.49	2.97	10.0
30–34.9	3,635	4.34	3.49	18.0	3,168	3.51	3.06	10.6
>35	1,421	4.36	3.64	18.4	636	3.76	3.33	12.4
Current smoking status								
Yes	9,860	5.00	3.76	23.2	3,675	3.91	3.28	13.6
Former	6,039	4.37	3.42	17.1	6,103	3.49	2.97	10.0
No	9,860	4.02	3.26	14.2	7,002	3.36	2.84	8.5
Alcohol (past 12 months)								
No recent drinking[a]	9,062	4.56	3.57	19.2	4,932	3.59	3.15	11.5
2–3 times per month	4,524	4.21	3.30	15.5	3,901	3.49	2.86	9.1
1 time per week	3,975	4.37	3.40	17.0	4,342	3.55	2.91	9.8
2–3 times per week	2,278	4.21	3.40	15.4	2,728	3.55	2.99	10.4
4–7 times per week	392	4.21	3.47	17.6	581	3.55	3.25	11.5
Median EPQ-E score[c]				*				*
Lower half	10,875	4.63	3.59	19.5	9,233	3.75	3.14	12.0
Upper half	10,847	4.11	3.31	15.2	7,788	3.28	2.80	8.1
Median EPQ-N score[d]				*				*
Lower half	10,938	2.49	2.08	2.2	11,101	2.37	1.99	1.6
Upper half	10,784	6.28	3.55	32.8	5,920	5.71	3.55	26.4
Chronic somatic diseases				*				*
Yes	8,691	4.75	3.68	20.9	6,133	3.75	3.17	12.4
No	13,031	4.12	3.29	15.1	10,888	3.41	2.89	9.0
Mental health problems in the family				*				*
Yes	4,788	5.44	3.94	27.0	2,714	4.53	3.58	19.1
No	14,768	3.90	3.15	13.1	12,414	3.20	2.72	7.3
Uncertain	1,315	5.49	3.68	26.8	1,422	4.45	3.36	17.2
Frequency of weekly PA				*				*
<1 time per week	3,647	4.77	3.80	21.6	4,315	3.64	3.13	11.7
Once per week	4,474	4.41	3.46	17.9	3,743	3.56	2.92	9.6

Table 2 continued

Characteristics	Women ($N = 21,722$)				Men ($N = 17,021$)			
	HADS-A				HADS-A			
	N	Mean	Std	% (>8)[e]	*N*	Mean	Std	% (>8)[e]
2-3 times per week	9,244	4.24	3.31	15.9	6,119	3.49	2.96	9.8
Almost every day	4,357	4.27	3.46	16.4	2,844	3.43	2.98	9.9
Duration of PA								
<15 min	725	5.18	3.89	25.8	755	3.76	3.06	11.3
15–30 min	3,260	4.48	3.54	19.2	2,477	3.69	3.15	11.5
30–60 min	12,331	4.30	3.39	16.5	7,880	3.45	2.89	9.3
>60 min	3,269	4.21	3.36	15.7	3,618	3.53	3.00	10.2
Intensity of PA				*				*
Take it easy	8,805	4.48	3.50	18.6	5,626	3.46	2.97	10.2
I push until I lose my breath	10,054	4.21	3.35	15.6	8,044	3.54	2.95	9.7
I practically exhaust myself	381	4.33	3.36	16.3	679	3.78	3.13	10.3
PA index[b]				*				*
Low	6,151	4.66	3.64	20.4	5,537	3.60	3.05	10.8
Moderate	9,160	4.24	3.33	16.0	6,167	3.48	2.89	9.4
High	5,209	4.19	3.38	15.5	4,134	3.48	3.00	10.1

PA physical activity, *HADS-A* hospital anxiety and depression scale anxiety subscale, *BMI* body mass index, *EPQ-E* Eysenck personality questionnaire subscale extroversion, *EPQ-N* Eysenck personality questionnaire subscale neuroticism

* Significant *p* values (<0.05) indicate results of the Pearson's Chi-square test

[a] No drinking in the past 2 weeks, but not a teetotaler

[b] Physical activity index: sum score of frequency, duration, and intensity

[c] Median extroversion score of 4.0

[d] Median neuroticism score of 1.0

[e] >8 = sum score of 8 or higher of HADS-A

intensity of activity among women was significantly associated with a higher score on EPQ neuroticism compared with those who practically exhausted themselves ($p < 0.05$) (Table 4). None of the two-way interactions in the models had reached statistical significance. The strength of the association between the PA index and reduced risk of HADS-defined depression and anxiety was independent of the EPQ extroversion and neuroticism scores among women and men (results not shown).

There was a statistically significant positive correlation between EPQ extroversion and HADS-D among women ($r = -0.23$, $p < 0.01$) and men ($r = -0.24$, $p < 0.01$). Among both women and men, a statistically significant negative correlation was observed between EPQ extroversion and HADS-A ($r = -0.08$, $p < 0.01$). There was a statistically significant positive correlation was found between EPQ neuroticism and HADS-D among women ($r = 0.43$, $p < 0.01$) and men ($r = 0.35$, $p < 0.01$). In addition, a statistically significant positive correlation was found between EPQ neuroticism and HADS-A among women ($r = 0.60$, $p < 0.01$) and among men ($r = 0.55$, $p < 0.01$) (results not shown).

Discussion

Individuals with higher levels of leisure-time PA had fewer symptoms of depression and anxiety measured by HADS, and scored higher on EPQ-measured extroversion and lower on neuroticism in comparison with individuals with less leisure-time PA. Lower odds ratios for HADS-defined depression and anxiety were associated with all features of PA among women, and lower odds ratios for HADS-defined depression were associated with all features of PA among men.

Cross-sectional studies with wide age ranges have been conducted to investigate the complex association between leisure-time PA and symptoms of both depression and anxiety in the general population. The findings of the present study indicate that lower symptoms of depression and anxiety were associated with higher scores on the calculated PA index, compared with low PA index scores, in agreement with a few previous studies [12, 16, 20]. Other studies have found only an association between levels of PA and symptoms of depression in adjusted analyses [19, 21]. The equivocal results could be due to the

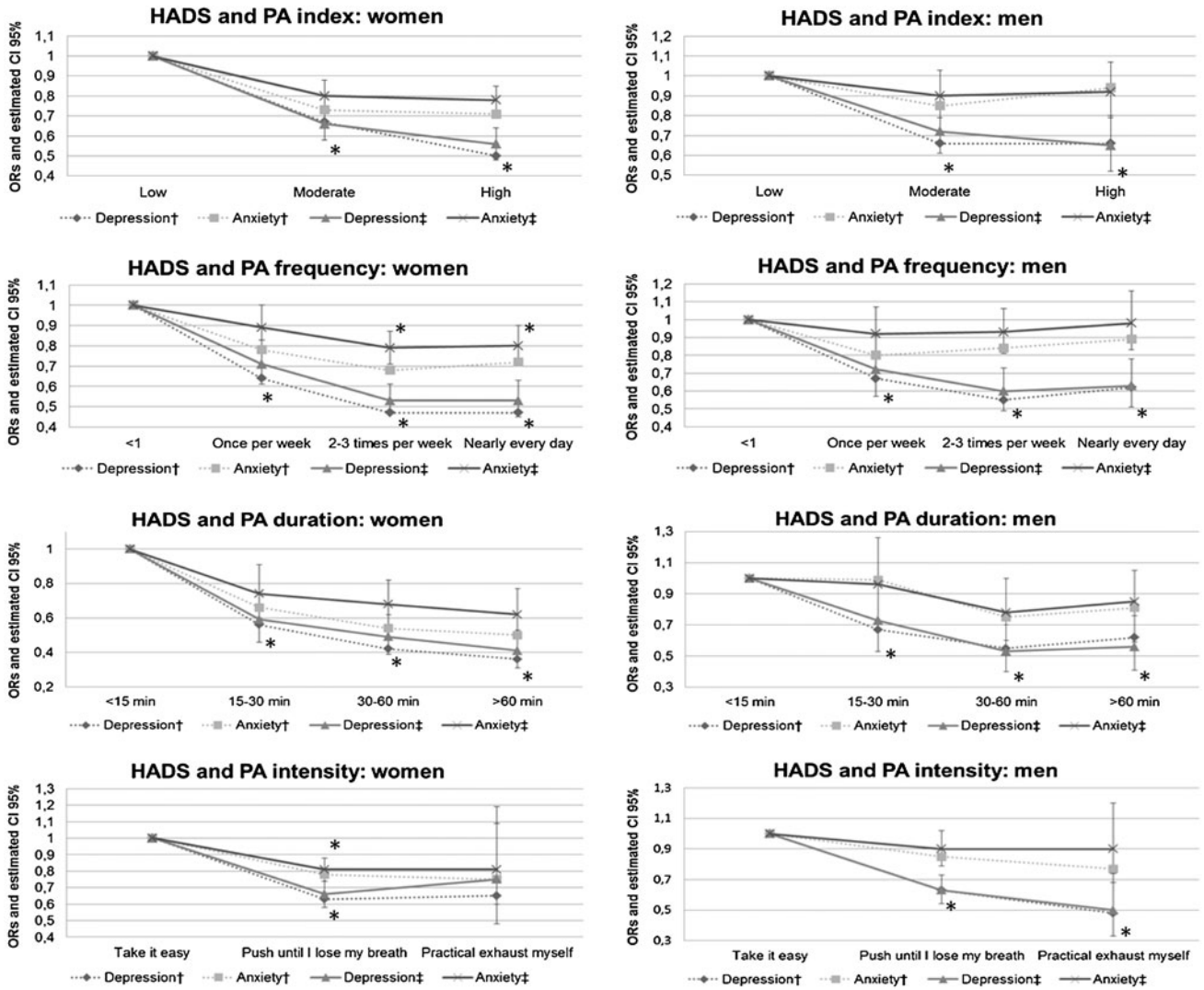

Fig. 1 Adjusted odds ratio from the logistic regression analysis of the association between HADS subscales and frequency, duration, and intensity of activity among women and men. (*PA* physical activity, *OR* odds ratio, *CI* confidence interval, * statistically significant *p*-value (< 0.05) from the multivariate logistic regression analysis; † adjusted for age, ‡ adjusted for age, body mass index, alcohol consumption during last 12 months, current smoking status, mental health problems in the family, occupational activity level, chronic somatic diseases, and marital status; PA index = calculated index of sum score of frequency, duration, and intensity)

lack of consistent self-reporting assessment tools, especially in the assessment of PA [12, 21].

In the current study, subjects reporting "heavy manual labor" had higher levels of reported symptoms of depression and anxiety compared with lower levels of occupational activity. Previous studies have found leisure-time PA to be more beneficial than occupational PA for reducing the risk of depression [16, 18, 19] and anxiety [16]. Leisure-time activities could support a more meaningful life for individuals through preventing negative behavior (e.g., by coping with stress) and promoting life satisfaction) [35].

To date, no definitive recommendations of optimal quantities related to PA and mental health have been made [36]. Our study revealed that physically active individuals are at lower risk of developing mental health problems than their inactive counterparts. However, this finding was less clear in the association between PA and symptoms of anxiety among men. Also, symptoms of depression and anxiety were found to be associated with all features of PA (frequency, duration, and intensity). For women, the association was the strongest for longer durations of activity. However, men had lower symptoms of depression from exercising to the level of exhaustion compared with when they undertook lower levels of intensity of exercise. Our study was conducted in line with the guidelines for obtaining physiologic health effects from at least 60 min of daily activity of moderate intensity [37], but lower levels of PA seem to be sufficient to experience mental health

Table 3 Adjusted beta (β) from general linear model analysis for extroversion in relation to physical activity in women and men

PA	Extroversion					
	Women ($N = 21{,}722$)			Men ($N = 17{,}021$)		
	Adjusted[a]	Adjusted[b]	CI 95 %	Adjusted[a]	Adjusted[b]	CI 95 %
PA index[c]						
Low	−0.20	−0.20	−0.27 to −0.17	−0.07	−0.08	−0.13 to −0.04
Moderate	−0.11	−0.15	−0.16 to −0.07	−0.05	−0.08	−0.14 to −0.02
High	Ref	Ref		Ref	Ref	
p for trend			**			**
R^2			0.049			0.028
Frequency of weekly PA						
<1	−0.25	−0.28	−0.34 to −0.22	−0.12	−0.15	−0.21 to −0.08
1 time per week	−0.11	−0.13	−0.19 to −0.08	−0.04	−0.05	−0.12 to 0.01
2–3 times per week	−0.06	−0.07	−0.12 to −0.03	−0.00	−0.01	−0.07 to 0.05
Almost every day	Ref	Ref		Ref	Ref	
p for trend			**			**
R^2			0.051			0.029
Duration of weekly PA						
<15 min	−0.11	−0.11	−0.22 to 0.01	−0.02	−0.04	−0.14 to 0.08
15–30 min	−0.19	−0.18	−0.25 to −0.12	−0.04	−0.04	−0.11 to 0.02
30–60 min	−0.09	−0.08	−0.13 to −0.03	−0.04	−0.03	−0.08 to 0.02
>60 min	Ref	Ref		Ref	Ref	
p for trend			**			
R^2			0.047			0.029
Intensity of PA						
Take it easy	−0.28	−0.27	−0.41 to −0.14	−0.20	−0.22	−0.33 to −0.11
Push until I lose my breath	−0.16	−0.16	−0.29 to −0.02	−0.15	−0.16	−0.27 to −0.06
Practically exhaust myself	Ref	Ref		Ref	Ref	
p for trend			**			**
R^2			0.070			0.065

PA physical activity, *CI* confidence interval, R^2 coefficient of determination

** *p*-value (<0.01) of the general linear model analysis with PA variables as covariates

[a] Adjusted for age

[b] Adjusted for age, alcohol consumption, current smoking status, chronic somatic diseases, and living with others

[c] Physical activity index: sum score of frequency, duration, and intensity

benefits. The underlying mechanism for this association between PA and mental health is not yet understood, but may be explained by neurobiological, physiologic, or psychologic hypotheses [3, 38].

Personality is suggested to be one of many the demographic, sociological, and psychologic determinants affecting the perception of the benefits of and barriers to health-related behaviors related to risk of disease [39]. Results from previous studies, including ours, indicate that a neurotic personality is strongly associated with mental health problems [23, 24, 40]. However, the interaction between depression, anxiety, and neuroticism is not entirely understood [40]. It is also unclear whether being more extroverted is a protective factor in the development of mental health problems [23, 24, 40], and results from current study indicate that being more extrovert is to some extent associated with fewer symptoms of depression and anxiety.

Our results show that higher scores on extroversion and lower scores on neuroticism are associated with higher levels of PA in agreement with previous studies [12, 25]. Extroverted individuals are claimed to be less aroused than introverted individuals [33], and could be attracted to PA because of challenging activities and the possibility to socialize with others [25]. On the other hand, highly emotional unstable individuals might avoid participating in

Table 4 Adjusted beta (β) from general linear model analysis for neuroticism in relation to physical activity in women and men

PA	Neuroticism					
	Women ($N = 21{,}722$)			Men ($N = 17{,}021$)		
	Adjusted[a]	Adjusted[b]	CI 95 %	Adjusted[a]	Adjusted[b]	CI 95 %
PA index[c]						
Low	0.40	0.32	0.26–0.38	0.21	0.17	0.12–0.23
Moderate	0.06	0.13	0.06–0.19	−0.00	0.03	−0.04 to 0.09
High	Ref	Ref		Ref	Ref	
p for trend			**			**
R^2			0.070			0.065
Frequency of weekly PA						
<1	0.42	0.31	0.23–0.39	0.19	0.16	0.08–0.23
1 time per week	0.14	0.13	0.06–0.21	−0.01	0.01	−0.07 to 0.09
2–3 times per week	−0.03	−0.02	−0.09 to 0.04	−0.05	−0.02	−0.09 to 0.05
Almost every day	Ref	Ref		Ref	Ref	
p for trend			**			**
R^2			0.072			0.066
Duration of weekly PA						
<15 min	0.80	0.62	0.47–0.77	0.52	0.42	0.29–0.54
15–30 min	0.31	0.22	0.13–0.31	0.30	0.24	0.16–0.32
30–60 min	0.10	0.08	0.02–0.15	0.06	0.06	−0.00 to 0.12
>60 min	Ref	Ref		Ref	Ref	
p for trend			**			**
R^2			0.071			0.069
Intensity of PA						
Take it easy	0.33	0.25	0.07–0.43	0.21	0.10	−0.02 to 0.23
Push until I lose my breath	0.01	0.03	−0.18 to 0.18	0.02	−0.01	−0.13 to 0.11
Practically exhaust my self	Ref	Ref		Ref	Ref	
p for trend			**			**
R^2			0.070			0.065

PA physical activity, *CI* confidence interval, R^2 coefficient of determination

** *p*-value (<0.01) of the general linear model analysis with PA run as covariate

[a] Adjusted for age

[b] Adjusted for age, alcohol consumption, current smoking status, chronic somatic diseases, and living with others

[c] Physical activity index: sum score of frequency, duration, and intensity

PA or perform low levels of PA because of lower barriers of arousal [25]. However, the observed association between personality characteristics and levels of PA in the present study was only modest, particularly in the case of scored extroversion. An explanation might be that introverted and emotionally unstable individuals may be physically active, but prefer activities in another context in comparison with their counterparts [25]. Further, personality is a biological construct that might set the stage for health behaviors such as leisure-time PA, but we cannot rule out the effect of other biological, social, and environmental factors [16, 22] on an individual's perception of being physically active.

Two possible scenarios might arise with the function of personality in the relationship between PA and mental health: PA might attract certain types of personality and over time prevent symptoms of mental health problems developing; alternatively, personality might influence the development of mental health problems and consequently lead to a sedentary lifestyle. However, certain personality traits could also lead to less favorable effects of regular PA, such as exercise dependence—a state where PA becomes a way of escaping from real-life problems and lack of exercise leads to somatic and mental symptoms such as feelings of tension, withdrawal, anxiety, and depression [41]. Studies indicate that both extroversion and neuroticism correlate positively with symptoms of exercise dependence [42, 43]. Therefore, personality might not only affect the subjective perception of

performing PA but also how physically active behavior affects mental health.

The main strength of the present study is its population-based observational nature. This made it convenient for estimating PA participation, prevalence of mental health problems, and personality traits in a large population with a wide age range.

The main limitation of the study is its cross-sectional design. Therefore, no firm conclusion can be made regarding the causal structure of the relationship between PA, mental health, and personality. Since most information was self-reported, misclassification may have occurred. It has been questioned whether gender differences in EPQ results truly reflect differences in personality or whether they measure social manifestations of dissimilarities between women and men [44]. Further, extroversion and neuroticism are independent traits on a continuum [34], and therefore it is possible to score low or high on both traits (e.g., high scored extroversion and high neuroticism), which might result in diverse behavioral outcomes. Residual confounding by incorrectly measured variables or confounding variables not included in the adjusted analysis might have affected the observed associations in both directions. In our study, approximately 41 % of the invited individuals were included in the final analyses and non-response bias might have occurred. Results from earlier studies showed that women tend to have higher occurrence of depression compared to men [4–6]. This is not the case in this study. One explanation could be due to the risk of selection bias. It might also be possible that people with mental health problems are more hesitant about participating in a population-based study such as ours, compared with people without mental health problems.

Mental health problems have serious consequences for the quality of life of individuals and for society as a whole. Since regular PA is relatively inexpensive and has beneficial effects for physical and mental health, with few side effects in comparison with medication, health practitioners should encourage and make arrangements for people to be regularly physically active.

Further research with longitudinal design is important for detecting causal relationships between PA, mental health, and personality in a general population. Furthermore, detailed and objective information on PA, depression, anxiety, and personality (i.e., specific parts of each trait) are important for verifying these underlying mechanisms. Moreover, research needs to focus on age and gender differences when studying causal relationships between PA, mental health problems, and personality.

To summarize, in this study, participants who were regularly physically active in leisure time were less likely to have symptoms of depression and anxiety. Physically active women had lower odds ratios for depression and anxiety, and physically active men had lower odds ratios for depression. The role of personality in the relationship with PA and mental health problems needs to be further examined.

Acknowledgments The Nord-Trøndelag Health Study (Helseundersøkelsen i Nord-Trøndelag, HUNT) is the result of collaboration between the HUNT Research Centre, Faculty of Medicine, Norwegian University of Science and Technology (NTNU), the Norwegian Institute of Public Health, and Nord-Trøndelag County Council.

Ethics The study was approved by the Regional Committee for Ethics in Medical Research and the National Data Inspectorate.

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