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Are flexibility and muscle-strengthening activities associated with a higher risk of developing low back pain?

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Abstract

Objective—To examine the association between participation in flexibility or muscle-strengthening activities with the development of low back pain (LBP).

Design—Observational cohort study.

Methods—The cohort included 4,610 adults, 17% female, between 20 and 81 years of age (mean 46.6, s.d. 4.96). The cohort was followed for a mean of 4.9 years for self-reported LBP. All participants reported at baseline whether they performed flexibility or muscle-strengthening activities, including specific sub-types.

Results—Neither general performance of flexibility or muscle-strengthening activities were associated with a higher incidence of LBP compared to those who did not perform these activities. Those who reported stretching, as a specific flexibility activity were at a higher risk of developing LBP compared with those who performed no flexibility exercises, reported calisthenic flexibility activities, or attended exercise classes. Those who reported using weight training machines, as part of muscle-strengthening activities, had a higher risk of reporting LBP, compared with those who did not perform muscle-strengthening activities or performed calisthenic or free weight activities.

Conclusion—In this sample, stretching or use of weight training machines is associated with increased risk of developing LBP compared to use of free weights, calisthenics or flexibility classes.

Keywords

Muscle Stretching Exercises; Weight Lifting; Low Back Pain; Epidemiology

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Introduction

Low Back Pain (LBP) is among the most commonly reported health problems in America and up to 80% of people can be expected to consult their physician about it at some point in their lifetime[1]. In spite of its prevalence, LBP is difficult to define. Some consider it actual nociception perceived in the lumbar region, others only consider it relevant if it worries the patient sufficiently to seek care or if it causes a functional impairment in their activities of daily living. To produce a definition of LBP is beyond the scope of this work, however, we recognise that to different people, both patients and physicians, it has different meanings, which can make it challenging to quantify. Dionne et al. met as a panel of back pain experts in 2008 and identified heterogeneity in the definition of back pain and agreed on a minimal and optimal definition, taking into account severity, site and duration of symptoms along with functional limitations[2]. Prevalence estimates vary among different populations ranging from 12% to 38%[3, 4].

Flexibility and muscle-strengthening exercises are core features of many physical training programs. Guidelines from the UK Department of Health indicate that it is important that all people include flexibility and muscular strength activities at least twice per week[5]. Canadian guidelines recommend that people participate in flexibility exercises four t0 seven times per week and muscle-strengthening activities two to four times per week[6]. US guidelines also recommend muscle-strengthening exercises at least twice a week[7] andalso suggest using flexibility exercises, such as stretching, but note that this does not count towards meeting the 150 minute per week physical activity target. Whilst these guidelines all suggest incorporating flexibility and muscle-strengthening exercises in a physical activity regimen, there are conflicting data and opinions as to whether these activities may be harmful to the back[8, 9].

A sizable percentage (up to 90%) of LBP sufferers are diagnosed with “non-specific” LBP[1]. There are conflicting reports relating to predictors of LBP. In a study of aircraft workers, higher baseline strength was associated with higher risk of developing LBP, however when adjusting for age, this association weakened[10]. Interestingly, in adolescents, reduced strength, poor leg flexibility and smoking are risk factors for developing LBP[11, 12]. Another study has shown no association between baseline strength and incidence of LBP[13]. There is evidence that treatment of LBP with regular flexibility exercises can provide symptom relief, when compared with general physical activity regimens[14], however flexibility does not seem to reduce the risk development of LBP[15, 16].

In this study, we investigated associations between incidence of LBP, and the use of flexibility and muscle-strengthening exercises in the Aerobics Centre Longitudinal Study (ACLS).

Methods

Participants were part of the ACLS, a prospective observational study. Study details have been described previously and the current work is a secondary analysis[17]. Study participants came to the Cooper Clinic (Dallas, Texas, USA) for periodic preventive health examinations and for counselling regarding diet, physical activity, and other lifestyle factors associated with chronic diseases. The majority of the participants were Caucasian (>95%), had a college education and were from middle and upper socioeconomic strata. After giving informed consent, participants underwent a thorough, physician-led physical examination, gave a blood sample for blood chemistry analyses, had anthropometric measurements taken, had their cardiorespiratory fitness measured by a maximal treadmill test and completed a detailed questionnaire on their personal and family medical history.

In the current analysis, 10,713 participants had at least two medical examinations between 1977 and 2005. We used their last examination to assess status for analysis and excluded those with cardiovascular disease (n=109), cancer (n=658), as well as those reporting a history of bone and joint problems such as swollen/stiff joints, arthritis, and gout (n=1764). In addition, those with missing data on flexibility and muscle-strengthening exercises (n=927), and those with baseline LBP (n=2146) or chronic joint pain (n=499) were excluded. The final analyses were based on a total of 4,610 people, comprised of 3,843 men and 767 women. This study was reviewed and approved annually by the Cooper Institute Institutional Review Board, which met U.S. government criteria for ethics approval. The senior investigators were certified annually as meeting institutional review board standards.

LBP complaints were obtained from standardized self-report medical history forms that also were reviewed by the physician during the examination. Patients were asked to indicate (yes or no) whether they had ever had a problem with LBP and whether LBP was a current problem.

Muscle-strengthening and flexibility activities were assessed by self-report on the medical history questionnaire. Participants were asked to provide yes/no answers to 4 separate questions:

1. “Are you currently involved in a muscle-strengthening program?”.
2. Can you specify the muscle-strengthening activity as “Calisthenics”, “Free Weights”, “Weight Training Machines” or “Other”?.
3. Are you currently involved in exercises to maintain or improve your joint flexibility?”
4. Can you specify the flexibility activity as “Stretching”, “Calisthenic”, “Exercise Class”, “Yoga” or “Other”?.

Baseline differences were examined using chi-square tests for categorical variables and t-tests for continuous variables across activity and outcome groups. Logistic regression was used to compute odds ratios (ORs) and 95% confidence intervals (CIs) for incident LBP according to categories of flexibility or muscle-strengthening activities including each of the four exposures: the muscle-strengthening activities (yes/no), specific-strengthening activity, the flexibility activities (yes/no), and specific-flexibility activity in order to quantify the strength of these associations. Adjusted models controlled for the potential confounding effects of baseline age (years), gender (female/male), aerobics activity (MET-minutes/ week), BMI, current smoking (yes/no), hypertension (yes/no), diabetes (yes/no), hypercholesterolemia (yes/no), cardiorespiratory fitness (CRF) (treadmill time duration in minutes), and muscle-strengthening (when flexibility was the exposure) or flexibility activities (when muscle-strengthening was the exposure). Statistical significance was set at α=0.05 level for all analyses. All analyses were conducted using SAS statistical software (V. 9.3, SAS Institute, Inc., Cary, North Carolina).

Results

The study population had a mean age of 46.7 ± 9.4 years and were followed for a mean of 4.9 ± 3.8 years. 590 (12.8%) reported new incidence of LBP, whilst 1,982 (43.0%) and 1,631 (35.4%) reported performing muscle-strengthening and flexibility activities respectively. The distributions of baseline characteristics by muscle-strengthening and flexibility activities are shown in Table 1. Participants who reported muscle-strengthening activities had lower BMI, higher fitness, lower diastolic blood pressure, reduced total cholesterol and fasting blood glucose, reduced prevalence of diabetes or hypercholesterolemia and a lower proportion of smokers than those who did not partake in muscle-strengthening activities. Those who reported performing flexibility activities were older, had a higher proportion of females, reduced BMI, higher fitness, MET-minutes per week, lower cholesterol and fasting blood glucose, lower diastolic blood pressure and lower prevalence of smoking, diabetes, hypertension and hypercholesterolaemia than those who did not.

The independent associations between muscle-strengthening activities, flexibility activities and incidence of LBP are shown in Tables 2 and 3 respectively. The reported use of muscle-strengthening exercises was not associated with incidence of LBP. Table 2 shows specific types of muscle-strengthening activity with the development of LBP. Those who reported using weight training machines were at higher risk of developing LBP (OR=1.36 (1.08–1.70), p=0.009) than those who did not, and those who reported “other” muscle-strengthening activities were at higher risk of developing LBP (OR=1.45 1.03–2.06), p=0.04) than those who did not. Calisthenics and free weight exercises were not associated with incident LBP.

Amongst this group, 9%, 2% and 0.1% of participants reported combinations of 2, 3 or 4 muscle-strengthening activities, respectively. Additional adjustment for other activities did not change the above association with risk of LBP.

Table 3 shows no significant associations in risk of developing LBP among participants who performed flexibility activities in general. However, those who reported specifically stretching (n=126) had a higher risk of developing LBP (OR=1.26 (1.01–1.58), p=0.04) compared to those who did not. Those who reported using calisthenic exercises or attending exercise classes for flexibility did not have a higher risk of developing LBP (p>0.05 for each) compared to those who did not.

Discussion

We examined the risk of developing LBP associated with muscle-strengthening and flexibility activities among white-collar workers. Muscle-strengthening and flexibility activities overall were not associated with a significantly higher risk of LBP. However, the risk of LBP among participants who specifically used weight-training machines, as part of their muscle-strengthening activities, and who used stretching as part of their flexibility activities, was significantly higher compared to those who did not. Participation in other specific muscle-strengthening activities, such as calisthenic and free weight exercises and other specific flexibility activities, such as calisthenics, yoga and exercise classes were not associated with a higher risk of developing LBP. There is evidence that the flexibility exercises are an effective way to relieve symptoms of LBP in certain populations[14, 18], but there is no evidence that flexibility exercises can prevent LBP.

Mikkelsson et al. assessed flexibility and strength in adolescents and followed them for 25 years to assess their predictive value for LBP and other joint pain incidence[15]. They found that, in women, good flexibility was associated with a decreased risk of neck tension but found that there was no association with LBP incidence. These data support our findings that general performance of flexibility activities was not associated with an increased risk of developing LBP.

Gibbons et al. reported that isokinetic and psychophysical lifting strength were not useful measures for predicting development of LBP[13]. They followed participants for 12 months and just 43/128 reported LBP, whilst in our work we followed participants for a mean of 4.9 years, with 590 incidental reports of LBP. Battie et al. reported that isometric lifting strength was a poor predictor of LBP in industrial workers. There was a significant trend that suggested the stronger workers were at a higher risk of developing LBP, but only a slight trend remained after adjustment for age[10]. Battie et al. took a baseline strength measurement and followed-up with reports of LBP for three years, whereas Gibbons et al. took baseline measurements and followed up for one year. Neither of these took into account changes in strength or leisure activity over the course of the study and considered them in the analysis of LBP incidence. Whilst our work carries the limitation of not using objective measurements, as opposed the two aforementioned studies, we believe that our longitudinal design and larger population size provide robust data.

In 90% of cases, a specific aetiology for LBP is not found and it can arise from various structures in the back, such as the vertical column or surrounding muscles, tendons, ligaments and fascia[1, 19]. However, other aetiologies include fractures, degenerative changes, disc herniation, inflammation and infection[20].

Our data show that participants, who report regular stretching, were at a greater risk of developing LBP compared to those who do not. One explanation for why pre-exercise stretching may put one at higher risk of developing LBP is the cytoskeletal damage to muscle which occurs when stretching[21]. Stretching also provides an increased pain tolerance to further stretching outside the original painless range of motion (ROM), which many consider the main benefit of stretching[22]. However, it can be speculated that by constantly being able to stretch further without pain, one can increase the amount of cytoskeletal damage induced by each stretch[23]. However, with respect to general stretching, this explanation may not apply, as stretch induces muscular hypertrophy which one would expect to be protective[24].

We found participants who regularly used weight training machines were at higher risk of developing LBP, but this association was not found in people who used free weights. One argument often given in favour of using free weights over machines is that it allows not only for the development of the main target muscle group, but also surrounding stabilizing muscles, such as those in the back and the abdomen. However, when using machines, the ROM is defined by the machine, providing isolation of movement in one plane, meaning the deep paraspinal stabilising muscles may not be engaged as much as they are with free weights, and subsequently underdevelop[25, 26]. Weakness of these muscles, disproportional to surrounding major muscles can predispose to LBP[27]. Machines are often seen as a safer way to lift weights, particularly in people who are inexperienced or less confident in their ability to control free weights, a lot of which is determined by the strength of stabilising muscles around the joints; therefore, it is interesting that by avoiding free weights in favour of machines, one may put themselves higher risk of developing LBP. One limitation is the lack of peer-reviewed physiological reports on the advantages and disadvantages of free weight and machine training; however, it is an opinion shared by many and can be found across a wide range of books and web pages.

It may also be that people are using weight machines with poor technique or increasing the weight they are lifting too quickly. Schwanbeck *et al.* showed that, the eight rep max for squatting was higher when using a Smith machine than a barbell[28]. Should people be lifting more weight using machines than free weights, they will gain strength in their major muscle groups but may not be developing the stabilising or core muscles to support lifting more weight in day-to-day life. This puts additional strain on the muscles they are working and may lead to pain and injury. Furthermore, people who are regularly lifting weights may confuse the ache in the day(s) following a weight lifting session and report this as LBP.

One strength of our paper is the sample size from the ACLS database including 4,610 people followed over a mean of 4.9 years. This was not a cohort of defined athletes, such as runners or army recruits, but a sample of white-collar workers, generally middle-to-upper socio-economic status. This allowed us to evaluate the exposures of flexibility and muscle-strengthening exercises on a cohort similar to the general population. Participants of this study had a mean BMI of 26, (slightly overweight), which is likely consistent with white collar workers. It is unclear whether our results would be replicated in more overweight or obese individuals[29].

A limitation of our study is reliance upon self-reported incidence of LBP. They were based on a complaint made to a physician rather than on the use of a standardized clinical interview or research diagnostic criteria specific to a LBP disorder. Problems arising from the use of self-report have been discussed[30]. It would be preferable to repeat this work using a standard definition of LBP such a definition Is not uniformly used, and has led to difficulties in analysing previous data[2].

Participation in flexibility and muscle-strengthening activities was self-reported in this work and we do not have details of specific exercises performed. Participants would report that they frequently participate in stretching exercises, but it is not known exactly which muscle groups they stretch, how they stretch them, and/or how frequently they stretch. It would be important to ensure that specific, specialist-approved, stretching and muscle-strengthening regimens were implemented before drawing any firm conclusions from this work. The use of weight-training machines is also not explored further. It would be prudent to identify the frequency and intensity of these activities and also which machines were being used. Furthermore, in all participants, the LBP may have arisen from causes unrelated to the exercise, such as trauma or inflammatory disease which was not detected in this work.

Conclusion

General participation in flexibility and muscle-strengthening activities does not increase the risk of developing LBP. However, specifically stretching or use of weight-machines may put one at increased risk of developing LBP.

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SB, XS, and RS conceptualized this paper. XS developed the analysis plan and conducted the data analysis. All authors were involved with the interpretation and review of the results. RS drafted the manuscript and revised it according to feedback from all authors, who were involved in critical revisions and provided important intellectual content.

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References

1. Hart LG, Deyo RA, Cherkin DC. Physician office visits for low back pain. Frequency, clinical evaluation, and treatment patterns from a U.S. national survey. Spine (Phila Pa 1976). 1995; 20(1): 11–9. [PubMed: 7709270]
2. Dionne CE, et al. A consensus approach toward the standardization of back pain definitions for use in prevalence studies. Spine (Phila Pa 1976). 2008; 33(1):95–103. [PubMed: 18165754]
3. Hoy D, et al. A systematic review of the global prevalence of low back pain. Arthritis Rheum. 2012; 64(6):2028–37. [PubMed: 22231424]
4. Omokhodion FO, Sanya AO. Risk factors for low back pain among office workers in Ibadan, Southwest Nigeria. Occup Med (Lond). 2003; 53(4):287–9. [PubMed: 12815127]
5. Department of Health, P.A. At least five a week. London: 2004. Health Improvement and Prevention.
6. Kesaniemi A, et al. Advancing the future of physical activity guidelines in Canada: an independent expert panel interpretation of the evidence. Int J Behav Nutr Phys Act. 2010; 7:41. [PubMed: 20459785]
7. Services, U.D.o.H.a.H. 2008 Physical Activity Guidelines for Americans. 2008. [cited 2012 09.05]; Available from: http://www.health.gov/paguidelines/pdf/paguide.pdf
8. Haladay DE, et al. Quality of Systematic Reviews on Specific Spinal Stabilization Exercise for Chronic Low Back Pain. J Orthop Sports Phys Ther. 2013
9. Liddle SD, Gracey JH, Baxter GD. Advice for the management of low back pain: a systematic review of randomised controlled trials. Man Ther. 2007; 12(4):310–27. [PubMed: 17395522]
10. Batti'e MC, et al. Isometric lifting strength as a predictor of industrial back pain reports. Spine (Phila Pa 1976). 1989; 14(8):851–6. [PubMed: 2528819]

11. Sjolie AN, Ljunggren AE. The significance of high lumbar mobility and low lumbar strength for current and future low back pain in adolescents. Spine (Phila Pa 1976). 2001; 26(23):2629–36. [PubMed: 11725246]
12. Feldman DE, et al. Risk factors for the development of low back pain in adolescence. Am J Epidemiol. 2001; 154(1):30–6. [PubMed: 11427402]
13. Gibbons LE, Videman T, Battie MC. Isokinetic and psychophysical lifting strength, static back muscle endurance, and magnetic resonance imaging of the paraspinal muscles as predictors of low back pain in men. Scand J Rehabil Med. 1997; 29(3):187–91. [PubMed: 9271154]
14. Purepong N, et al. Effect of flexibility exercise on lumbar angle: a study among non-specific low back pain patients. J Bodyw Mov Ther. 2012; 16(2):236–43. [PubMed: 22464123]
15. Mikkelsson LO, et al. Adolescent flexibility, endurance strength, and physical activity as predictors of adult tension neck, low back pain, and knee injury: a 25 year follow up study. Br J Sports Med. 2006; 40(2):107–13. [PubMed: 16431995]
16. Battie MC, et al. The role of spinal flexibility in back pain complaints within industry. A prospective study. Spine (Phila Pa 1976). 1990; 15(8):768–73. [PubMed: 2146755]
17. Blair SN, et al. Physical fitness and all-cause mortality. A prospective study of healthy men and women. JAMA. 1989; 262(17):2395–401. [PubMed: 2795824]
18. Cramer H, et al. A Systematic Review and Meta-analysis of Yoga for Low Back Pain. Clin J Pain. 2012
19. Waddell, G. The Back Pain Revolution. 2. New York: Churchill-Livingstone; 2004.
20. Levin, K. Low Back Pain. 2010. [cited 2012 18.09]; Available from: http://www.clevelandclinicmeded.com/medicalpubs/diseasemanagement/neurology/low-back-pain/
21. Macpherson PC, Schork MA, Faulkner JA. Contraction-induced injury to single fiber segments from fast and slow muscles of rats by single stretches. American Journal of Physiology - Cell Physiology. 1996; 271(5):C1438–C1446.
22. Halbertsma JP, Goeken LN. Stretching exercises: effect on passive extensibility and stiffness in short hamstrings of healthy subjects. Arch Phys Med Rehabil. 1994; 75(9):976–81. [PubMed: 8085933]
23. Shrier I. Stretching before exercise: an evidence based approach. British Journal of Sports Medicine. 2000; 34(5):324–325. [PubMed: 11049139]
24. Goldspink DF, et al. Muscle growth in response to mechanical stimuli. Am J Physiol. 1995; 268(2 Pt 1):E288–97. [PubMed: 7532362]
25. Exercise, A.C.o. Free Weights vs. Strength-training Equipment. Fit Facts. 2012. [cited 2012 09.27]; Available from: http://www.acefitness.org/fitfacts/fitfacts_display.aspx?itemid=2655
26. Colado JC, et al. The progression of paraspinal muscle recruitment intensity in localized and global strength training exercises is not based on instability alone. Arch Phys Med Rehabil. 2011; 92(11):1875–83. [PubMed: 22032222]
27. Zatsiorsky, VM.; KW. Science and Practise of Strength Training. Human Kinetics; 2006. Chapter 7: Injury Prevention; p. 137-154.
28. Schwanbeck S, Chilibeck PD, Binsted G. A comparison of free weight squat to Smith machine squat using electromyography. J Strength Cond Res. 2009; 23(9):2588–91. [PubMed: 19855308]
29. Shiri R, et al. The association between obesity and low back pain: a meta-analysis. Am J Epidemiol. 2010; 171(2):135–54. [PubMed: 20007994]
30. Biering-Sorensen F, Hilden J. Reproducibility of the history of low-back trouble. Spine (Phila Pa 1976). 1984; 9(3):280–6. [PubMed: 6233715]

Practical Implications

- Performing general flexibility and muscle-strengthening activities does not increase the risk of developing low back pain
- Specifically stretching or using weight training machines may increase this risk, compared to doing free weights, calisthenics and exercise classes
- Varied programmes including a range of activities, rather than exclusively stretching and using machines may help reduce the risk of developing low back pain.

Table 1

Baseline characteristics of participants by activity types

Characteristic	Muscle-strengthening activity			Flexibility activity		
	No (n=2,628)	Yes (n=1,982)	*P* value	No (n=2,979)	Yes (n=1,631)	*P* value
Age (years)	46.6 ± 9.3	46.6 ± 9.6	0.86	46.0 ± 9.1	**47.6 ± 9.8**	**<0.0001**
Female (%)	16.2	17.3	0.33	14.6	**20.3**	**<0.0001**
Body Mass Index (kg/m^2)	25.9 ± 3.7	**25.1 ± 3.3**	**<0.0001**	26.0 ± 3.7	**24.8 ± 3.1**	**<0.0001**
MET-minutes/week	872 ± 1039	**1462 ± 1417**	**<0.0001**	936 ± 1208	**1471 ± 1253**	**<0.0001**
Treadmill test duration (min)	18.2 ± 4.6	**20.7 ± 4.6**	**<0.0001**	18.5 ± 4.6	**20.7 ± 4.7**	**<0.0001**
Total cholesterol (mmol/L)	5.4 ± 1.0	**5.2 ± 0.9**	**<0.0001**	5.3 ± 1.0	**5.2 ± 1.0**	**<0.0001**
Fasting blood glucose (mmol/L)	5.5 ± 0.8	**5.4 ± 0.6**	**0.0001**	5.5 ± 0.8	**5.4 ± 0.6**	**<0.0001**
Resting blood pressure (mmHg)						
Systolic	120 ± 13	120 ± 14	0.79	120 ± 13	120 ± 14	0.05
Diastolic	81 ± 9	**80 ± 9**	**0.03**	81 ± 9	**79 ± 9**	**<0.0001**
Current smoker (%)	10.7	**7.0**	**<0.0001**	10.8	**6.1**	**<0.0001**
Diabetes (%)	4.2	**2.7**	**0.005**	4.2	**2.4**	**0.002**
Hypertension (%)	25.5	23.4	0.09	26.0	**22.1**	**0.004**
Hypercholesterolemia (%)	26.9	**21.8**	**<0.0001**	26.8	**20.9**	**<0.0001**

Data shown as Means ± SD unless specified otherwise. MET, metabolic equivalent.

Table 2

Odds ratios (ORs) and 95% confidence intervals (CIs) for low back pain incidence by muscle-strengthening activities.

	No. of Incidence/Total	Model 1a	Model 2b	Model 3c	Model 4d
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Muscle-strengthening activity					
No	342/2628	1.00	1.00	1.00	1.00
Yes	248/1982	0.96 (0.80 – 1.14)	0.93 (0.78 – 1.11)	0.91 (0.75 – 1.09)	0.86 (0.71 – 1.05)
P value		0.62	0.42	0.30	0.14
Specific strengthening activity					
Calisthenics					
No	545/4314	1.00	1.00	1.00	1.00
Yes	45/296	1.26 (0.91–1.75)	1.20 (0.86–1.68)	1.18 (0.85–1.65)	1.14 (0.81–1.60)
P value		0.17	0.28	0.33	0.47
Free weights					
No	514/4020	1.00	1.00	1.00	1.00
Yes	76/590	1.00 (0.77–1.29)	0.96 (0.73–1.24)	0.93 (0.72–1.22)	0.91 (0.70–1.20)
P value		1.00	0.73	0.62	0.50
Weight training machines					
No	466/3854	1.00	1.00	1.00	1.00
Yes	124/756	**1.42 (1.14–1.76)**	**1.39 (1.11–1.74)**	**1.37 (1.10–1.72)**	**1.36 (1.08–1.70)**
P value		**0.002**	**0.004**	**0.006**	**0.009**
Other					
No	547/4371	1.00	1.00	1.00	1.00
Yes	43/239	**1.54 (1.10–2.18)**	**1.50 (1.06–2.12)**	**1.48 (1.05–2.10)**	**1.45 (1.03–2.06)**
P value		**0.01**	**0.02**	**0.03**	**0.04**

[q] Adjusted for age and gender.

[b] Adjusted for variables in Model 1 plus total aerobics activity (MET-minutes/wk), body mass index, current smoking (yes or no), hypertension (present or not), diabetes (present or not), and hypercholesterolemia (yes or no).

[c] Adjusted for variables in Model 2 plus cardiorespiratory fitness (treadmill time duration in minutes).

[d] Adjusted for variables in Model 3 plus flexibility activity (yes or no).

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Table 3

Odds ratios (ORs) and 95% confidence intervals (CIs) for low back pain incidence by flexibility activities.

	No. of Incidence/Total	Model 1[a]	Model 2[b]	Model 3[c]	Model 4[d]
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Flexibility activity					
No	365/2979	1.00	1.00	1.00	1.00
Yes	225/1631	1.17 (0.98–1.40)	1.14 (0.94–1.37)	1.12 (0.93–1.35)	1.18 (0.96–1.44)
P value		0.09	0.18	0.25	0.12
Specific flexibility activity					
Stretching					
No	464/3776	1.00	1.00	1.00	1.00
Yes	126/834	**1.29 (1.04 – 1.59)**	1.24 (1.00 – 1.54)	1.22 (0.98 – 1.52)	**1.26 (1.01 – 1.58)**
P value		**0.02**	0.05	0.07	**0.04**
Calisthenics					
No	558/4401	1.00	1.00	1.00	1.00
Yes	32/209	1.28 (0.87–1.89)	1.24 (0.84–1.83)	1.23 (0.83–1.81)	1.28 (0.86–1.90)
P value		0.21	0.29	0.31	0.23
Exercise class					
No	574/4503	1.00	1.00	1.00	1.00
Yes	16/107	1.25 (0.72–2.17)	1.22 (0.70–2.13)	1.22 (0.70–2.13)	1.25 (0.72–2.19)
P value		0.42	0.48	0.48	0.43

[a]Adjusted for age and gender.

[b]Adjusted for variables in Model 1 plus total aerobics activity (MET-minutes/wk), body mass index, current smoking (yes or no), hypertension (present or not), diabetes (present or not), and hypercholesterolemia (yes or no).

[c]Adjusted for variables in Model 2 plus cardiorespiratory fitness (treadmill time duration in minutes).

[d]Adjusted for variables in Model 3 plus muscle-strengthening activity (yes or no)