Acta Orthop Scand 56, 72–74, 1985

Age-related changes in proprioception and sensation of joint position

With a clinical goniometer we measured the ability of 29 normal women to (a) reproduce the perceived position of each knee with that of the other knee, and (b) reproduce from memory the perceived resting position of each knee following its return to rest. Fifteen subjects were under 30 years old and 14 were over 60. The younger group scored higher in all trials. This study suggests the existence of an age-related change in proprioception and static joint position sensation in women and provides a basis for further investigation of contributory factors of musculoskeletal trauma in the elderly.

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Elderly persons require a longer time than younger people to carry out movements, and fail to adjust their movements to compensate for errors (Brocklehurst et al. 1982, Dornan et al. 1979, Horch et al. 1975, Kokmen et al. 1978, Laidlaw & Hamilton 1937). Disability in organ systems other than bone may play a contributory role in limb fractures in the elderly (Brocklehurst et al. 1978, 1982, Dornan et al. 1979, Garraway et al. 1979, Iskrant 1968, Johnson & Hawkins 1972, Overstall et al. 1977). We undertook this study to answer the question: "Are there age-related changes in proprioception and static joint position sensation?"

Patients and methods

We studied 29 normal women in two age groups: 15 were under 30 years old with a mean age of 24 (22–27) years and 14 were 60 years and older with a mean age of 70 (60–80) years. All subjects were selected from a pool of normal hospital volunteers.

Any patient with a history of neuromuscular, arthroskeletal, rheumatologic, or cardiovascular disease, as well as any patient with a history of diabetes or lower limb fractures was excluded. All subjects had a normal pre-testing examination to exclude peripheral vascular disease and peripheral neuropathy.

Each subject wore a hospital gown and sat on a Bloomquist quadriceps table with a backrest and adjustable padded leg supports. The heels rested securely on a foam rubber bar to negate sensory tactile input from movement of clothing across the skin and joint surfaces.

With a translucent degree-calibrated clinical goniometer, the therapist measured the ability of each volunteer to: (a) reproduce the perceived position of each knee placed at 15°, 30°, and 70° with that of the contralateral knee at 15 and 60 s following static positioning of the knee.

Following the matching of static limb position, the short-term memory of ipsilateral knee position was tested. With the subject in a sitting position, on the quadriceps table, the right knee was placed in 20° of flexion and held in that position for 15 s before being returned to rest at 90°. At 15 and 60 s following the return to the resting position, the subject was asked to reproduce the knee joint position with the same limb. The test was also conducted at the position of 70° knee flexion. The entire test was repeated with the left knee.

All tests were performed on both lower limbs. All 29 subjects had all tests completed. The standard deviation of measurement error attributable to the clinical goniometer was 5°.

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This paper was presented in part at the 29th Annual Meeting of The Orthopaedic Research Society, Anaheim, California; March 10, 1983.

Statistical analysis

Direct comparison was made between the control and experimental groups for both direct matching and memory data. Paired *t*-tests were used to compare the right and left sides in all experimental groups. Sample Student's *t*-tests were performed for the two age groupings, and $p < 0.05$ was chosen as the criterion for statistical significance.

Results

The younger age group had higher ability to match the resting position of the contralateral knee joint at all times and in all positions (Table 1). The average absolute difference in the matching test was 4 degrees for individuals under 30 and 7 degrees for individuals aged 60 and older.

On comparing the sequential runs, the recorded error within each group was constant throughout all of the trials, again with a difference between the two age groups.

In the matching data for the set angles of 15°, 30°, and 70° there was consistency in both the under 30-year-old and over 60-year-old groups, with a significant difference in the older group at knee joint angles of 70°.

In analyzing the data to see what percentage of the trials overshot or undershot the set angle on the matching trials, we found no difference in the under 30-year-old, but a tendency to underestimate knee joint angle in the older group (Figure 1).

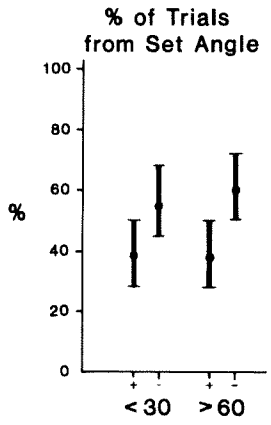

Figure 1. Age-related direction of error in direct matching trials (mean ± SEM).

Analysis of the data from the ipsilateral memory tests revealed a difference ($p < 0.05$) between the two age groups in all categories.

The memory data for ipsilateral knee joint positioning following return of the knee joint to a resting position after 15 and 60 s revealed a difference between the two times within each group.

*Table 1. Summary of derived data from direct matching experiments (mean ± SEM). * <0.05*

	Matching data (in degrees)		
Test	<30	>60	*P*
All	4±1	7±1	*
Symm.			
R	3±1	6±1	*
L	4±1	7±2	*
Runs			
1st	4±1	6±1	*
2nd	3±1	6±1	*
3rd	4±1	6±1	*
Flex.			
15°	3±1	5±1	*
30°	3±1	5±1	*
70°	4±1	8±1	*
%Δ			
+	39±11	39±11	NS
−	56±11	61±11	NS

Discussion

Human subjects are aware of the position of their limbs, both while stationary and while they are moving (Burgess 1976, Cohen 1958, Grigg et al. 1973, Grillner 1979, Horch et al. 1975, Laidlaw & Hamilton 1937, Lloyd & Caldwell 1965, Mountcastle & Powell 1959, Mountcastle 1980, Rymer & D'Almeida 1980, Skinner et al. 1984).

In a study of perception of passive movement in 60 normal control subjects, there was a wide range in the perceived movement threshold, most marked among the older age-group (Laidlaw & Hamilton 1937); the percentage of error in judging the direction of the passive movement was higher in the older age-group. However, neither determinations of the normal limit of error in perceiving joint position among older people nor consideration of static joint sensation was undertaken. Recently, Kokmen

et al. (1978) found that there was some decline in joint motion sensation with aging in normal subjects from 61 to 84 years of age.

An increased incidence of falls in the elderly has been correlated with loss of proprioception (Brocklehurst et al. 1978, Iskrant 1968, Overstall et al. 1977). Age-related changes have been shown to occur in other sensory systems, and dysfunction of any of these inter-related systems may contribute to the final outcome of falls with fractures (Dornan et al. 1979, Johnson & Hawkins 1972, Brocklehurst et al. 1982).

Although the measurements were obtained using a standard clinical goniometer (Boone & Azen 1979), our tests did not attempt to establish absolute values, but rather significant differences between joint positions at various angles and various times. Our study suggests that a large-scale investigation of age-related threshold measurement for the perception of joint motion should be performed in both males and females. Any changes in joint position sensation could be compared in the same individual with threshold of joint motion sensation, a modality which Kokmen et al. (1978) did not find changes appreciably with age.

Although socially active and neurologically normal, our small number of patients may not adequately reflect the normal heterogeneity of the world's elderly women. The perception of joint position sensation in the elderly was either equal to or larger than the error in the younger age-group in all subgroups analyzed.

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