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Original Contribution

Physical Exercise, Body Mass Index, and Risk of Chronic Pain in the Low Back and Neck/Shoulders: Longitudinal Data From the Nord-Trøndelag Health Study

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Chronic musculoskeletal pain constitutes a large socioeconomic challenge, and preventive measures with documented effects are warranted. The authors' aim in this study was to prospectively investigate the association between physical exercise, body mass index (BMI), and risk of chronic pain in the low back and neck/shoulders. The study comprised data on approximately 30,000 women and men in the Nord-Trøndelag Health Study (Norway) who reported no pain or physical impairment at baseline in 1984–1986. Occurrence of chronic musculoskeletal pain was assessed at follow-up in 1995–1997. A generalized linear model was used to calculate adjusted risk ratios. For both females and males, hours of physical exercise per week were linearly and inversely associated with risk of chronic pain in the low back (women: P-trend = 0.02; men: P-trend < 0.001) and neck/shoulders (women: P-trend = 0.002; men: P-trend < 0.001). Obese women and men had an approximately 20% increased risk of chronic pain in both the low back and the neck/shoulders. Exercising for 1 or more hours per week compensated, to some extent, for the adverse effect of high BMI on risk of chronic pain. The authors conclude that physical inactivity and high BMI are associated with an increased risk of chronic pain in the low back and neck/shoulders in the general adult population.

body mass index; exercise; low back pain; neck pain; prospective studies; shoulder pain

Abbreviations: BMI, body mass index; CI, confidence interval; HUNT, Nord-Trøndelag Health Study.

Chronic musculoskeletal pain in the low back and neck/shoulders is a common cause of reduced quality of life, sick leave, and disability in Western industrialized countries, and the problem is expected to grow with the aging population (1–4). The negative consequences, for both the individual and society, highlight the importance of identifying primary preventive measures that are easily accessible for the general population.

Promotion of regular physical exercise and prevention of obesity are initiatives assumed to reduce the incidence of musculoskeletal pain (2). For example, obesity has been associated with increased prevalence of low back pain in several cross-sectional studies (5). A few prospective cohort studies have shown that exercise may reduce the risk of musculoskeletal pain (6–8), while other studies have found moderate or no associations (9). This inconsistency may be due to methodological limitations, such as small study samples and inclusion of persons with musculoskeletal pain at baseline.

Few studies have investigated the combined effect of exercise and excess body mass on future risk of chronic musculoskeletal pain. A recent study showed that overweight and obesity increased the risk of widespread chronic musculoskeletal pain (i.e., fibromyalgia) during an 11-year follow-up period, whereas physical exercise could compensate for this adverse effect to some extent (10). Whether physical exercise and excess body mass have a similar effect on risk of localized chronic pain in the low back or neck/shoulders is unknown.

Our primary aim in the current study was to investigate the association between physical exercise, body mass index (BMI), and risk of chronic musculoskeletal pain in the low back and neck/shoulders in a large unselected population of women and men without musculoskeletal pain or any physical impairment at baseline. We hypothesized 1) that an inverse relation exists between physical exercise and risk of chronic pain in the low back and neck/shoulders and 2) that physical exercise can compensate for the adverse effect of excess body mass on risk of chronic pain in the low back and neck/shoulders.

MATERIALS AND METHODS

Study population

In Nord-Trøndelag County, Norway, all inhabitants aged 20 years or older were invited to participate in 2 waves of a large health survey (the Nord-Trøndelag Health Study (HUNT)), the first in 1984–1986 (HUNT 1) and the second in 1995–1997 (HUNT 2). Among 87,285 eligible persons, 77,216 (89%) accepted the invitation to participate in HUNT 1, filled in a questionnaire, and underwent a clinical examination. At the examination, body mass and height were measured, and the participants were given a second questionnaire to complete at home and return in a prestamped envelope. During HUNT 2 in 1995–1997, 94,187 persons were invited to participate, and 66,215 (70%) accepted the invitation. The procedures were similar to those described for HUNT 1, although both the questionnaires and the clinical examination were more comprehensive. More detailed information about selection procedures, participation, and questionnaires used in the HUNT Study can be found at http://www.hunt.ntnu.no.

For the purpose of the present study, we selected all 24,357 women and 21,568 men who had participated in both surveys. We excluded 4,085 women and 3,446 men without baseline information on hours of physical exercise per week, 167 women and 113 men without data on musculoskeletal pain, and 13 women without information on weight. Moreover, we excluded 1,527 women and 1,528 men who reported being physically impaired at baseline because of a movement disorder or who had no information on this variable. To obtain a study sample of persons without musculoskeletal pain at baseline (i.e., at the time of HUNT 1), we excluded participants who reported that the pain had lasted for 10 years or more (1,613 women and 1,016 men with low back pain; 2,802 women and 1,669 men with neck/shoulder pain). Thus, the prospective analyses of chronic low back pain were based on 16,952 women and 15,465 men, while prospective analyses of chronic pain in the neck/shoulders were based on 15,763 women and 14,812 men. There was no difference in mean BMI (24.9 (standard deviation, 3.7) vs. 27.7 (standard deviation, 3.6)) or distribution of physical activity (39.4% inactive vs. 39.6% inactive) between the total population and the study sample, indicating no selection bias. The study was approved by the Regional Committee for Ethics in Medical Research and carried out according to the Declaration of Helsinki.

Study variables

Physical exercise. At baseline (HUNT 1), the participants were asked to complete a questionnaire that included questions on frequency, duration, and intensity of leisure-time physical exercise (i.e., walking, skiing, swimming, or other sports) per week. The frequency question had 5 response options (0, <1, 1, 2–3, or ≥4 times per week; coded 1–5). Participants who reported no activity or less than 1 exercise session per week were classified as inactive. Participants who reported exercising once a week or more often were also asked about the average duration of activity per session (<15, 15–30, 31–60, or >60 minutes; coded 1–4) and the average exercise intensity (no sweating or heavy breathing (i.e., low), sweating and/or heavy breathing (i.e., moderate), or nearly exhausted (i.e., vigorous); coded 1–3). In the analysis, moderate and vigorous activity were combined, resulting in a dichotomous variable of low-intensity activity versus moderate- or vigorous-intensity activity.

Based on information on frequency and duration, we calculated the average number of hours spent in physical exercise per week. The response option "2–3 times per week" was counted as 2.5 times per week, and "≥4 times per week" was counted as 5 times per week. The response option "<15 minutes" was counted as 10 minutes, "15–30 minutes" was counted as 25 minutes, "31–60 minutes" was counted as 45 minutes, and ">60 minutes" was counted as 75 minutes.

Body mass index. Standardized measurements of body height (to the nearest centimeter) and body weight (to the nearest half kilogram) obtained at the baseline examination in HUNT 1 were used to calculate BMI as weight (kg) divided by the square of height (m^2). Participants were then classified into one of 4 BMI groups according to the cutpoints suggested by the World Health Organization (11): underweight (BMI <18.5), normal weight (BMI 18.5–24.9), overweight (BMI 25.0–29.9), or obese (BMI ≥30.0).

Chronic musculoskeletal pain. The questions about musculoskeletal symptoms were adopted from the Standardized Nordic Questionnaire (12). On the first questionnaire in HUNT 2, the participants were asked, "During the last year, have you had pain and/or stiffness in your muscles and limbs that lasted for at least 3 consecutive months?" Response options were "yes" and "no." If answering yes, the participants were asked to indicate the affected body area(s). In the statistical analyses, chronic pain in the neck, chronic pain in the shoulders, and chronic pain in the upper back were combined to indicate chronic pain in the neck/shoulders, whereas chronic low back pain was analyzed separately.

Statistical analyses

A generalized linear model for the binomial family (log link) was used to estimate risk ratios for chronic musculoskeletal pain in the low back and neck/shoulders. Participants who reported different levels of physical exercise at baseline were compared with the reference group of physically inactive participants. The risk ratio for chronic musculoskeletal pain between categories of BMI was estimated in similar models. The precision of the estimated risk ratios was assessed using 95% confidence intervals, and tests for trends across categories of physical exercise and BMI were conducted by treating the categories as an ordinal variable in the regression model. All analyses were stratified by gender.

Table 1. Baseline Characteristics of the Study Population According to Level of Physical Exercise, Nord-Trøndelag Health Study, 1984–1997

Characteristic	Women						Men					
	Inactive			Active (≥1 Hour/Week)			Inactive			Active (≥1 Hour/Week)		
	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)
No. and % of participants	10,733	63		6,219	37		9,613	62		5,852	38	
Age, years			43.2 (13.8)			45.9 (14.6)			43.1 (13.3)			45.2 (14.6)
Body mass index[a]			24.4 (4.2)			24.5 (3.8)			25.2 (3.1)			24.9 (2.8)
Overweight or obese[b]	4,080	38		2,287	37		4,755	44		2,568	50	
Manual worker	1,756	16		957	15		3,506	37		1,954	33	
Current smoker	3,796	35		1,609	26		3,638	39		1,401	24	

Abbreviation: SD, standard deviation.
[a] Weight (kg)/height (m)^2.
[b] Body mass index ≥25.

The basic models were adjusted for age in 10-year categories (20–29, 30–39, . . ., 60–69, or ≥70 years). In additional multivariable analyses, we adjusted for occupation (manual, nonmanual, farmer/fisher, nonworker, or unknown) and smoking (never smoker, former smoker, current smoker, or unknown). In addition, BMI (<18.5, 18.5–24.9, 25.0–29.9, or ≥30.0) and frequency of physical exercise (inactive, 1 times/week, 2–3 times/week, or ≥4 times/week) were mutually adjusted for in the full models.

Additionally, we conducted a stratified analysis to examine whether exercise intensity modified the association between hours of exercise and risk of pain and included a product term for intensity × hours of exercise in the regression model to formally evaluate the statistical interaction using a likelihood ratio test. The combined effect of BMI (i.e., normal weight, overweight, or obese) and exercise (i.e., inactive vs. ≥1 hour/week) was also assessed, using participants with normal weight who exercised for 1 hour or more per week as the reference group. The effect of exercise within each BMI category was estimated in subsequent stratified analysis.

All statistical tests were 2-sided, and all statistical analyses were performed using Stata for Windows, version 10.0 (StataCorp LP, College Station, Texas).

RESULTS

Table 1 and Table 2 present the characteristics of the study population according to physical exercise and BMI at baseline, respectively. At follow-up, 1,824 (11%) women and 1,490 (10%) men reported chronic low back pain, whereas 3,317 (21%) women and 2,567 (17%) men reported chronic pain in the neck/shoulders.

Table 3 shows that hours of leisure-time physical exercise per week were inversely associated with risk of chronic pain in the low back (P-trend = 0.02 in women and P-trend < 0.001 in men) and the neck/shoulders (P-trend = 0.002 in women and P-trend < 0.001 in men). Women who exercised for 1.0–1.9 hours per week had an adjusted risk ratio for low back pain of 0.84 (95% confidence interval (CI): 0.74, 0.95) in comparison with inactive women, and the corresponding risk ratio for men was 0.88 (95% CI: 0.77, 1.00). The risk ratio was further reduced among men who exercised for ≥2.0 hours per week (risk ratio = 0.75, 95% CI: 0.64, 0.88). The associations between exercise and neck/shoulder pain followed a pattern similar to that for low back pain. Women and men who exercised for 1.0–1.9 hours per week had adjusted risk ratios of 0.87 (95% CI: 0.80, 0.95) and 0.88 (95% CI: 0.80, 0.97), respectively, compared with inactive women and men. Increasing the amount of exercise to ≥2.0 hours per week further reduced the risk ratio for neck/shoulder pain in men (risk ratio = 0.81, 95% CI: 0.72, 0.91).

The effect of exercise intensity was assessed in stratified analyses (data not shown). Overall, the inverse associations between hours per week of exercise and risk of pain in the low back and neck/shoulders were largely similar among those who reported that their usual exercise intensity was moderate or vigorous and those who reported that their usual exercise intensity was low (i.e., the mean difference between adjusted risk ratios was less than 3% for low back pain and less than 6% for neck/shoulder pain). Accordingly, none of the interaction terms were significant (P values from likelihood ratio tests among women and men were 0.09 and 0.79, respectively, for low back pain and 0.41 and 0.11, respectively, for neck/shoulder pain).

Table 4 shows that BMI was consistently and positively associated with risk of chronic pain in the low back and neck/shoulders among women (P-trend < 0.001 and P-trend = 0.002, respectively) and with risk of neck/shoulder pain in men (P-trend < 0.001). Women who were obese had an adjusted risk ratio of 1.21 (95% CI: 1.04, 1.41) for low back pain and 1.19 (95% CI: 1.07, 1.33) for neck/shoulder pain, compared with women with normal weight. The corresponding risk ratios among men were 1.21 (95% CI: 0.99, 1.46) and 1.22 (95% CI: 1.06, 1.41).

Table 5 shows the combined effect of physical exercise and BMI on risk of chronic pain in the low back and neck/shoulders. The overall results indicated that, irrespective of their baseline BMI, women and men who reported exercising for ≥1 hour per week had a lower risk of chronic pain in

Table 2. Baseline Characteristics of the Study Population According to Body Mass Index[a], Nord-Trøndelag Health Study, 1984–1997

Characteristic	Women									Men								
	Normal Weight (BMI 18.5–24.9)			Overweight (BMI 25–29.9)			Obese (BMI ≥30)			Normal Weight (BMI 18.5–24.9)			Overweight (BMI 25–29.9)			Obese (BMI ≥30)		
	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)
No. and % of participants	10,257	61		4,706	28		1,661	10		8,093	52		6,362	41		961	6	
Age, years			40.5 (12.8)			50.0 (13.9)			52.6 (13.4)			41.2 (13.7)			46.7 (13.4)			48.5 (13.1)
Inactive	6,418	64		2,961	63		1,119	67		4,820	60		4,081	64		674	70	
Manual worker	1,669	16		757	16		248	15		2,902	36		2,222	35		316	33	
Current smoker	3,755	37		1,127	24		318	19		2,865	35		1,897	30		256	27	

Abbreviations: BMI, body mass index; SD, standard deviation.
[a] Weight (kg)/height $(m)^2$.

the low back and neck/shoulders than those who reported being inactive. Compared with the reference group of normal-weight women who exercised for ≥1 hour per week, women who were obese and inactive had a risk ratio of 1.41 (95% CI: 1.13, 1.77) for low back pain, whereas those who were obese and exercised for ≥1 hour per week had a risk ratio of 1.16 (95% CI: 0.87, 1.56). Correspondingly, the risk ratio was 1.50 (95% CI: 1.16, 1.95) for low back pain in obese and inactive men and 1.16 (95% CI: 0.78, 1.73) in obese men who exercised for ≥1 hour per week. Similar effects of exercise were seen among those who were classified as overweight and in analysis of neck/shoulder pain.

DISCUSSION

The main finding in the present study was a consistently lower risk of chronic pain in the low back and neck/shoulders associated with a relatively small amount of physical exercise per week. The reductions in risk were of similar magnitude among women and men. Independently of physical exercise, persons classified as overweight and obese had a higher risk of chronic pain in the low back and neck/shoulders than persons classified as normal weight. Physical exercise could compensate, to some extent, for the adverse effect of excess body mass on risk of chronic pain in both the low back and neck/shoulders.

Musculoskeletal pain is one of the most common reasons for seeking medical advice in Western societies (13, 14). Pain in the neck/shoulders and pain in the low back constitute the majority of all musculoskeletal disorders (4), and in the Netherlands the total economic cost of low back pain alone has been estimated as 1.7% of the gross national product (15). Thus, just a small reduction in the incidence of chronic low back pain would have a profound economic impact. Importantly, the current study indicates that a relatively small amount of physical exercise (i.e., 1–1.9 hours/week) lowers the risk of chronic pain in the low back and neck/shoulders. Increasing numbers of hours of exercise per week were associated with a further reduction in risk among men. However, analyses of high-intensity versus low-intensity exercise showed no major differences in the estimated risk ratios. If these results reflect a true causal association, they could potentially be of great value for public health. Accumulating 1−2 hours of low- to moderate-intensity physical exercise during a week should be manageable for most people.

Several cross-sectional studies have shown a relatively strong association between obesity and the prevalence of chronic pain in the neck, shoulders, and low back, especially among women (5, 16, 17). However, the cross-sectional design of these studies prevents inference about causality, and results from a few prospective studies have shown somewhat conflicting results; a Finnish study found no association between body mass at baseline and future risk of low back pain (18), whereas a larger and more recent study found that obesity at age 23 years increased the risk of low back pain among women 10 years later (19). Excess body weight has also been associated with increased 1-year incidence of neck and shoulder complaints in occupation-based

Table 3. Risk Ratio for Chronic Pain in the Neck/Shoulders and Low Back at 11-Year Follow-up According to Hours of Physical Exercise per Week at Baseline, Nord-Trøndelag Health Study, 1984–1997

Gender and Category of Exercise, hours/week	Pain in the Low Back					Pain in the Neck/Shoulders				
	No. of Persons	No. of Cases	Multivariate-Adjusted[a] RR	95% CI	*P*-Trend	No. of Persons	No. of Cases	Multivariate-Adjusted[a] RR	95% CI	*P*-Trend
Women										
Inactive[b]	6,408	741	1.00			5,915	1,338	1.00		
<1	4,774	494	0.90	0.81, 1.01		4,456	928	0.95	0.88, 1.02	
1–1.9	3,802	361	0.84	0.74, 0.95		3,565	661	0.87	0.80, 0.95	
≥2	1,968	196	0.92	0.79, 1.07	0.02	1,827	335	0.91	0.81, 1.01	0.002
Men										
Inactive[b]	6,478	690	1.00			6,188	1,189	1.00		
<1	3,338	314	0.91	0.80, 1.03		3,228	556	0.93	0.85, 1.02	
1–1.9	3,303	299	0.88	0.77, 1.00		3,150	493	0.88	0.80, 0.97	
≥2	2,346	173	0.75	0.64, 0.88	<0.001	2,246	306	0.81	0.72, 0.91	<0.001

Abbreviations: CI, confidence interval; RR, risk ratio.
[a] Adjusted for age (20–29, 30–39, . . ., or ≥70 years), body mass index (continuous), smoking (never smoker, former smoker, current smoker, or unknown), and occupation (manual, nonmanual, farmer/fisher, nonworker, or unknown).
[b] Less than 1 exercise session per week.

cohorts (20−22). Unlike previous studies, our study focused on chronic musculoskeletal pain in the general adult population. Overweight and obesity were associated with an increased risk of chronic pain in the neck/shoulders and low back among both women and men, although the result for low back pain among men was marginally nonsignificant. Thus, the current findings add novel information concerning the effect of excess body weight as a modifiable risk factor for chronic pain in the low back and neck/shoulders in the general adult population.

The relation between high BMI and risk of chronic musculoskeletal pain underlines the importance of promoting preventive measures aimed at reducing the incidence of overweight and obesity. Of particular concern is the recent increase in overweight and obesity among adolescents and young adults, with a strong carryover effect into adulthood (23). Thus, preventive initiatives should focus on promoting healthy nutrition and regular physical exercise among both children and adolescents and adults. However, the findings of the current study indicate that overweight and obese

Table 4. Risk Ratio for Chronic Pain in the Neck/Shoulders and Low Back at 11-Year Follow-up According to Body Mass Index at Baseline, Nord-Trøndelag Health Study, 1984–1997

Gender and BMI[a] Category[b]	Pain in the Low Back					Pain in the Neck/Shoulders				
	No. of Persons	No. of Cases	Multivariate-Adjusted[c] RR	95% CI	*P*-Trend	No. of Persons	No. of Cases	Multivariate-Adjusted[c] RR	95% CI	*P*-Trend
Women										
Underweight	318	31	0.94	0.67, 1.32		298	65	1.00	0.81, 1.25	
Normal weight	10,267	1,056	1.00			9,564	1,976	1.00		
Overweight	4,706	522	1.18	1.06, 1.30		4,381	902	1.12	1.04, 1.21	
Obesity	1,661	183	1.21	1.04, 1.41	<0.001	1,520	319	1.19	1.07, 1.33	0.002
Men										
Underweight	49	5	1.08	0.47, 2.47		49	6	0.75	0.35, 1.58	
Normal weight	8,093	764	1.00			7,787	1,258	1.00		
Overweight	6,362	601	1.03	0.93, 1,14		6,071	1,100	1.12	1.04, 1.21	
Obesity	961	106	1.21	0.99, 1.46	0.13	905	180	1.22	1.06, 1.41	<0.001

Abbreviations: BMI, body mass index; CI, confidence interval; RR, risk ratio.
[a] Weight (kg)/height (m)^2.
[b] According to the World Health Organization cutpoints: underweight (BMI <18.5), normal weight (BMI 18.5–24.9), overweight (BMI 25.0–29.9), and obesity (BMI ≥30.0).
[c] Adjusted for age (20–29, 30–39, . . ., or ≥70 years), frequency of physical exercise (inactive, <1 hour/week, 1–1.9 hours/week, or ≥2 hours/week), smoking (never smoker, former smoker, current smoker, or unknown), and occupation (manual, nonmanual, farmer/fisher, nonworker, or unknown).

Table 5. Risk Ratio for Chronic Pain in the Neck/Shoulders and Low Back at 11-Year Follow-up According to the Combined Effect of Physical Exercise and Body Mass Index at Baseline, Nord-Trøndelag Health Study, 1984–1997

Pain Location, Gender, and BMI[a] Category[b]	Active[c]				Inactive[d]				*P* Value[e]
	No. of Persons	No. of Cases	Multivariate-Adjusted[f] RR	95% CI	No. of Persons	No. of Cases	Multivariate-Adjusted[f] RR	95% CI	
Low back									
Women									
Normal weight	3,241	331	1.00		3,288	419	1.17	1.02, 1.35	<0.001
Overweight	1,453	173	1.26	1.05, 1.50	1,592	216	1.36	1.15, 1.60	0.10
Obesity	440	47	1.16	0.87, 1.56	652	89	1.41	1.13, 1.77	0.06
Men									
Normal weight	2,906	266	1.00		2,861	327	1.17	1.00, 1.37	0.02
Overweight	2,017	181	1.04	0.87, 1.25	2,467	298	1.28	1.09, 1.50	0.05
Obesity	244	24	1.16	0.78, 1.73	434	61	1.50	1.16, 1.95	0.13
Neck/shoulders									
Women									
Normal weight	2,708	636	1.00		2,661	767	1.09	0.99, 1.20	0.03
Overweight	1,260	254	0.99	0.86, 1.13	1,272	401	1.31	1.17, 1.46	<0.001
Obesity	358	95	1.28	1.05, 1.55	537	134	1.15	0.97, 1.36	0.83
Men									
Normal weight	2,624	422	1.00		2,505	553	1.19	1.05, 1.34	<0.001
Overweight	1,757	331	1.15	1.01, 1.32	2,101	529	1.34	1.19, 1.51	0.01
Obesity	206	44	1.28	0.96, 1.69	367	104	1.49	1.23, 1.81	0.30

Abbreviations: BMI, body mass index; CI, confidence interval; RR, risk ratio.

[a] Weight (kg)/height (m)^2.

[b] According to the World Health Organization cutpoints: normal weight (BMI 18.5–24.9), overweight (BMI 25.0–29.9), and obesity (BMI ≥30.0).

[c] 1 or more hours of physical exercise per week.

[d] Less than 1 physical exercise session per week.

[e] *P* value comparing active and inactive persons within each BMI category.

[f] Adjusted for age (20–29, 30–39, . . ., or ≥70 years), smoking (never smoker, former smoker, current smoker, or unknown), and occupation (manual, nonmanual, farmer/fisher, nonworker, or unknown).

women and men who exercise regularly have a consistently lower risk of chronic pain in the low back and neck/shoulders than those who are inactive. Among overweight and obese men, exercising for 1 hour or more per week was associated with a >20% reduction in the risk of chronic pain in both the low back and the neck/shoulders compared with being inactive. A similar but less consistent effect was found among women.

The exact physiologic mechanisms underlying the contrasting effects of excess body mass and physical exercise on risk of chronic musculoskeletal pain are unclear. One possible explanation may be that obesity induces chronic low-grade systemic inflammation (24, 25), while exercise has an opposite effect by promoting a reduction in inflammatory factors (26). Several cross-sectional studies have shown a positive association between obesity and serum levels of proinflammatory cytokines such as interleukin-6 and tumor necrosis factor α (for review, see Das (25)). Recent evidence indicates that interleukin-6 and tumor necrosis factor α may be involved in the progression of chronic pain (27, 28) and that the serum level of these cytokines predicts pain intensity in chronic pain patients (29). However, further studies are needed to elucidate the exact mechanism.

The strengths of the current study are the large and unselected population, the prospective design, the standardized measurement of height and weight, the exclusion of persons with pain and physical impairments at baseline, and the possibility of adjusting for several potentially confounding factors. The questions on chronic musculoskeletal pain used in HUNT 2 have acceptable reliability and validity (12, 30), and the physical exercise questionnaire used in HUNT 1 has been validated against measured maximal oxygen uptake in a random sample of men and found to perform well, with a correlation coefficient of 0.48 (31). A limitation of the study is that information on exercise and BMI was obtained only at baseline, and changes occurring during the follow-up period could not be taken into account.

In conclusion, this prospective population-based study showed that men and women who reported exercising for 1 hour or more per week had a lower risk of chronic pain in the low back and neck/shoulders than inactive persons. Conversely, overweight and obesity were associated with increased risk of chronic pain in both the low back and neck/shoulders. Physical exercise may compensate to some extent for the adverse effect of excess body mass on risk of chronic musculoskeletal pain. Community-based initiatives aimed at reducing the incidence of chronic pain in the low back and neck/shoulders should include the promotion of regular physical exercise and maintenance of normal body weight.

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