ORIGINAL ARTICLE

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

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Objective: To examine whether adolescent flexibility, endurance strength, and physical activity can predict the later occurrence of recurrent low back pain, tension neck, or knee injury.
Methods: In 1976, 520 men and 605 women participated in a sit and reach test (flexibility) and a 30 second sit up test (endurance strength). In 1976 and 2001 (aged 37 and 42 years) they completed a questionnaire. Lifetime occurrence and risk of self reported low back pain and self reported, physician diagnosed tension neck and knee injury were calculated for subjects divided into tertiles by baseline results of strength and flexibility tests.
Results: Men from the highest baseline flexibility tertile were at lower risk of tension neck than those from the lowest tertile (odds ratio (OR) 0.51, 95% confidence interval (CI) 0.28 to 0.93). Women from the highest baseline endurance strength tertile were at lower risk of tension neck than those from the lowest tertile (OR 0.60, 95% CI 0.40 to 0.91). Men from the highest baseline endurance strength tertile were at higher risk of knee injury than those from the lowest tertile (OR 1.96, 95% CI 1.05 to 3.64). Men who at school age participated in physical activity were at lower risk of recurrent low back pain (OR 0.61; 95% CI 0.42 to 0.88) than those who did not.
Conclusions: Overall good flexibility in boys and good endurance strength in girls may contribute to a decreased risk of tension neck. High endurance strength in boys may indicate an increased risk of knee injury.

The role of physical fitness characteristics and participation in physical activity as predictors of musculoskeletal pain symptoms and injuries has been studied with different study designs. These studies include reports on how baseline muscular strength, flexibility, or physical activity are associated with the future occurrence of low back pain or tension neck in adults.[1–3] Higher endurance strength in boys predicted lower occurrence of neck/shoulder pain in adulthood, and higher strength in adolescent girls predicted lower occurrence of low back pain.[3] Participation in specific types of sports and exercise can increase the risk of specific injuries. The most common clinically significant acute injury in sport is knee injury, often causing permanent disability and leading to the development of osteoarthritis.[4 5] Some sports, such as soccer, predispose the player to knee injury, but it is not known whether some fitness characteristics have either a protective or a predisposing role in knee injury. However, it has been reported that occupational activities such as kneeling or squatting, or independent joint laxity, increase the risk of degenerative meniscal lesion.[6]

Twin and family studies have shown that physical fitness characteristics (including flexibility and muscle strength) are at least moderately determined by genes,[7–10] and differ by sex. Physical activity habits also represent a mild to moderate genetic component, and inherited physical fitness characteristics may play a role in the adoption of a physically active lifestyle.[11–14] Physical fitness tracks more consistently from adolescence to adulthood than does physical activity.[15–17] Flexibility tracking from adolescence to adulthood[18] is higher than endurance strength tracking measured by sit ups,[19] or endurance or maximal aerobic power tracking.[15]

Inherited factors also influence some but not all musculoskeletal symptoms.[20] A significant genetic influence on the risk of low back pain has been established in both sexes[21–24] and on the risk of neck pain in women.[24] The influence of genetic factors on knee injury may appear through joint laxity, which is a risk factor for meniscal lesions,[6] but contradictory results exist.[25]

Overall, our understanding of the association between physical fitness characteristics, participation in physical activity, and the occurrence of musculoskeletal pain syndromes and injuries is limited. We investigated whether physical fitness characteristics (flexibility, endurance strength) and physical activity in adolescence predict the occurrence of common chronic musculoskeletal symptoms (low back pain and tension neck) or knee injuries up to the age of about 40 (37–42 years) separately in men and women.

METHODS

Subjects

At baseline in April–May of 1976, a trained measuring group, who followed exactly the rules of the International Standards for School Fitness Tests, measured fitness in a random sample of 9–21 year old Finnish pupils in school.[26] A total of 20 towns and communities were randomly selected from the four geographical areas (west, east, middle, and north) of Finland. The random sample of 56 schools was taken from these towns and communities so that the sizes of the schools from towns and communities corresponded to each other. Classes were randomly selected and either pupils were chosen from the beginning or the end of the alphabet or, at the beginning of the measurement, they were lined up and chosen at equal intervals (every second or third etc). The target group in this study included 801 boys and 886 girls aged 12–17 years, all apparently healthy, who in 1976 participated in a sit and reach test and a 30 second sit up test (table 1) and responded to a questionnaire. The final study group consisted of the 520 men and 605 women who

Table 1 Number of subjects in 1976 and proportion who responded to questionnaire in 2001

Test	1976	2001
Sit and reach test		
Boys	801	522 (65%)
Girls	886	611 (69%)
30 second sit up test		
Boys	801	521 (65%)
Girls	880	607 (69%)

participated in both of the baseline tests and responded to a follow up questionnaire in 2001.

In winter 2001, a questionnaire on health, physical activity, and disease risk factors was sent to all 1687 subjects (801 men and 886 women). Of these, 1133 (67%) responded (522 (65%) men and 611 (69%) women) (table 1). No differences in school fitness test results existed between those who participated in 1976 and returned the questionnaire and those who failed to answer the questionnaire in 2001.

Baseline measurements

The baseline tests had been recommended by an international standardising committee for the testing of children and young adults.[27] Flexibility was measured by a sit and reach test[27] in which subjects sat on the floor, with legs held straight by a tester. They were then asked to bend forward slowly and reach as far forward as possible. A bench bearing the measurement scale was placed in front of the subject, whose hands reached along the top of the bench to measure maximum reach.

Endurance strength was measured by a sit up test,[27] in which subjects lay on their backs with knees flexed at a right angle and with hands on the back of the neck. A tester kept the subject's heels in contact with the floor. For 30 seconds subjects continually sat up to touch their knees with their elbows.

The reliability of the chosen tests has been shown to be good.[28] The construct validity of the whole test battery was tested at baseline with factor analysis and correlations. Varimax rotation of four factors (flexibility versus power, endurance strength, endurance, explosive strength) showed that the variance in the sit and reach test was mostly explained by flexibility. The variance in the sit up test was explained by endurance strength and endurance. The concurrent validity of fitness tests was evaluated by comparing field tests conducted in schools with individual tests in the laboratory. The correlation of the sit up test in boys was 0.84. The correlation between two consecutive sit and reach tests was 0.98 in both boys and girls. The intratester reliability in a subgroup of 15 year old boys, who were tested again after two months, was 0.93 for the sit and reach test and 0.83 for the sit up test.[26] Intertester reliability was not tested.

The baseline test results at school showed that the mean (SD) sit and reach test was 56.8 (7.5) cm for boys and 60.9 (6.1) cm for girls, whereas the mean (SD) sit up result was 20.40 (4.1) repetitions for boys and 16.6 (3.8) repetitions for girls.

For our statistical analyses, we divided each age group into three age specific tertiles according to their flexibility test and endurance strength test results at school (low, intermediate, and high tertile) in 1976.

At baseline, the subjects responded to a questionnaire on their physical activity habits. This questionnaire included the question ''How often do you participate in physical activity outside school hours for at least 30 minutes per session?'' with seven response alternatives (never, every day, 2–6 times a week, once a week, 2–3 times a month, once a month, less than once a month). Those who reported participating at least twice a week were classified as ''physically active''.

Follow up questionnaire

The follow up questionnaire included 52 questions, nine of which concerned musculoskeletal problems. The main outcome variables determined before statistical analyses were based on the following questions: ''Has a doctor said that you have or have ever had (*a*) tension neck symptoms, (*b*) meniscal knee injury, or (*c*) ligamentous knee injury?'' Those who reported having had either meniscal or ligamentous knee injury were combined into one group of subjects with medically confirmed knee injuries. The definition of low back pain was based on self reports to the question ''Have you ever had low back pain lasting longer than one day?'' with five response alternatives (never, 1–2 times, 3–9 times, 10–20 times, more than 20 times). Those who reported having had low back pain at least 10 times were classified as having recurrent low back pain.

Other questions dealt with (*a*) the number of days during the preceding 12 months on which difficulties in daily living had been experienced because of neck pain, (*b*) the age at which the back pain had been at its worst, (*c*) if the back pain was sciatica, lumbago, or other back problem, (*d*) if hospital admission had been necessary because of low back pain, (*e*) the number of days during the preceding 12 months on which difficulties in daily living had been experienced because of low back pain, (*f*) frequency of knee symptoms during preceding 12 months, (*g*) if hospital admission had been necessary because of a sports injury to the knee. On the basis of a structured question on the frequency of participation in leisure physical activity, we classified the subjects into three activity categories (at least 5 times a week, 1–4 times a week, or less than once a week). The questionnaire also included a question on current height (cm) and weight (kg), from which body mass index (BMI, kg/m^2) was calculated. The correlation between self reported and measured BMI in a subgroup of 64 subjects was 0.99.

Statistical analysis

All analyses were carried out for men and women separately. After descriptive statistics had been produced, logistic regression univariate analysis was used to estimate the crude odds ratio (OR) with 95% confidence interval (CI) for the risk for occurrence of tension neck, knee injury, and recurrent low back pain by baseline flexibility and endurance strength tertiles, and by participation in leisure physical activity at school age and in adulthood and by follow up age and BMI. A multivariate analysis was then performed including all the variables in the model. Differences between the prevalence of symptoms in low, intermediate, and high tertiles of fitness in adolescence were calculated using the Cochran-Armitage trend test. Analyses were performed with SPSS 12.0 and Stata Statistical Software version 8.0.

RESULTS

The occurrence of tension neck was 2.5 times higher for women (37.4% (226 of 605); 95% CI 33.5 to 41.4) than for men (15.2% (79 of 520); 95% CI 12.2 to 18.6). During the preceding year, 2.7% of men and 2.9% of women reported having difficulties in daily living for more than 30 days because of neck pain.

The occurrence of recurrent low back pain was 1.5 times higher for men (23.1% (120 of 520); 95% CI 20.0 to 26.1) than for women (15.2% (92 of 604); 95% CI 12.5 to 18.3). The mean age at which low back pain was worst was 31.4 (6.7) years in men and 32.8 (6.0) years in women. The worst back

Table 2 Musculoskeletal problems in men and women by flexibility, endurance strength tertiles, school age physical activity, and adult physical activity

	Men	% with symptoms	Women	% with symptoms
Tension neck				
Flexibility tertiles				
Low	176	19.9 (35)	212	41.5 (88)
Intermediate	168	14.3 (24)	189	34.4 (65)
High	176	11.4 (20)	204	35.8 (73)
Endurance strength tertiles				
Low	162	14.2 (23)	186	44.1 (82)
Intermediate	190	15.8 (30)	226	36.3 (82)
High	168	15.5 (26)	193	32.1 (62)
School age physical activity				
Inactive	152	17.8 (27)	170	40.6 (69)
Active	356	14.6 (52)	428	35.7 (153)
Adult physical activity				
Less than once a week	143	27.8 (22)	112	16.7 (38)
1–4 times a week	306	58.2 (46)	389	68.4 (156)
5–7 times a week	69	13.9 (11)	103	14.5 (33)
Recurrent low back pain				
Flexibility tertiles				
Low	177	23.7 (42)	211	14.2 (30)
Intermediate	167	23.4 (39)	189	15.9 (30)
High	176	22.2 (39)	204	15.7 (32)
Endurance strength tertiles				
Low	162	22.2 (36)	185	15.1 (28)
Intermediate	191	22.5 (43)	226	15.0 (34)
High	167	24.6 (41)	193	15.5 (30)
School age physical activity				
Inactive	152	29.1 (44)	170	17.6 (30)
Active	356	20.7 (74)	428	14.1 (60)
Adult physical activity				
Less than once a week	143	25.8 (31)	112	26.9 (25)
1–4 times a week	306	63.3 (76)	389	58.1 (54)
5–7 times a week	69	10.0 (12)	103	14.0 (13)
Knee injury				
Flexibility tertiles				
Low	176	13.6 (24)	212	7.1 (15)
Intermediate	168	11.3 (19)	189	9.0 (17)
High	176	18.2 (32)	204	5.4 (11)
Endurance strength tertiles				
Low	162	11.1 (18)	186	5.4 (10)
Intermediate	190	12.6 (24)	226	8.4 (19)
High	168	19.4 (33)	193	7.3 (14)
School age physical activity				
Inactive	152	11.8 (18)	170	4.1 (7)
Active	356	15.4 (55)	428	7.9 (34)
Adult physical activity				
Less than once a week	143	22.4 (17)	112	23.3 (10)
1–4 times a week	306	63.2 (48)	389	62.8 (27)
5–7 times a week	69	10.5 (8)	103	14.0 (6)

Values in parentheses are numbers. The number of subjects by tertile varies because at baseline not all subjects participated in both strength and flexibility tests, and not all subjects answered the questionnaire in 2001. Data for school age physical activity were missing for 12 men and seven women. Data for adult physical activity were missing for four men and five women.

pain experienced was sciatica in 22.6% of men and 21.8% of women and lumbago in 22.5% of men and 17.0% of women. Back pain had been treated at hospital in 6.7% of men and 3.9% of women. During the preceding year, 4.4% of men and 3.7% of women reported having difficulties in daily living for more than 30 days because of back pain.

The occurrence of meniscal or ligamentous knee injury was two times higher for men (14.4% (75 of 520); 95% CI 11.5 to 17.7) than for women (7.1% (43 of 605); 95% CI 5.2 to 9.5). During the preceding year, 7.4% of men and 6.0% of women had had at least weekly knee symptoms. Hospital admission for a sports knee injury had occurred in 13.3% of men and 4.0% of women.

Table 2 shows the occurrence of tension neck, low back pain, and knee injuries in both sexes by tertiles of flexibility and endurance strength, school age physical activity, and adult physical activity.

Table 3 shows the results of univariate and multivariate analysis of the risk of tension neck for subjects in the highest and intermediate tertiles compared with those in the lowest tertile. The risk of tension neck increased with each unit increase in BMI by 9% in men and 5% in women. Men from the highest baseline flexibility tertile were at about 50% lower risk of the occurrence of tension neck than were those from the lowest tertile. Significance of the trend over the tertiles was 0.026, showing an inverse dose-response type of association. Good flexibility decreased the risk of tension neck in women, too, but significantly only in the intermediate group in multivariate analysis. The trend over tertiles was not significant ($p = 0.18$). Women with high endurance strength were at 34% lower risk of tension neck than women with low endurance strength. Significance of the trend over the tertiles was 0.016.

Adult BMI had a slight effect of increased risk of recurrent low back pain (table 4). Men who were physically active in adolescence were at a lower risk of recurrent low back pain. Women showed a similar but insignificant tendency. In univariate analysis, risk of low back pain was lower in women who were moderately active at follow up.

Table 3 Odds ratio (OR) and confidence interval (CI) of tension neck at follow up by flexibility, endurance strength, and physical activity at baseline, and age, body mass index (BMI), and physical activity at follow up

	Men				Women			
	Univariate		Multivariate		Univariate		Multivariate	
Variable	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value
Age at follow up	1.01 (0.88 to 1.16)	0.85	0.99 (0.84 to 1.17)	0.89	1.07 (0.98 to 1.18)	0.14	1.07 (0.95 to 1.20)	0.29
BMI at follow up	1.06 (1.00 to 1.12)	0.049	1.09 (1.01 to 1.64)	0.021	1.05 (1.01 to 1.09)	0.014	1.05 (1.00 to 1.10)	0.033
Flexibility tertiles								
Low	1 (Reference)*		1 (Reference)		1 (Reference)		1 (Reference)	
Intermediate	0.67 (0.38 to 1.19)	0.17	0.67 (0.67 to 1.21)	0.18	0.74 (0.50 to 1.11)	0.15	0.65 (0.43 to 1.00)	0.049
High	0.51 (0.28 to 0.93)	0.028	0.49 (0.26 to 0.93)	0.028	0.76 (0.52 to 1.13)	0.18	0.79 (0.52 to 01.19)	0.25
Endurance strength tertiles								
Low	1 (Reference)		1 (Reference)		1 (Reference)		1 (Reference)	
Intermediate	1.13 (0.63 to 2.04)	0.68	1.24 (0.67 to 2.28)	0.50	0.72 (0.49 to 1.07)	0.11	0.73 (0.48 to 1.10)	0.13
High	1.11 (0.60 to 2.03)	0.74	1.40 (0.73 to 2.67)	0.31	0.60 (0.40 to 0.91)	0.017	0.66 (0.42 to 1.02)	0.063
School age physical activity								
Inactive	1 (Reference)		1 (Reference)		1 (Reference)		1 (Reference)	
Active	1.09 (0.69 to 1.72)	0.70	0.83 (0.49 to 1.43)	0.51	0.89 (0.64 to 1.22)	0.47	0.86 (0.59 to 1.26)	0.44
Physical activity at follow up								
Less than once a week	1 (Reference)		1 (Reference)		1 (Reference)		1 (Reference)	
1–4 times a week	1.04 (0.65 to 1.66)	0.87	1.06 (0.60 to 1.87)	0.85	1.17 (0.79 to 1.73)	0.80	1.43 (0.89 to 2.29)	0.14
5–7 times a week	0.98 (0.49 to 1.95)	0.96	1.20 (0.53 to 2.71)	0.65	0.99 (0.60 to 1.67)	0.99	1.01 (0.56 to 1.84)	0.97

*Denominator of odds ratios.

The risk of knee injury in men increased 1.3 times for each successive 1 year increase in age (table 5). In women, an increase of one unit of BMI increased the risk of knee injury by 16%. Men with high school age endurance strength had twice the risk of knee injury as those with low endurance strength. Significance of the trend over tertiles was 0.027. The tendency was similar in women but insignificant ($p = 0.48$). Physical activity in adolescence increased the risk of knee injury in both sexes, but the finding was statistically insignificant.

DISCUSSION

In our 25 year follow up study, high adolescent flexibility predicted low occurrence of tension neck in men. In women, high endurance strength predicted low occurrence of tension neck, whereas in men it was a predictor of knee injury. Participation in leisure physical activity in adolescence predicted low occurrence of recurrent low back pain in men. Of the adulthood factors, physical activity 1–4 times a week may lower the risk of low back pain in women. In addition, the higher the BMI, the greater the risk of tension neck and low back pain in both sexes, and knee injury in women.

Our study cohort was a representative sample of Finnish children. The strengths of our study include the fitness test results from 1976, a very thorough follow up despite the various whereabouts of the subjects, and a reasonable response rate (68%) after 25 years of follow up. Unfortunately, we could follow up only 65% of men and 69% of women, which may have influenced the results. In addition, differences in morbidity, physical activity, or social class among subjects and dropouts cannot be excluded. At follow up, our subjects were about 40 years old, when severe musculoskeletal degeneration is uncommon. The occurrence of degenerative changes in older subjects, however, could modify associations found in our study.

Our original aim was to study components of adolescent physical fitness (endurance, endurance strength, and flexibility) as predictors of adult musculoskeletal problems (tension neck, low back pain, knee injury, and Achilles

Table 4 Odds ratio (OR) and confidence interval (CI) of recurrent low back pain at follow up by flexibility, endurance strength, and physical activity at baseline, and age, body mass index (BMI), and physical activity at follow up

	Men				Women			
	Univariate		Multivariate		Univariate		Multivariate	
Variable	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value
Age at follow up	1.01 (0.90 to 1.13)	0.87	0.95 (0.82 to 1.09)	0.45	1.01 (0.89 to 1.16)	0.85	1.05 (0.90 to 1.23)	0.52
BMI at follow up	1.03 (0.99 to 1.10)	0.15	1.08 (1.02 to 1.15)	0.021	1.05 (1.01 to 1.10)	0.031	1.04 (0.98 to 1.10)	0.17
Flexibility tertiles								
Low	1 (Reference)*		1 (Reference)		1 (Reference)		1 (Reference)	
Intermediate	0.98 (0.60 to 1.61)	0.94	1.08 (0.63 to 1.82)	0.73	1.14 (0.66 to 1.97)	0.65	1.19 (0.67 to 2.11)	0.56
High	0.91 (0.55 to 1.49)	0.70	0.94 (0.55 to 1.59)	0.80	1.16 (0.68 to 1.98)	0.59	1.17 (0.67 to 2.11)	0.56
Endurance strength tertiles								
Low	1 (Reference)		1 (Reference)		1 (Reference)		1 (Reference)	
Intermediate	1.02 (0.62 to 1.68)	0.95	1.08 (0.63 to 1.82)	0.79	0.99 (0.58 to 1.71)	0.98	1.11 (0.62 to 1.97)	0.72
High	1.14 (0.68 to 1.90)	0.62	1.37 (0.78 to 2.35)	0.28	1.03 (0.59 to 1.81)	0.91	1.24 (0.68 to 2.28)	0.47
School age physical activity								
Inactive	1 (Reference)		1 (Reference)		1 (Reference)		1 (Reference)	
Active	0.61 (0.42 to 0.88)	0.009	0.62 (0.39 to 0.98)	0.039	0.69 (0.45 to 1.05)	0.084	0.80 (0.48 to 1.32)	0.39
Physical activity at follow up								
Less than once a week	1 (Reference)		1 (Reference)		1 (Reference)		1 (Reference)	
1–4 times a week	1.08 (0.72 to 1.62)	0.71	1.31 (0.80 to 2.14)	0.29	0.60 (0.37 to 0.97)	0.038	0.65 (0.37 to 1.15)	0.14
5–7 times a week	0.84 (0.45 to 1.56)	0.58	0.88 (0.41 to 1.87)	0.74	0.58 (0.29 to 1.14)	0.11	0.54 (0.25 to 1.18)	0.12

*Denominator of odds ratios.

Table 5 Odds ratio (OR) and confidence interval (CI) of knee injury at follow up by flexibility, endurance strength, and physical activity at baseline, and age, body mass index (BMI), and physical activity at follow up

	Men				Women			
	Univariate		Multivariate		Univariate		Multivariate	
Variable	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value
Age at follow up	1.23 (1.07 to 1.42)	0.004	1.30 (1.09 to 1.56)	0.004	1.11 (0.93 to 1.33)	0.26	1.15 (0.92 to 1.45)	0.21
BMI at follow up	1.05 (0.99 to 1.12)	0.09	1.06 (0.98 to 1.14)	0.17	1.10 (1.03 to 1.16)	0.002	1.16 (1.07 to 1.24)	0.000
Flexibility tertiles								
Low	1 (Reference)*		1 (Reference)		1 (Reference)		1 (Reference)	
Intermediate	0.81 (0.42 to 1.53)	0.51	0.66 (0.33 to 1.32)	0.24	1.30 (0.63 to 2.68)	0.48	1.03 (0.47 to 2.27)	0.94
High	1.45 (0.82 to 2.57)	0.20	1.11 (0.59 to 2.08)	0.75	0.75 (0.33 to 1.66)	0.47	0.66 (0.28 to 1.55)	0.34
Endurance strength tertiles								
Low	1 (Reference)		1 (Reference)		1 (Reference)		1 (Reference)	
Intermediate	1.16 (0.60 to 2.22)	0.66	1.28 (0.63 to 2.58)	0.49	1.61 (0.73 to 3.57)	0.24	1.56 (0.67 to 3.64)	0.30
High	1.96 (1.05 to 3.64)	0.034	2.05 (1.03 to 4.11)	0.042	1.38 (0.60 to 3.18)	0.45	1.70 (0.70 to 4.13)	0.24
School age physical activity								
Inactive	1 (Reference)		1 (Reference)		1 (Reference)		1 (Reference)	
Active	1.34 (0.83 to 2.18)	0.23	1.47 (0.79 to 2.73)	0.23	1.78 (0.88 to 3.61)	0.11	2.07 (0.88 to 4.90)	0.10
Physical activity at follow up								
1–3	1 (Reference)		1 (Reference)		1 (Reference)		1 (Reference)	
4–5	1.17 (0.71 to 1.91)	0.54	1.25 (0.67 to 2.33)	0.48	0.84 (0.41 to 1.70)	0.62	0.98 (0.42 to 2.29)	0.95
6–7	0.88 (0.42 to 1.87)	0.75	0.96 (0.53 to 2.71)	0.65	1.07 (0.44 to 2.62)	0.88	0.78 (0.26 to 2.39)	0.67

*Denominator of odds ratios.

tendon problems). However, the endurance running test was conducted out of doors and by only a proportion of the subjects who performed the indoor tests used in this study. Also the number of these with Achilles tendon problems during follow up was small. So, because of low statistical power, we could use neither the endurance test as a predictor nor Achilles tendon problems as an outcome in our study.

By definition, tension neck is a pain syndrome related to tightened neck musculature. We have not found any studies about the association between flexibility and neck problems. Previous studies of risk factors for adult neck pain include both mechanical factors and psychological and mental workload related factors in both sexes.[29–31] The sit and reach test measures mainly hamstring flexibility, but is dependent on hip and back mobility, too. If we assume that the sit and reach test describes overall flexibility, one explanation for the association between low flexibility and tension neck is that general stiffness predicts tension neck. Flexibility, as well as neck pain itself, could be related to both genetic and lifestyle factors.[24 32 33] Another theoretical explanation is that hamstring and low back stiffness change the biomechanics of the spine, predisposing to tension neck. We use the term tension neck because it represents a direct translation of the word used in our questionnaire and is commonly used by healthcare professionals. Laymen understand this term best, although ''non-specific neck pain'' is used more often in recent scientific literature.

In our study, low endurance strength at adolescence predisposed women to tension neck. Barnekow-Bergkvist and coworkers[3] reported in a 16 year follow up that high performance in bench press at the age of 16 was associated with a significant decrease in risk of neck/shoulder symptoms at the age of 34 in men, but not women. Women attain 50–80% of the neck strength of men.[34–36] Although our study is not an intervention study, based on our finding that low strength levels predispose women to tension neck, the training of neck musculature may be effective in the prevention and treatment of tension neck syndrome in women. The latter conclusion is supported by a recent, well designed, controlled trial which showed that specific neck muscle training is effective in the treatment of chronic neck pain in women.[37] High performance in the two hand lift test in adolescence was associated with a decrease in risk of low back problems in adulthood in women.[3]

High endurance strength was a predictor of knee injury in men, and the same tendency was found in women. Men with greater endurance strength are likely to participate in sport more often than those with poorer fitness, as many ligamentous and meniscal knee injuries occur during sport. This is supported by our finding that men and women who participated in leisure physical activity at school age were at higher but insignificant risk of knee injury. In Finland, men participate more frequently in sport and are thus at greater risk of knee injury than women.[4] However, in active athletes, proper rehabilitation of muscle function after knee injury may be important in reducing the reinjury risk.

Physical activity in boys is usually more vigorous than in girls.[38] Hypotheses differ about the mechanism by which adolescent physical activity in boys prevents adult low back pain. Although extreme sport related loading may cause injury to an adolescent's back,[39] physical activity during growth may improve the development of some of the low back structures enabling them to withstand more robustly physical loading in adulthood. Also, physical activity

What is already known on this topic

- Participation in specific types of sports and exercise can increase the risk of specific injuries
- There are few data on how childhood or adolescent activity or fitness is associated with later musculoskeletal problems

What this study adds

- Low flexibility in adolescence increases the risk of tension neck in men
- High endurance strength in adolescence reduces the risk of tension neck in women, and is a predictor of knee injury in men
- Physical activity in adolescence reduces the risk of low back pain in men

increases trunk muscle strength, endurance, and motor abilities, which may help the back to function better.[40 41] On the other hand, high physical performance is also related to sports with increased risk of low back pain, and this may dilute the beneficial effects of physical activity. Interestingly, hyperalgesia resulting from differences in experiencing pain stimuli at the level of the central nervous system occurs more often in patients with chronic low back pain than in controls.[42] Physical activity during adolescence may modify the sensory perception of peripheral pain at the level of the central nervous system, which is one possible explanation for fewer pain symptoms in subjects who have been physically active during adolescence.

Our study agrees with the conclusions of most previous long term follow up studies: high muscular strength[1 2] appears not to be a strong predictor of low back pain. Again, enhancing strength and flexibility may be important components in the rehabilitation of patients with chronic low back pain.

Our hypothesis suggested that predictors of different musculoskeletal problems would differ by outcome and sex. In cross sectional studies or short term follow ups, the cause and effect evaluation between factors such as neck pain and neck muscle strength is problematic. Also, the results of our study cannot simply be interpreted as causal associations; rather they may result from third variable differences. The inherited nature of these characteristics because of our long follow up period may at least partly explain the predictive value of measured physical fitness characteristics. Previous studies have shown that tracking of fitness characteristics is better in shorter follow ups,[18] may vary between sexes, and may depend on the timing of the baseline measurement in relation to puberty.[19]

Our study has several limitations. Low back pain was based only on self reports. However, in the *International classification of diseases*, diagnosis of low back pain is also based on self report. The study lacks the intertester reliability of the baseline measurements, has limitations in evaluating the validity, and only two fitness tests could be used. The validity of the questionnaire at baseline was not tested separately. The validity of the follow up questionnaire was not tested either, but it included questions tested and used before in other epidemiological studies in Finland.[43] The effect of maturation cannot be excluded because the timing of puberty is not known. It is probable that some of the boys had not completed puberty.

Overall, our study adds an important, often unrecognised, perspective to studies evaluating the associations between physical fitness characteristics, activity, and musculoskeletal problems.

In conclusion, our results provide evidence that overall good flexibility in men and good endurance strength in women may help to decrease the risk of tension neck symptoms. High endurance strength in boys may indicate an increased risk of knee injury probably because of covariation with participation in activities with high injury risk. The possible beneficial effects of childhood and adolescent physical activity on low back pain in men and women require further study.

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ECHO

Sports activities 5 years after total knee or hip arthroplasty: the Ulm Osteoarthritis Study

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Please visit the *British Journal of Sports Medicine* website [www.bjsportmed.com] for a link to the full text of this article.

Objective: To analyse sports activities of patients with hip or knee osteoarthritis (OA) over lifetime, preoperatively, and 5 years after arthroplasty.

Methods: In a longitudinal four centre study, 809 consecutive patients with advanced OA of the hip (420) or the knee (389) joint under the age of 76 years who required total joint replacement were recruited. A completed questionnaire about sports activities at 5 year follow up was received from 636 (79%) of the 809 patients.

Results: Although most patients with hip (97%) and knee (94%) OA had performed sports activities during their life, only 36% (hip patients) and 42% (knee patients) had maintained sports activities at the time of surgery. Five years postoperatively, the proportion of patients performing sports activities increased to 52% among patients with hip OA, but further declined to 34% among those with knee OA. Accordingly, the proportion of patients with hip OA performing sports activities for more than 2 hours a week increased from 8 to 14%, whereas this proportion decreased from 12 to 5% among patients with knee OA. Pain in the replaced joint was reported by 9% of patients with hip and by >16% with knee OA.

Conclusion: Differences in pain 5 years after joint replacement may explain some of the difference of sports activities between patients with hip and knee OA. Reasons for reduction of sports activities may include the increasing age of the patients, their worries about an "artificial joint", and the advice of their surgeon to be cautious.

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