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Excess body mass and leisure-time physical activity in the incidence and persistence of chronic pain

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Declaration of interest

The authors declare that they have no conflicts of interest.

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Contributors' Statement

TL and OR participated in design and acquisition of the data. RS carried out the analyses. All authors interpreted the results and participated in the preparation of the manuscript. All authors reviewed the final version of the manuscript and approved it to be submitted for publication.

Abstract

OBJECTIVE: To estimate the effects of excess body mass and leisure-time physical activity on the incidence and persistence of chronic pain.

DESIGN: A prospective cohort study.

METHODS: As a part of the Finnish Helsinki Health Study, we included three cohorts of employees of the City of Helsinki (18562 observations) and defined incident chronic pain as having pain in any part of the body >3 months at follow-up in participants without chronic pain at baseline (N=13029 observations). Persistent chronic pain was defined as having pain >3 months at both baseline and follow-up (N=5533 observations).

RESULTS: Overweight (adjusted odds ratio (OR)=1.18, 95% CI 1.06-1.31) and obesity (OR=1.65, CI 1.45-1.88) increased the incidence of chronic pain. Moreover, overweight (OR=1.16, CI 1.02-1.32) and obesity (OR=1.48, CI 1.26-1.74) increased the risk of persistent chronic pain. Vigorous leisure-time physical activity reduced the incidence of chronic pain (OR=0.85, CI 0.75-0.96). Physical activity did not influence the risk of persistent chronic pain. Furthermore, overweight/obesity modified the effect of leisure-time physical activity on incident chronic pain. Inactive overweight or obese participants were at the highest risk of chronic pain (OR=1.71, CI 1.40-2.09), while the OR dropped to 1.44 (CI 1.19-1.75) in moderately active overweight or obese participants and to 1.20 (CI 0.97-1.47) in highly active overweight or obese participants.

CONCLUSION: Obesity not only increases the risk of developing chronic pain, but also increases the risk of persistent pain, while leisure-time physical activity reduces the risk of developing chronic pain.

KEYWORDS: Exercise, leisure activities, overweight, obesity

Introduction

Chronic pain is a common condition in the general population [1-6], and a common reason to visit a primary care doctor [7], a medical specialist [5] or other health professionals [5].

Chronic pain contributes to disability and mental health problems, reduces the quality of life and imposes high burden on society [5, 6, 8, 9]. Previous studies estimate that 16% to 43% of the general population report pain in any body site lasting longer than three months [1-6].

Furthermore, the prevalence of chronic pain has increased over time [1, 2], is more common in women than in men, and increases with age [1-6]. The most common sources of chronic pain in adults are back disorders, arthritis and headache [6].

Many cross-sectional studies have found that chronic pain is more common in people who are overweight or obese than in individuals who are normal weight [5, 10-13]. Both body mass index and abdominal obesity defined by waist circumference have shown similar relationships with chronic pain [14]. Obesity and chronic pain are comorbid conditions and have adverse effects on each other [15], and reverse causation cannot be ruled out in cross-sectional studies. Thus, overweight/obesity can be either a cause or a consequence of chronic pain. Prospective cohort studies on this topic are, however, scarce.

To date, the role of exercise and other leisure-time physical activities in chronic pain is still uncertain [16]. Systematic reviews of controlled trials showed that exercise reduces pain severity and improves physical functioning [16], however, the size of beneficial effects of exercise on pain is small [16]. Similarly, a systematic review and meta-analysis of observational studies [17] found that leisure-time physical activity reduces the risk of developing chronic low back pain only by 10-15%.

To date, little is known whether overweight or obesity modifies the effect of leisure-time physical activity on chronic pain. A population-based prospective cohort study [18] found that exercise compensates, to some degree, for the adverse effect of excess body mass on chronic musculoskeletal pain. The aim of the current study was to estimate the effects of body mass index and leisure-time physical activity on the incidence of chronic pain and risk of persistent chronic pain and to determine whether body mass index modifies the effect of leisure-time physical activity on these outcomes.

Methods

Population

This study is part of the ongoing Finnish Helsinki Health Study [19]. A total of 8960 employees of the City of Helsinki aged 40 to 60 years (response rate 67%) participated in the baseline survey in 2000/2002 (Figure 1) and 8755 responded to pain questions. Of those, 7132 took part in the first follow-up survey in 2007, 6664 in the second in 2012, and 6518 in the third follow-up survey in 2017. Three cohorts (2000/2002-2007, 2007- 2012, and 2012-2017) were included in the current analysis. After excluding subjects with missing data, 7000 participants were included in the 2000/2002-2007 cohort, 5973 in the 2007- 2012 cohort, and 5589 in the 2012-2017 cohort. Altogether 13029 observations without chronic pain at baseline were included in the analyses on incident chronic pain, and 5533 observations with chronic pain at baseline in the analysis on persistent chronic pain.

The ethics committees of the health authorities of the City of Helsinki and of the Department of Public Health, University of Helsinki, approved the study.

Lifestyle factors (exposure variables)

Leisure-time physical activity, including commuting, was assessed with four identical questions in all phases [20]. Information on the participants' average weekly hours of leisure-time physical activity within the past 12 months was collected regarding four grades of intensity: 1) walking, 2) brisk walking, 3) jogging, and 4) running, or their equivalent activities [21]. The number of hours per week for each activity grade ranged between 0 and 4 hours. A metabolic equivalent (MET) index was calculated for each participant by multiplying the MET-values of each activity intensity by the time spent on them, and summing [20, 21]. The intensity of leisure-time physical activity was classified into three groups: low (<14 MET-hours per week), moderate (≥ 14 MET-hours of moderate intensity activities with no vigorous activities), and vigorous (≥ 14 MET-hours, including some vigorous activity such as jogging or running) activity. The three groups were mutually exclusive. Body weight and height and tobacco smoking status were self-reported in all phases [20]. *Body mass index* (BMI) was calculated based on weight and height and grouped into four levels: underweight (BMI <18.5 kg/m²), normal (BMI 18.5-24.9 kg/m²), overweight (BMI 25.0-29.9 kg/m²) and obese (BMI ≥ 30 kg/m²). *Smoking status* was classified into never smokers, past smokers and current daily smokers of cigarettes, cigars or pipe.

Chronic pain (outcome)

Information on current pain was gathered by two identical questions in all phases. The first question was: "Do you have any pain or ache right now? (No/Yes)". Those who gave an affirmative response were further asked: "When did the pain start? (not more than 3 months ago/ more than 3 months ago)". The outcome variable in the current study was chronic pain, defined as pain or ache in any part of the body for longer than 3 months. We defined incident

chronic pain as having pain for longer than 3 months at follow-up in participants free from chronic pain at baseline, and persistent chronic pain as having pain for longer than 3 months at both baseline and follow-up.

Covariates

Information on age, gender, marital status (single, cohabiting, married, divorced or widowed), education (elementary school, middle school, vocational school or equivalent, college degree, university degree), household income, and frequency of alcohol consumption was gathered in all surveys. Physical workload factors were assessed with eight items: (i) awkward postures, (ii) rotation of back, (iii) repetitive movements, (iv) standing, (v) sitting, (vi) walking, (vii) heavy physical effort or lifting and carrying heavy loads, and (viii) vibration. Job demands and job control were assessed using the Karasek's Job Content Questionnaire [22].

Statistical analysis

We used the generalized estimating equation method to analyze repeated measures data on chronic pain [23]. We adjusted the estimates for age (continuous), gender, education, marital status, household income, smoking, body mass index, leisure-time physical activity, job demands (continuous), job control (continuous), heavy physical work or lifting/carrying heavy loads, awkward posture, rotation of the back, repetitive movements, and prolonged standing or sitting.

We performed gender-specific analyses and stratified analyses by body mass index to determine whether overweight or obesity modifies the effect of leisure-time physical activity on chronic pain. In the models, we tested for the presence of multiplicative interaction of body mass index (two groups: overweight or obesity vs. normal) with leisure-time physical activity (three groups). Furthermore, in the analysis of incident chronic pain we conducted a sensitivity analysis including only the participants free from any pain at baseline (acute/subacute or

chronic pain). We used STATA, version 15, (StataCorp, College Station, TX, USA) for the analyses.

Results

Incident chronic pain

Of 13029 observations without chronic pain at baseline (Table 1), 34.7% were overweight and 14.8% obese at baseline. Furthermore, 17.9% were current daily smokers, 38.5% were moderately and 40.0% highly active during leisure-time. Overall, 20.5% reported incident chronic pain at follow-up.

Obesity was associated with incident chronic pain in both men (odds ratio (OR) = 1.47, 95% CI 1.06-2.04, Table 2) and women (OR = 1.68, CI 1.46-1.94) after adjustment for age, education, smoking and leisure-time physical activity, whereas overweight was associated with incident chronic pain in women only (OR = 1.21, CI 1.08-1.36, Table 2). Vigorous leisure-time physical activity was inversely associated with incident chronic pain in women only (OR = 0.84, CI 0.73-0.96) after adjustment for age, education, smoking and body mass index. Among those occupationally active and with information available on work-related factors (N = 9383 observations), both overweight (OR=1.13, CI 1.00-1.27) and obesity (OR= 1.54, CI 1.32-1.79) were associated with incident chronic pain after adjustment for age, gender, education, marital status, household income, smoking, leisure-time physical activity, job demands, job control, heavy physical work or lifting/carrying heavy loads, awkward posture, rotation of the back, repetitive movements, prolonged standing and prolonged sitting (Table 3). Leisure-time physical activity was not associated with incident chronic pain. In gender-specific analyses, the OR for overweight was 0.96 (CI 0.72-1.28) in men and 1.16 (CI 1.02-1.32) in women and the

OR for obesity was 1.38 (CI 0.93-2.04) in men and 1.56 (CI 1.32-1.84) in women. Leisure-time physical activity was not associated with chronic pain in either men or women.

Overweight or obesity modified the effect of leisure-time physical activity on incident chronic pain (Table 4). Leisure-time physical activity compensated for the adverse effect of overweight or obesity on incident chronic pain. There was a statistically significant multiplicative interaction between overweight/obesity and moderate (P for interaction = 0.01) and vigorous (P for interaction = 0.002) leisure-time physical activity for incident chronic pain. Overweight or obese participants who were also inactive during leisure time were at the highest risk of chronic pain (OR = 1.71, CI 1.40-2.09), while the OR dropped to 1.44 (CI 1.19-1.75) in overweight or obese participants who were moderately active and to 1.20 (CI 0.97-1.47) in overweight or obese participants who were highly active (Table 4). In a sensitivity analysis, where we included only participants free from acute/subacute or chronic pain at baseline (10260 observations), the results were similar to the main analysis of the 13029 observations without chronic pain at baseline.

Persistent chronic pain

Of the 5533 observations with chronic pain at baseline (Table 1), 37.8% were overweight, 21.9% obese, and 18.6% were current daily smokers. Moreover, 42.2% were moderately and 29.7% highly active during leisure-time. At follow-up, 55% experienced persistent chronic pain.

After adjustment for age, education, smoking and leisure-time physical activity, overweight (OR = 1.19, CI 1.04-1.37) and obesity (OR = 1.52, CI 1.28-1.81) increased the risk of persistent chronic pain in women only. Moderate and high levels of leisure-time physical activity reduced the risk in men; however, the estimates did not reach statistical significance

after adjustment for age, education, smoking and body mass index (Table 2). Among the occupationally active with data available on work-related factors (3792 observations), only obesity increased the risk of persistent chronic pain in both genders combined (OR=1.30, CI 1.08-1.58, Table 3). In gender-specific analyses, the OR for obesity was 1.26 (CI 1.02-1.54) in women and 1.64 (CI 0.97-2.78) in men, while it was 0.61 (CI 0.39-0.96) for moderate and 0.74 (CI 0.48-1.13) for high leisure-time physical activity in men.

Overweight or obesity did not modify the effect of leisure-time physical activity on persistent chronic pain (Table 4).

Discussion

The current prospective cohort study among municipal employees suggests that being overweight or obese increases the risk of incident as well as persistent chronic pain. Vigorous leisure-time physical activity reduced the risk of new episodes of chronic pain, but not that of persistent chronic pain.

Association between BMI and chronic pain

Most of the previous studies on the associations of excess body mass and leisure-time physical activity with chronic pain have been cross-sectional. Because of physical disability or fear of movement, individuals with chronic pain are more likely to be physically inactive than individuals without chronic pain [24]. Physical inactivity consequently leads to weight gain and overweight [25]. In line with our results on any chronic pain, a large prospective cohort study showed that both overweight and obesity increased the risk of chronic musculoskeletal pain, whereas leisure-time physical activity reduced the risk [18]. Our results show that obesity

not only increases the risk of new episodes of chronic pain, but also that of persistent pain. Also among young people, obese individuals showed smaller improvement in chronic pain over time than normal weight individuals [26].

To date, very few studies have determined whether overweight or obesity modifies the effect of leisure-time physical activity on chronic pain. The present study suggests that both moderate and high levels of physical activity during leisure-time protect against the development of chronic pain in overweight or obese individuals. In line with the current study, prospective cohort studies found that leisure-time physical activity compensates to some extent for the adverse effect of overweight/obesity on chronic pain [18] and low back pain [27].

In gender-specific analysis, overweight slightly increased the risk of incident and persistent chronic pain in women only. A stronger effect of excess body mass on musculoskeletal pain in women than men has also been reported by other studies [28, 29]. In the present study, the effect of obesity on persistent chronic pain was not statistically significant in men, which is more likely due to low statistical power of the study. Vigorous leisure-time physical activity reduced the risk of persistent chronic pain in men only. Of the participants with persistent chronic pain, men were more active during leisure-time than women (48% vs. 39%), however, the observed difference may be due to a relatively small male population.

Mechanisms

Mechanisms underlying the association between obesity and chronic pain are not well-known. The effect of obesity on chronic pain may be mediated through mechanical loading, inflammation, and psychological factors [30]. Obesity can cause pain via abdominal loading on weight-bearing joints [31]. Reducing abdominal fat reduces the systemic markers of inflammation [32]. Leisure-time physical activity may therefore reduce chronic pain through

reducing systemic inflammation in individuals who are obese [32]. However, a study [14] found that the association of abdominal obesity with chronic pain is independent of insulin resistance, inflammatory marker of high-sensitivity C-reactive protein, osteoarthritis, and neuropathy. The association between excess body mass and chronic pain can also partly be explained by depression [33].

Exercise may have modest beneficial effects on chronic pain [34]. However, it is still unclear what types of exercise are effective in the prevention and management of chronic pain [34]. In people free from chronic low back pain, moderate or vigorous leisure-time physical activity protects against the development of chronic low back pain [17], and in patients with chronic low back pain, walking reduces pain and disability [35]. Moreover, in patients with chronic pain, weight loss improves health-related quality of life [24]. Future studies should explore whether physical activity during leisure-time plus diet low in fat and sugar can prevent against chronic pain and whether moderate or vigorous leisure-time physical activity reduces the rate of recurrent or persistent chronic pain.

Strengths and limitations

In this prospective cohort study with long follow-up, four repeated surveys collected data on chronic pain using identical questions among a relatively large sample. The response rates to the follow-up surveys were high (78-83%). Information on a large set of the potential determinants of pain was available and we could control the observed associations for socioeconomic factors, workplace physical and psychosocial factors, and other lifestyle factors. The current study, however, had some limitations. The study had low statistical power to determine the role of lifestyle factors in chronic pain among men. Data on body weight and height, and leisure-time physical activity were based on self-reports. Self-report measures of physical activity may both over- and under-report physical activity [36]. Women may

underreport their weight and men may over-report their height [37]. We may have therefore underestimated the association between body mass index and chronic pain in both men and women. In all time points, we have collected data on pain in various body locations, such as pain in neck or shoulders, low back, upper limbs, and lower limbs. However, we did not report the associations of body mass index and leisure-time physical activity with pain in different body locations.

Conclusions

Obesity not only increases the risk of developing chronic pain, but also increases its persistence rate. On the other hand, leisure-time physical activity protects against the development of chronic pain, particularly among individuals who are overweight or obese.

Figure legend

Figure 1: Flow chart of the study population, Helsinki Health Study

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Table 1. Baseline characteristics of the study population, proportions (%).

Characteristic	Sample without chronic pain at baseline (N=13029 observations)	Sample with chronic pain at baseline (N=5533 observations)
Age in 2000/2002		
40	20.5	15.1
45	21.3	19.5
50	21.1	24.2
55	25.2	27.9
60	11.9	13.3
Female	80.3	85.7
Body mass index		
Overweight	34.7	37.8
Obese	14.8	21.9
Smoking		
Past	26.8	28.7
Current	17.9	18.6
Leisure-time physical activity (MET)		
Moderate	38.5	42.2
Vigorous	40.0	29.7
Physical workload factors		
Awkward postures	44.0	64.3
Rotation of the back	35.9	55.6
Repetitive movements	33.7	54.8
Heavy physical effort or lifting/carrying heavy loads	8.3	20.7
Prolonged standing	15.9	30.3
Prolonged sitting	26.4	40.4
Exposure to vibration	4.2	5.7

Table 2: The associations of body mass index and leisure-time physical activity with incident and persistent chronic pain

Characteristic	Men				Women				Both genders			
	N	Cases	OR *	95% CI	N	Cases	OR *	95% CI	N	Cases	OR *	95% CI
Incident pain												
Body mass index												
Underweight	4	1	-	-	106	22	1.17	0.72-1.91	110	23	1.19	0.74-1.91
Normal	1021	151	1		5376	998	1		6397	1149	1	
Overweight	1138	184	1.04	0.81-1.33	3337	752	1.21	1.08-1.36	4475	936	1.18	1.06-1.31
Obese	377	82	1.47	1.06-2.04	1530	448	1.68	1.46-1.94	1907	530	1.65	1.45-1.88
Leisure-time physical activity												
Low	577	105	1		2186	529	1		2763	634	1	
Moderate	711	119	0.97	0.72-1.30	4239	947	0.96	0.84-1.09	4950	1066	0.96	0.86-1.08
Vigorous	1229	189	0.90	0.67-1.19	3920	739	0.84	0.73-0.96	5149	928	0.85	0.75-0.96
Persistent pain												
Body mass index												
Normal	274	126	1		1886	969	1		2160	1095	1	
Overweight	323	151	0.98	0.69-1.39	1743	996	1.19	1.04-1.37	2066	1147	1.16	1.02-1.32
Obese	177	100	1.29	0.82-2.03	1017	639	1.52	1.28-1.81	1194	739	1.48	1.26-1.74
Leisure-time physical activity												
Low	238	131	1		1304	740	1		1542	871	1	
Moderate	237	110	0.74	0.52-1.05	2068	1191	1.08	0.93-1.24	2305	1301	1.02	0.89-1.16
Vigorous	299	135	0.73	0.51-1.05	1323	702	1.02	0.86-1.20	1622	837	0.97	0.83-1.12

* Adjusted for age, gender (both genders combined), education, smoking, body mass index (for leisure-time physical activity) and leisure-time physical activity (for body mass index)
OR, odds ratio; N, number of observations; CI, confidence interval

Table 3: The associations of body mass index and leisure-time physical activity with incident and persistent chronic pain among working population

Characteristic	Men		Women		Both genders	
	OR*	95% CI	OR*	95% CI	OR*	95% CI
Incident pain						
Body mass index						
Underweight	-	-	1.18	0.68-2.05	1.19	0.70-2.04
Normal	1		1		1	
Overweight	0.96	0.72-1.28	1.16	1.02-1.32	1.13	1.00-1.27
Obese	1.38	0.93-2.04	1.56	1.32-1.84	1.54	1.32-1.79
Leisure-time physical activity						
Low	1		1		1	
Moderate	1.04	0.72-1.51	1.08	0.93-1.25	1.07	0.93-1.23
Vigorous	0.92	0.65-1.28	0.99	0.85-1.16	0.98	0.85-1.13
Persistent pain						
Body mass index						
Underweight	-	-	0.90	0.41-1.99	0.85	0.39-1.84
Normal	1		1		1	
Overweight	0.91	0.60-1.36	1.11	0.95-1.31	1.08	0.93-1.25
Obese	1.64	0.97-2.78	1.26	1.02-1.54	1.30	1.08-1.58
Leisure-time physical activity						
Low	1		1		1	
Moderate	0.61	0.39-0.96	1.11	0.93-1.32	1.03	0.87-1.21
Vigorous	0.74	0.48-1.13	1.09	0.90-1.32	1.03	0.86-1.23

* Adjusted for age, gender (both genders combined), education, marital status, household income, smoking, body mass index (for leisure-time physical activity), leisure-time physical activity (for body mass index), back rotation, back repetitive, heavy physical work or lifting/carrying heavy loads, awkward posture, prolonged standing, prolonged sitting, job demands and job control

OR, odds ratio; N, number of observations; CI, confidence interval

Table 4: The joint effects of body mass index and leisure-time physical activity on incident and persistent chronic pain

Body mass index	Leisure-time physical activity	Men				Women				Both genders			
		N	Cases	OR*	95% CI	N	Cases	OR *	95% CI	N	Cases	OR*	95% CI
Incident pain													
Normal	Low	167	21	1		803	145	1		970	166	1	
Overweight or obese	Low	407	83	1.79	1.06-3.04	1354	380	1.71	1.37-2.13	1761	463	1.71	1.40-2.09
Normal	Moderate	235	39	1.51	0.84-2.69	2040	404	1.13	0.91-1.39	2275	443	1.16	0.95-1.42
Overweight or obese	Moderate	470	80	1.43	0.84-2.43	2153	527	1.45	1.18-1.78	2623	607	1.44	1.19-1.75
Normal	Vigorous	604	90	1.26	0.75-2.12	2582	457	0.99	0.80-1.22	3186	547	1.03	0.85-1.25
Overweight or obese	Vigorous	613	96	1.29	0.77-2.17	1301	274	1.19	0.95-1.50	1914	370	1.20	0.97-1.47
Persistent pain													
Normal	Low	62	37	1		370	186	1		432	223	1	
Overweight or obese	Low	170	91	0.81	0.45-1.46	917	546	1.34	1.05-1.73	1087	637	1.25	0.99-1.58
Normal	Moderate	78	35	0.56	0.30-1.04	792	419	1.10	0.85-1.41	870	454	1.00	0.79-1.27
Overweight or obese	Moderate	158	75	0.66	0.36-1.20	1256	758	1.38	1.08-1.75	1414	833	1.24	0.99-1.55
Normal	Vigorous	129	53	0.55	0.30-1.02	748	376	1.01	0.78-1.31	877	429	0.93	0.73-1.17
Overweight or obese	Vigorous	165	81	0.64	0.35-1.16	559	318	1.31	1.00-1.72	724	399	1.18	0.92-1.51

* Adjusted for age, gender (both genders combined), education and smoking
OR, odds ratio; N, number of observations; CI, confidence interval