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KNEE DISORDERS IN CARPET AND FLOOR LAYERS AND PAINTERS

Part I. Isometric Knee Extension and Flexion Torques

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ABSTRACT. Knee morbidity, knee extension torque and knee flexion torque were examined among 168 actively working carpet and floor layers and 146 painters. The study included a questionnaire concerning knee disorders and knee symptoms, a clinical examination of the knees and measurement of isometric knee extension and flexion torque. Knee accidents were reported more frequently by carpet and floor layers than by painters. Tenderness of the knees was noted to an equal extent in the two groups. Knee extension torques gradually decreased by increasing age among carpet and floor layers, but not among painters. Body weight and thigh girth were not related to age among carpet and floor layers, but gradually increased with age among painters. Analysis of covariance showed that the torques were most consistently related to thigh girth and age. In addition, the right knee extension torque was related to occupation and tenderness of the patellofemoral joint; the left knee extension torque was related to the knee pain index. These results suggest that occupational kneeling and internal derangement of the knee affect thigh muscles among actively working house builders.

Key words: kneeling work, muscle strength, overuse injury, repetitive strain injury.

Many studies have shown increased prevalence of knee disorders in occupations in which the lower limbs of workers are heavily loaded. Knee pains have been noted more frequently in occupations that require kneeling (5, 9). Increased risk for knee arthrosis has been noted among shipyard workers, firemen, farm labourers, construction workers and other workers whose lower extremities are highly loaded at work (1, 6, 10, 19). Miners are operated on for meniscal lesions more often and at a younger age than other workers (2, 15). Operative and clinical findings of chondromalacia patellae are frequent among workers who often kneel or squat in their work (11). Bursitis and other soft-tissue changes in the anterior aspect of the knee are the most typical clinical findings among workers who often adopt kneeling postures (16–18).

The objective of this study was to evaluate the effect of kneeling work on the muscular function of the knee. We studied carpet and floor layers, who frequently kneel in their work, and painters who seldom adopt kneeling postures (6).

MATERIAL AND METHODS

Subjects

All actively working carpet and floor layers who ranged in age between 25 and 49 years, who lived in southern Finland, had at least 5 years' experience in their current occupation, and were registered members of the trade union were enlisted for the study. House painters were selected by the same criteria by the use of frequency matching according to five-year age strata. One hundred and sixty-eight (78%) of 216 carpet and floor layers and 146 (66%) of 221 house painters participated in the study. All of the subjects were men.

Methods

Questionnaire. In a self-administered questionnaire the subjects were asked to indicate their height, weight, number of years in their present occupation and average work hours in a week. Information on knee accidents treated by a doctor, knee operations and knee disorders confirmed by a doctor was also requested. The subjects were asked about pain in the following situations in the right and left knees separately during the preceding month: ascending stairs, descending stairs, walking on even ground, sitting still, resting at night, squatting and kneeling. For further data analysis, a dichotomous knee pain index was formed based on the first five tasks (0 = no pain in any of the tasks; 1 = pain in one or several tasks). Pain during squatting and kneeling was excluded from this categorization because of the differences in the occurrence of the postures in the two occupations in question.

Clinical examination

A clinical examination was carried out by a specialist in physical medicine (J.K.) who was unaware of the history of

Table I. *Age and anthropometric data by occupation means ($\bar{x}$) and standard deviation (SD)*

	Carpet and floor layers ($n=168$)		Painters ($n=146$)	
	$\bar{x}$	SD	$\bar{x}$	SD
Age (yrs)	38.5	6.8	39.1	6.7
Height (cm)	176.8	5.8	176.4	6.4
Weight (kg)	78.5	10.3	80.2	12.6

knee disorders or the actual knee symptoms of the subject. He could not be blinded with regard to occupation because in many cases skin changes on the anterior aspect of the knees revealed the subject's occupation. Knee extension was estimated to be normal or restricted while the subject stood in relaxed position with the feet 10 cm apart.

Tenderness of the patellofemoral joint was studied with direct compression of the patella with the subject lying supine and his thigh muscles relaxed. For the data analysis the finding of patellar compression was classified in three grades; no tenderness, slight tenderness and severe tenderness. Possible knee pain in prompt passive knee extension was also recorded. The thigh girth was measured 10 cm proximal from the medial tibiofemoral joint space.

Isometric knee extension and flexion torques. A specially trained assistant measured the extension and flexion torque of the right and left knee with an isometric testing apparatus (Muskeli, Finland). The extension torque was measured with the subject sitting and the knee flexed 60° (totally extended = 0°).

The knee flexion torque was measured with the subject prone on an examination table and the knee flexed 30°. Knee extension and flexion efforts were repeated three times, and the best result was recorded. For 6 carpet and floor layers and 7 painters current injuries in the lower extremities prevented the measurement of either or both torques.

Statistical methods

The Student's *t*-test was used for statistical testing of continuous variables and the chi-square test for contingency tables. The effect of age on the knee extension and flexion torques in the two occupations was studied with the regression analysis.

In covariance analysis with GLIM (12) the extension and flexion torques separately for the right and left knee were the dependent variables. In each analysis of covariance the independent variables were subject's age, weight, height, thigh girth, occupation, reported knee accidents, knee pain index, tenderness at patellar compression and reported knee operations (no/yes). The significance of the interaction between age and occupation was also tested for.

RESULTS

The groups did not significantly differ from each other according to age or anthropometric data, but weight was slightly greater among the carpet and floor layers (Table I). Among the painters the mean weight linearly increased with increasing age, but among the carpet and floor layers this increase was not noted.

Table II. *Prevalence of knee symptoms according to occupation, percentages of the knees*

	Carpet and floor layers ($n=334$)	Painters ($n=290$)
Pain according to knee pain index	36	33
Pain during kneeling	62	46***
Pain during level walking	23	14*
Pain during sitting still	26	19*
Pain during resting at night	23	12*
Pain during ascending stairs	25	24
Pain during descending stairs	20	19
Pain during squatting	40	39

* $p<0.05$.
*** $p<0.001$.

The average work time in the current occupation was 14.7 (SD 7.7) years for the carpet and floor layers and 18.1 (SD 7.5) years for the painters.

Two percent of the subjects in either occupational group reported knee arthrosis verified by a doctor. Ten percent of the carpet and floor layers and 5% of the painters reported verified meniscal lesions. Fourteen percent of the carpet and floor layers and 10% of the painters reported operations on their knees. Knee pain during kneeling, walking, sitting still and resting at night was reported more frequently by the carpet and floor layers than by the painters (Table II).

In the relaxed standing posture 8% of the carpet and floor layers' knees and 6% of the painters' knees were slightly flexed. Pain at compression of the patella was reported in 17% of the carpet and floor layers' and 19% of the painters' knees. The respective figures for knee pain during prompt passive extension were 10 and 9%.

The mean thigh girth was 392 (SD 30) mm for the carpet and floor layers and 400 (SD 34) mm for the painters ($p<0.05$). Among the painters the average girth linearly increased from 384 mm in the youngest age group to 408 mm in the oldest. Among the carpet and floor layers there was no relation between age and thigh girth.

The mean isometric knee extension torque was 177 (SD 50) Nm in both occupational groups. The knee flexion torque averaged 70 (SD 25) Nm in the carpet and floor layers and 72 (SD 26) Nm in the painters. There were no significant differences between the right

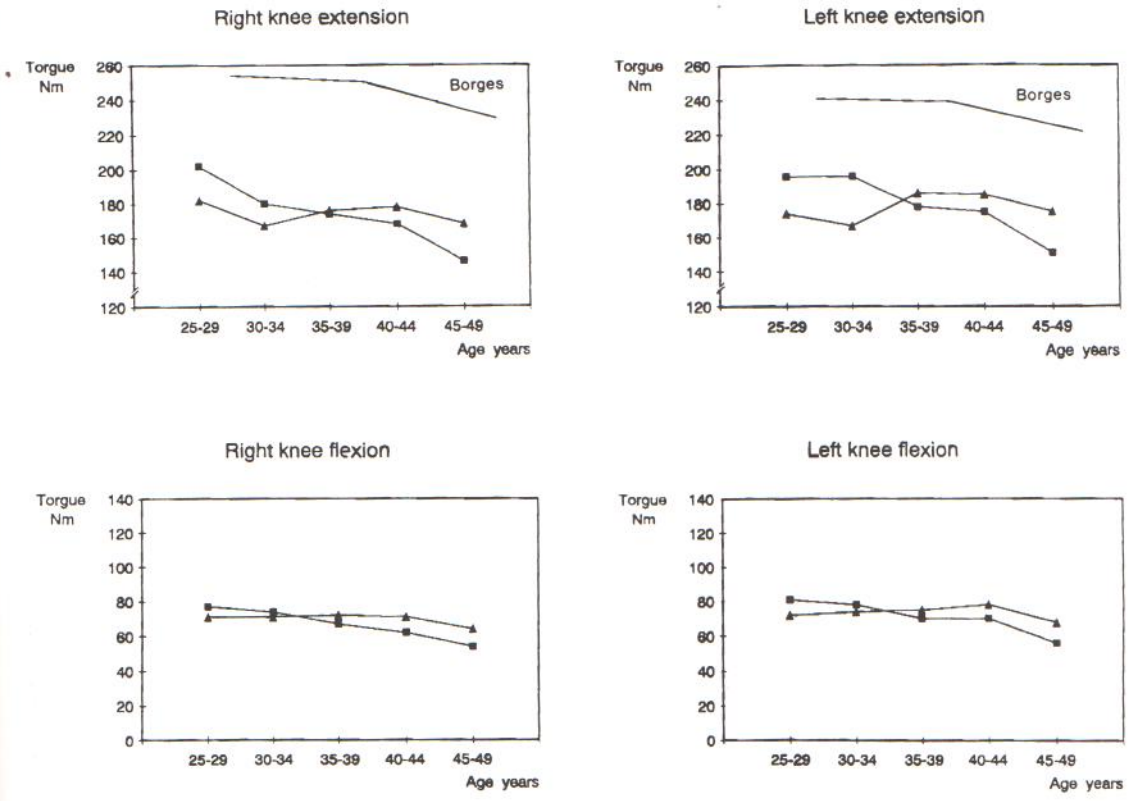

Fig. 1. Means of isometric knee extension and flexion torques in 161 carpet and floor layers' and 139 painters' extension torques according to Borges (1989). ■——■ Carpet and floor layers; ▲——▲ Painters.

and left knee torques. A linear decrease in all muscle torques with increasing age was noted for the carpet and floor layers ($p < 0.001$; regression analysis), but not for the painters (Fig. 1).

Covariance analysis showed that the right knee extension torque was related to subject's age, occupation, thigh girth and tenderness at patellar compression; an interaction between age and occupation was noted (Table III). The left knee extension torque was related to thigh girth and knee pain index. The right knee and left knee flexion torques were related to subject's age and thigh girth.

DISCUSSION

Carpet and floor layers participated in our study more frequently than painters. Those subjects who had knee trouble were obviously more interested in having their knees studied than the other subjects. Seventy per cent of the 35 subjects (19 carpet and floor layers and 16 painters) who did not participate in the examination but had filled out the questionnaire had no knee pain according to the knee pain index.

Our results on working postures, reported knee disorders and knee symptoms are quite well in concordance with the results of previous studies in which carpet and floor layers' knee load and knee morbidity have been studied (5, 16, 17).

Carpet and floor layers reported knee pain more frequently than painters in the four tasks in which rather low forces are directed to the knees (13), and three out of these four tasks were not typical for either occupation. These findings suggest that carpet and floor layers have painful knee changes more often than painters.

The knee extension and flexion torques have frequently been used to characterize the functional capacity of the knee joint. In this study we used the

Table III. *Association of knee extension and flexion torques with several covariates.* Regression coefficients (b) and their standard error (SE_b) analysis of covariance ($n=271$)

	Knee extension torque				Knee flexion torque			
	Right knee		Left knee		Right knee		Left knee	
Covariate	b	SE_b	b	SE_b	b	SE_b	b	SE_b
Age	−24.45	5.21***	−8.32	4.25	−8.50	2.20***	−8.32	4.25
Occupation	−57.69	25.33	−13.69	10.98	3.95	5.61	2.10	5.76
Age occupation*	15.87	7.55*						
Thigh girth	1.18	0.16***	1.23	0.18***	0.61	0.09***	0.76	0.09***
Tenderness at patellar compression								
Slight	−30.55	14.52*	−24.43	16.22	9.65	8.14	−0.72	8.52
Severe	−53.41	23.81*	−48.94	31.85	−9.77	13.36	−19.35	16.72
Knee pain			−41.46	12.18***				

* $p<0.05$.
** $p<0.01$.
*** $p<0.001$.

static torque measurements that have had a good correlation with more sophisticated dynamic torque tests (7, 8). We measured lower extension torques which Borges (3) measured in randomly selected healthy subjects with the Cybex II apparatus. This difference may be related to measurement techniques; we did not, for instance, use the backrest, which is known to increase maximal isometric torque of the knee extensor muscles (14).

Among the carpet and floor layers the lack of an age-related increase in weight may indicate that a physically demanding occupation prevents overweight.

The most important finding was that the thigh muscles weakened with age among the carpet and floor layers, but not among the painters. The difference between the two occupations was statistically significant only in the right knee extension torque, but the same tendency was noted in the left knee extension torque and, to a lesser extent, in the knee flexion torques. Among younger workers the occupational differences in knee extension and flexion torques may reflect the fact that they are selected to carry out heavy work. Among carpet and floor layers the knee extension torques decreased with age more evidently than the knee flexion torques. Subjects with knee pain possibly tend to walk with flexed knees and avoid knee movements in a manner that could explain weakening of the thigh extension muscles.

The multifactorial analysis showed that the measured knee extension and flexion torques were very significantly associated with thigh girth. This finding indicates that among our subjects the thigh muscles were an important determinant for variation in the thigh girth.

Age, occupation, knee pain and tenderness at patellar compression were related to the right knee torques more evidently than to the left knee torques. The right knee may be more loaded than the left knee in the carpet and floor layers' typical work postures where the dominant upper extremity is working, while the knees and the nondominant upper extremity are supporting the body weight.

The effect of knee pain and patellar tenderness on the knee extension torque may be caused by the reflex inhibition mechanism by which certain changes of the knee joint impair the function of the knee extensor muscles (4).

It can be concluded that among building workers knee pain, knee tenderness and occupational knee load were associated with weak knee extensor muscles. The knees are protected by good thigh muscles and this protection may be particularly important in occupations with high risk for knee injuries. In these occupations training of the knee extensor muscles could possibly decrease knee morbidity.

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