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Muscle Strength and Balance in Post-stroke Patients

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ABSTRACT

Isokinetic torque of the knee and elbow during maximal extension and flexion and isometric strength of the handgrip, as well as balance and some circulatory variables, were tested in 37 patients one year after an acute stroke. Correlations with locomotion, household work and other activities of daily living (ADL) were tested. Male patients who had received special activation on the ward for up to 4 weeks after the stroke showed a significantly smaller difference in strength between the paretic and non-paretic knee at an angular velocity of 90 degrees per second than males who had received only routine activation on their ward. There was a high correlation between locomotion and the isokinetic torque of the paretic knee and also between locomotion and balance. The correlations between elbow strength and ADL functions were weaker. It was concluded that the evaluation of the isokinetic muscle torque of the knee and the balance tests are valid instruments for estimating functional capacity after a stroke.

INTRODUCTION

The decline of muscular performance and balance with age has been studied by several authors. Larsson et al. studied age-related changes of the quadriceps femoris muscle in 114 healthy males between 11 and 70 years of age (13). Both isometric and isokinetic strength increased up to the age of 30 years, remained nearly constant until the age of 50 and then gradually decreased.

Falls are associated with a reduction in the efficiency of physiological mechanisms controlling posture. In a random sample of 963 people over 65 living at home, Exton-Smith found a linear increase of falls between the ages of 65 and 84, with an especially high frequency for women (7). Up to 50% of women over 85 had a history of falls.

The main aim of this study was to find out whether tests of muscle strength and balance are valid as a supplement to other functional tests previously used on stroke patients in their own surroundings one year after an acute stroke. The patients belonged to a sample who had previously been admitted, during a ninemonth period, to the Department of Internal Medicine at Uppsala University Hospital with manifest stroke (9, 10).

SUBJECTS

The original patient material consisted of 60 patients (experimental group) who had received special activation on the ward for up to 4 weeks after a stroke and 52 patients (control group) who had been given only routine activation. Thirty-seven patients took part in this investigation. These comprised 23 of the 33 survivors from the experimental group (Group 1, 13 men and 10 women), and 14 of the 26 survivors from the control group (Group 2, 8 men and 6 women). These two groups fulfilled the following criteria for participation:

1) the presence of weakness in one or more extremities
2) the patient should be able to communicate and understand instructions
3) no medical contraindication and
4) free and informed consent of the patient.

Fifteen patients in Group 1 lived in their own homes, while eight were in hospitals for long-term care or in homes for the elderly. The corresponding figures for Group 2 were 12 and 2 respectively. For anthropometric characteristics, paretic side and muscle tone, see Table 1.

Table 1. Patients one year after acute stroke. Anthropometric characteristics, paretic side and muscle tone. Group 1 had received systematic activation on the wards for up to 4 weeks after the stroke. Group 2 had received activation according to the conventional routines of the wards for up to 4 weeks after the stroke. Age = age at the time of acute stroke. Values for age, height and weight are means ±SD. Muscle tone was tested by clinical examination (passive extension and flexion in the joints).

	Age range years	Age years	Height cm	Weight kg	Paretic side			Muscle tone	
					Right	Left	Right/ Left	Increased	Normal or nearly normal
Group 1									
Males n=13	46-79	69 ±10	171 ± 5	69 ± 8	5	7	1	6[a]	7
Females n=10	51-79	71 ± 8	159 ± 6	61 ± 5	2	6	2	3	7
Group 2									
Males n=8	54-82	71 ± 8	176 ± 7	79 ± 6	2	5	1	3	5[b]
Females n=6	49-75	68 ±10	158 ± 9	70 ±16	3	3	0	1	5

a) One patient was excluded from the muscle strength test, since measurements could only be performed in the non-paretic extremity.

b) One patient was excluded from the muscle strength test for medical reasons.

Muscle strength

A dynamometer for isokinetic movements (Cybex II, Lumex Inc., New York), modified with a strain gauge transducer, was used to record torque movement of muscle force during knee and elbow extension and flexion at maximal effort and constant angular velocity. The method has been described earlier (12, 14). The torque output was registered on paper by means of an X-Y recorder (Bryans 26700 High Speed Recorder A 3). The subject sat or lay on an examination table (ALFEX, constructed in our hospital by A. Elmeskog), which could be adjusted for measurements at different joints (see Fig. 1). For measuring the torque along with the axis of rotation of the knee, the patient sat on the table with the legs hanging over the edge. The dynamometer arm was attached to the leg at the ankle. For measuring the torque along with the axis of rotation of the elbow, the patient lay on the table with the dynamometer arm attached to the wrist.

Fig. 1. Stroke patient with left hemiplegia sitting on an examination table (Alfex) for testing of maximum isokinetic knee extension with a Cybex II apparatus. Photograph: Leif Kumlin, University Hospital, Uppsala.

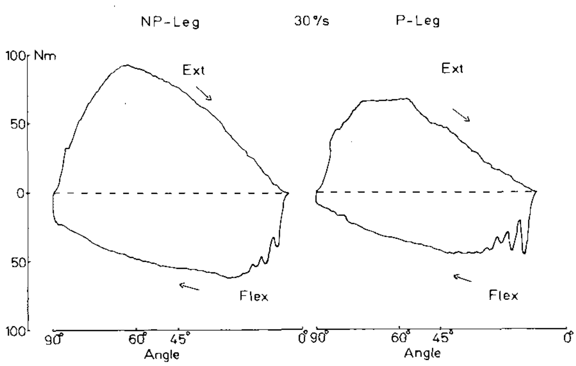

Fig. 2. An example of maximal torque for knee extension from 90 to 0 degrees and knee flexion from 0 to 90 degrees at a velocity of 30 degrees/s. P-leg = paretic leg, NP-leg = non-paretic leg. Since the extension is not complete in either of the legs, flexion starts at an angle of 5 degrees for the NP-leg and 10 degrees for the P-leg.

Three repeated extensions and flexions were made at preset angular speeds of 90 and 30 degrees per second. For the knee, the maximum torque at angular positions of 60 and 45 degrees was measured (see Fig. 2), and for the elbow the maximum torque at an angular position of 90 degrees.

Corrections were made for the torque of the gravitational force on the leg and the dynamometer arm. A recording was made with the leg and the dynamometer arm passively lowered from extension (0 degrees) to flexion (90 degrees). The mean values of the "gravitational torque" from seven paretic and four non-paretic legs in male patients and five paretic and two non-paretic legs in female patients were calculated. These were then added to the recorded knee torque during extension and subtracted during flexion at the force measurements in question. Since the maximum torque of the elbow was measured at an angular position of 90 degrees, no corrections were made for the gravitational torque in this case.

If the preset angular speed was not reached in one extremity (paretic side) either at the fast or at the slow velocity, the torque of the muscle force was not measured in the other non-paretic extremity.

A handgrip test apparatus measuring isometric muscle strength described by Bäcklund and Nordgren (4) was also used.

Arterial blood pressure was measured with a sphygmomanometer before and after the isokinetic and isometric force measurement periods.

Balance

For evaluation of balance or equilibrium two different tests were used. Test 1 has been described by Fugl-Meyer et al. (8) and consists of seven variables, three for sitting balance and four for standing balance (maximum score 14). In our analysis only the variables for standing balance were used (standing with and without support, standing on the affected side and on the unaffected side), with a maximum score of 8.

Test 2 has been described by Eklund and Löfstedt (6). During this test the patient stood on a force platform measuring 35 x 35 cm and 9 cm high (see Fig. 3). As a rule, ordinary shoes were worn and the patient was asked to stand comfortably with the body weight equally distributed. The signal from the force transducer was amplified (Bofors, BK-1) and displayed on an X-Y recorder (Hewlett Packard 7046A, Fig. 3). At first the patient stood for about half a minute while the lateral sway was recorded. After sitting down for some rest, the antero-posterior sway was tested. This included ordinary symmetrical standing with the eyes open and closed and with attempts to lean far forward and backward. With the help of the recording the standing ability was estimated, using a maximum score of 3 (normal or nearly normal balance).

Fig. 3. Stroke patient (left hemiplegia) standing on a force platform for balance tests by methods described by Eklund and Löfstedt (5). Photograph: Leif Kumlin, University Hospital, Uppsala.

Circulation and other functional tests

Peripheral circulation was studied through segmental indirect blood pressure measurements in the legs with ultrasonic detection of flow (19). The gradient between the pressure in the brachial artery and the arteries of the ankle was calculated. Electrocardiogram (ECG) was recorded at rest.

Before coming to the out-patient department, all patients had been examined at home or in institutions from a functional viewpoint (10). Variables of primary ADL functions included in an Activity Index (11) and variables concerning locomotion, household and psychosocial functions were recorded (10). Some of the variables were correlated with the results of the isokinetic muscle strength tests and/or the balance tests.

RESULTS

Muscle strength

The isokinetic torques of the knee during maximal extension and flexion are given in Table 2. Data were compared with the average torques of the muscle force at the same angular speed and angular position of both legs of seven males and six females, who were 70-year-old healthy volunteers from the study of Borges et al. (3). The mean difference in torque output between the paretic and non-paretic side among the male patients was significantly smaller in Group 1 at the faster velocity (90 degrees per second) than among males in Group 2. There was no significant corresponding difference among the female patients. The values for relative force (average torque of muscle force in the patients compared with that in the healthy 70-year-old volunteers) were espe-

Table 2. Torques of muscle force at isokinetic knee extensions and flexions at angular positions of 60 and 45 degrees. Patients one year after a stroke compared with healthy volunteers. Group 1 had received special activation on their wards for up to 4 weeks after the stroke (males n=12; females n=10). Group 2 had received activation according to the conventional routines of the wards for up to 4 weeks after the stroke (males n=7; females n=6). Values for average torque of muscle force at the same speed and angular position of both legs of 70-year-old healthy volunteers (males n=7; females n=6) are given for comparison. Relative force was defined as the ratio between the average torque of muscle force in patients, paretic leg (P-leg) and non-paretic leg (NP-leg), and that in the legs of the healthy volunteers (H-leg). Values are given in Newtonmeter, mean and SD. P-value refers to the mean differences between Groups 1 and 2 with respect to the difference in strength between the P-leg and NP-leg (Mann Whitney U-test, two-tailed).

Movement	Velocity °/s	Ang. pos. deg.	Group 1 P-leg Nm	Group 1 NP-leg Nm	Group 2 P-leg Nm	Group 2 NP-leg Nm	p-value	Healthy H-leg Nm	Relative force Group 1 P/H %	Relative force Group 1 NP/H %	Relative force Group 2 P/H %	Relative force Group 2 NP/H %
Males												
Extension	90	60	62 ±44	75 ±29	42 ±30	92 ±29	0.009	110 ±22	56	68	38	84
Extension	90	45	58 ±41	71 ±27	38 ±28	81 ±23	0.02	105 ±18	55	68	36	77
Extension	30[a]	60	93 ±54	119 ±34	57 ±38	109 ±51	0.29	139 ±24	67	86	41	78
Extension	30[a]	45	73 ±43	96 ±33	47 ±31	87 ±43	0.51	112 ±16	65	86	42	78
Flexion	90	60	25 ±29	33 ±22	11 ±20	45 ± 9	0.02	67 ±23	37	49	16	67
Flexion	90	45	25 ±31	32 ±22	8 ±24	44 ±14	0.008	68 ±24	37	47	12	65
Flexion	30[a]	60	33 ±28	48 ±22	27 ±20	48 ±27	0.48	74 ±23	45	65	36	65

Table 2 cont.

Flexion	30[a]	45	36 ±34	51 ±25	15 ±24	52 ±36	0.16	83 ±29	43	61	18	63
Females												
Extension	90	60	32 ±17	54 ±25	33 ±26	55 ±22	0.96	73 ±10	44	74	45	75
Extension	90	45	32 ±15	51 ±23	32 ±23	45 ±20	0.55	70 ± 8	46	73	46	64
Extension	30[a]	60	55 ±25	78 ±30	55 ±43	61 ±23	0.46	87 ±10	63	90	63	70
Extension	30[a]	45	48 ±20	65 ±25	45 ±36	48 ±18	0.35	73 ± 7	66	89	62	66
Flexion	90	60	12 ±12	23 ±14	10 ±14	21 ±14	0.83	32 ± 6	38	72	31	66
Flexion	90	45	10 ±12	24 ±16	8 ±17	23 ±19	0.91	33 ± 7	30	73	24	70
Flexion	30[a]	60	20 ±15	29 ±16	19 ±23	27 ±16	0.74	38 ± 8	53	76	50	71
Flexion	30[a]	45	21 ±16	32 ±18	21 ±27	29 ±14	0.69	42 ± 7	50	76	50	69

a) For one male patient and one female patient in both Group 1 and Group 2, the slow velocity was 12 °/s. These patients were not included in the mean values for 30 °/s.

Table 3. Torque of muscle force of isokinetic elbow extension and flexion at an angular position of 90 degrees. Patients one year after a stroke compared with healthy volunteers. Group 1: males n=8, females n=7. Group 2: males n=6, females n=6. The average torques of muscle force of both arms of healthy 60- and 70-year-old volunteers at the same speed and angular position are given for comparison (males n=6, females n=7). Relative force was defined as the ratio between the average torque of muscle force in patients, paretic arm (P-arm) and non-paretic arm (NP-arm), and that in the arms of the healthy volunteers (H-arm). Values are given in Newtonmeter, mean ±SD. P-value refers to the mean difference between Groups 1 and 2 with respect to the difference in strength between the P-arm and NP-arm (Mann Whitney U-test, two-tailed).

Movement	Velocity °/s	Ang pos. deg.	Group 1 P-arm Nm	Group 1 NP-arm Nm	Group 2 P-arm Nm	Group 2 NP-arm Nm	p-value	Healthy H-arm	Relative force Group 1 P/H %	Relative force Group 1 NP/H %	Relative force Group 2 P/H %	Relative force Group 2 NP/H %
Males												
Extension	90	90	26 ± 9	25 ±10	18 ±12	25 ±13	0.09	34 ± 7	77	74	53	74
Extension	30[a]	90	31 ±11	33 ±13	23 ±16	31 ± 9	0.27	37 ± 8	84	89	62	84
Flexion	90	90	26 ± 9	29 ±10	14 ±11	24 ±13	0.30	41 ±11	63	71	34	59
Flexion	30[a]	90	31 ± 9	33 ±11	19 ±12	29 ±12	0.11	44 ±10	71	75	43	66
Females												
Extension	90	90	13 ± 6	21 ± 7	14 ±12	19 ±10	0.47	22 ± 5	59	96	64	86
Extension	30[a]	90	19 ± 6	24 ± 7	18 ± 9	21 ±13	0.52	23 ± 6	83	104	78	91
Flexion	90	90	9 ± 6	16 ± 7	14 ±12	18 ±11	0.37	23 ± 5	39	70	61	78
Flexion	30[a]	90	15 ± 6	20 ± 3	18 ±15	22 ±15	0.83	23 ± 4	65	87	78	96

a) For one female patient in Group 1 and one male and one female patient in Group 2 the slow velocity was 12 °/s. These patients were not included in the mean values for 30 °/s.

cially low for flexion. In all movements, the torque reduction was greatest at the faster velocity (90 degrees per second).

The results for elbow extension and flexion are given in Table 3. Because of increased muscle tone (spasticity), all patients could not be tested for isokinetic muscle torque of the elbow. The values were compared with the average torque of muscle force of the elbows of six males and seven females 60 or 70 years old from the study of Borges et al. Although not significant, the mean difference between the paretic and non-paretic arm was slightly smaller among the males in Group 1 than among the males in Group 2. The reduction in strength was most pronounced for the fast movements as compared with the healthy volunteers, both for males and for females.

There was a highly significant correlation between locomotion and the torque of the muscle force at an angle of 60 degrees in the paretic leg for both men and women ($p < 0.001$) on all test occasions (Table 4). There was also a positive correlation, although weaker, between locomotion and the torque of the muscle force of the non-paretic leg. The correlation between the primary ADL functions personal hygiene and dressing and the torque of muscle force for elbow extension and flexion was significant in a few movements for the male group, see Table 5. For the females a significant positive correlation was found between household work and elbow strength at an angular velocity of 30 degrees per second, at both extension and flexion. For the men a significant correlation was noted only for flexion on the paretic side at the same speed.

Table 4. Correlation coefficients (r_s) between isokinetic muscle torque of the knee at an angular position of 60 degrees and scores for locomotion one year after a stroke.

Activity	Velocity 90 °/s				Velocity 30 °/s			
	Extension		Flexion		Extension		Flexion	
	P-leg	NP-leg	P-leg	NP-leg	P-leg	NP-leg	P-leg	NP-leg
Males n=18					n=17			
Locomotion	0.80***	0.53*	0.81***	0.38	0.75***	0.57**	0.78***	0.47*
Females n=16					n=14			
Locomotion	0.71***	0.58**	0.80***	0.67**	0.80***	0.43	0.90***	0.63**

*** = $p < 0.001$
** = $p < 0.01$
* = $p < 0.05$

Table 5. Correlation coefficients (r_s) between isokinetic muscle torque of the elbow at an angular position of 90 degrees and scores of personal hygiene and dressing, activity index (AI) and household work one year after a stroke.

Activity	Velocity 90 °/s				Velocity 30 °/s			
	Extension		Flexion		Extension		Flexion	
	P-arm	PN-arm	P-arm	NP-arm	P-arm	NP-arm	P-arm	NP-arm
Males n=14					n=13			
Hygiene	0.48*	0.32	0.45	0.19	0.54*	0.12	0.59*	0.15
Dressing	0.31	0.22	0.43	0.11	0.37	0.03	0.55*	0.04
Household	0.27	0.26	0.49*	0.25	0.38	0.09	0.67**	0.22
Females n=12					n=10			
Hygiene	0.48	0.48	0.48	0.39	0.53	0.41	0.52	0.53
Dressing	0.48	0.48	0.48	0.39	0.53	0.41	0.52	0.53
Household	0.17	0.44	0.27	0.23	0.77**	0.63*	0.60*	0.68*

** = $p < 0.01$
* = $p < 0.05$

Owing to marked spasticity, not all patients took part in the measurements of isometric handgrip. The results are presented in Table 6. The mean difference in strength between the paretic and non-paretic side was significantly smaller in the male patients of Group 1 than in those of Group 2 ($p < 0.05$). Relative force was calculated from the values of the same healthy volunteers as for the elbow movements.

Table 6. Maximum isometric strength of handgrip in patients one year after a stroke, compared with healthy volunteers. Group 1: males n=9, females n=8. Group 2: males n=6, females n=5. Values for the average torque of muscle force of both handgrips of healthy 60- and 70-year-old volunteers are given for comparison (males n=6, females n=7). Relative force was defined as the ratio between the average torque of muscle force in patients, paretic handgrip (P-h) and non-paretic handgrip (NP-h), and that for the handgrips in the healthy volunteers (H-h). Values are given in Newton (N), mean ± SD. P-value represents the mean difference in strength between Groups 1 and 2 (Mann Whitney U-test, two-tailed).

	Group 1		Group 2		p-value	Healthy	Relative force			
							Group 1		Group 2	
	P-h	NP-h	P-h	NP-h		H-h	P/H	NP/H	P/H	NP/H
	N	N	N	N			%	%	%	%
Males	314 ±157	363 ±118	196 ±79	402 ±128	0.018	451 ±128	70	80	44	89
Females	128 ± 79	186 ± 88	137 ±59	216 ±108	0.38	245 ± 49	52	76	56	88

Balance

The results of the two balance tests are shown in Table 7. There was a high correlation between Tests 1 and 2 ($r_s = 0.90$; $p < 0.001$). Altogether only four men (19%) and two women (13%) had a maximum score for both tests. The differences between Groups 1 and 2 were not significant. Concerning Test 1, standing in a balanced position on one leg at a time was difficult for most of the patients. Fifteen could not balance at all on one leg, five balanced better on the paretic side and 10 on the non-paretic side, and in seven both sides were equal.

In Test 2 the majority of the patients stood fairly symmetrically (cf. Fig. 4). The patient in Fig. 4 C is a typical example of those who tended to put somewhat more weight on the non-paretic leg. This was found in five cases,

Table 7. Balance tests on stroke patients, one year after an acute stroke.
Test 1: Balance test described by Fugl-Meyer, standing only (maximum score 8). The patients were grouped into 4 categories from 0-3 according to score (0=score 0-2, 1=score 3-4, 2=score 5-6, 3=score 7-8).
Test 2: Balance test described by Eklund & Löfstedt, standing on a force platform. The patients were grouped into 4 categories from 0-3 (0=unable to perform the test, 1=severe impairment of balance, 2=moderate impairment of balance, 3=normal or nearly normal balance). Spearman rank correlation coefficient between Test 1 and Test 2 (n=36) = 0.90 (p<0.001).

	Test 1					Test 2				
	0	1	2	3	Total patients	0	1	2	3	Total patients
Group 1										
Males	5	1	4	3	13	5	2	1	5	13
Females	1	3	5	1	10	1	2	4	3	10
Group 2										
Males	1	1	2	4	8	2	1	1	4	8
Females	0	4	1	1	6	0	2	2	1	5[a]

a) One patient could not be tested, for technical reasons.

whereas the opposite was observed in only two cases. A reduction of the ability to deviate from the resting position and lean forwards or backwards was frequent. Fig. 4 A represents a very mobile patient; his ability to perform such swaying was probably normal for his age, compared to the patient in B, where there was a reduction. Many of the patients were able to stand with closed eyes for at least 10-15 seconds. This was accompanied by an increase of the faster components in the sway signal (Fig. 4 B).

The signal in Fig. 4 D is from a patient with "intermittent standing ability". When fully rested he was able to stand and walk to some extent with technical aid, but at the time when the platform test was performed, he needed strong personal support, otherwise he would fall.

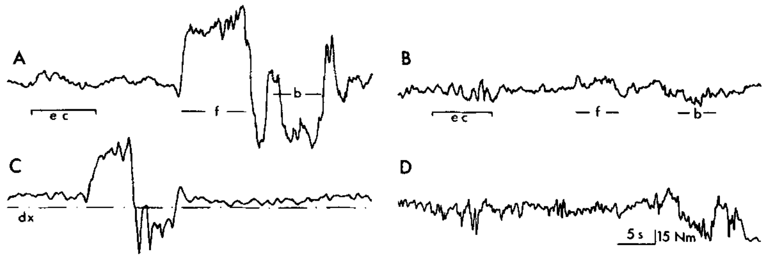

Fig. 4. Examples of the signal from the force platform. Calibration in D; 15 Nm corresponds to a displacement of the common centre of gravity about 1.5-2 cm in a patient weighing 70 kg. A bar marked e c indicates eye closure, and f and b indicate attempts to lean far forward and backward respectively. A, B and D show the antero-posterior sway signal of different patients.

The values for correlation between motor activity (according to the Activity Index) and balance are given in Table 8. There was a highly significant correlation between motor activity of the upper extremity and balance, and between the scores for locomotion and balance, both for males and for females. The motor activity of the upper and lower extremity combined was also highly significantly correlated to balance.

Table 8. Correlation coefficients (r_s) between two balance tests (Tests 1 and 2) and motor activity (according to Activity Index) and locomotion one year after an acute stroke.
Test 1: Balance test described by Fugl-Meyer, standing only.
Test 2: Balance test described by Eklund & Löfstedt, with the patient standing on a force platform.

Activity	Males		Females	
	Test 1 n=21	Test 2 n=21	Test 1 n=16	Test 2 n=15
Motor activity				
Upper extr.	0.77***	0.80***	0.76***	0.70**
Lower extr.	0.52**	0.53**	0.35	0.28
Upper and lower extr.	0.71***	0.73***	0.70***	0.65**
Locomotion	0.80***	0.83***	0.80***	0.65**

*** = $p < 0.001$
** = $p < 0.01$

Circulation

The blood pressure elevations after the muscle strength tests were small and not significant. The mean systolic pressure was even decreased after the isometric handgrip test and the isokinetic knee contraction, whereas it was increased slightly after the elbow contraction.

The systolic pressure gradient between the brachial artery and the arteries of the ankle, which normally is negative, was positive in one or both legs in 60% of the stroke patients (n = 35). Nine patients even had gradients as high as between 30 and 120 mm Hg. The blood pressure in the ankle arteries of two patients could not be registered properly; in one of them because of media sclerosis (too high pressure), and in the other because of a skin wound (diabetic). There was no significant difference in blood pressure between Groups 1 and 2, with the men and women tested separately, nor between the paretic and non-paretic legs (men and women tested irrespective of group).

The ECG of the 37 patients revealed a pathological pattern in 54%. The studied variables were left ventricular hypertrophy, supraventricular and ventricular ectopic beats, atrial fibrillation or flutter (AF), bundle branch block and status post myocardial infarction (PMI). There were no significant differences in pathological variables between Groups 1 and 2, with males and females tested separately, but AF and PMI were more frequent in Group 1 (AF = 35%, PMI = 30%) than in Group 2 (AF and PMI = 7%).

Statistics

Mainly non-parametic tests were used (16), namely Mann Whitney U-test for independent samples, two-tailed, and Spearman rank correlation coefficient, r_s (significance level with one-tailed tests). The blood pressure gradients were tested with Student's t-test.

DISCUSSION

The main aim of the present study was to find out whether isokinetic torque of the knee and elbow during maximal extension and flexion and different tests of balance could be useful supplements for validation of other functional test instruments used in the patient's own surroundings. It was also of interest to find out whether there were any differences in the performance of patients coming from two different samples. In Group 1 emphasis had been placed on activation during the first 4 weeks after the stroke, whereas Group 2 had received care according to conventional routines. Of the total number of patients, 81% were 65 years old or older at the time of the stroke. Since the ageing population in Sweden is increasing, it would be of value to find useful evaluation instruments for functional capacity which could be used in the laboratory as well as in the patients' homes.

The male patients from Group 1 showed less difference in strength between the paretic and non-paretic knee than the males from Group 2. This was also the case for handgrip strength. One reason for this difference may be that the patients of Group 1 had greater motivation to train their paretic extremity. There was no significant difference in this respect among the women.

Like other authors, we found that in general the torque of the muscle force was more reduced at fast than at slow movements and also more during flexion than during extension in our stroke patients, compared with healthy volunteers. Using EMG recordings of prime movers and antagonists of the knees of 24 spastic patients, Knutsson et al. confirmed that the mean antagonist restraint was more pronounced at fast than at slow voluntary movements (12). They used a Cybex II equipment similar to that used in the present study and also showed that the antagonist restraint was stronger at flexions than at extensions. In the present study, spastic restraint was estimated clinically by passive extension and flexion movements. Patients with "clinical" muscle hypertonus had greater difficulty in reaching the preset speed as compared with those with a normal muscle tone. This was especially marked in elbow movements. Seventy percent of the patients with muscle hypertonus could not perform the handgrip test on the paretic side.

Our reference group of healthy volunteers represented only a part of a larger randomized material (3). We have compared the values for our healthy volunteers with those from other series of approximately the same age group. Aniansson et al. have studied the isometric and isokinetic quadriceps muscle strength in 70-year-old men and women (2). The sample was representative of the healthy 70-year-old urban population of Göteborg in Sweden. The mean values from our healthy group correspond well with Aniansson's findings, especially concerning the women.

The highly significant correlation between isokinetic torque of the paretic knee and locomotion in the present study supports the validity of the test. The torque of the non-affected extremity, the values for which were generally lower than those for the extremities of the healthy group, also showed a positive correlation with locomotion, although weaker. The correlations between the isokinetic torque of the elbow and household work and between elbow strength and primary ADL functions (hygiene and dressing) were weaker. This could be due to several factors. The patients living in institutions usually did no household work and got low scores for household activity irrespective of elbow strength. The patients who were well enough to take part in the muscle strength tests usually had a high score for the primary ADL functions, but a correlation could not be demonstrated because of the small range of variations.

Aniansson et al. also looked into different activities of daily living in healthy 70-year-old men and women (1). Positive correlations were found between quadriceps strength and both walking speed and maximum step-height among the women, but not among the men.

In the present study a normal or nearly normal balance was only found in 19% of the males and 13% of the females. Furthermore, there was a high correlation between scores for locomotion and balance. Especially the scores for motor activity of the upper extremity (measured by an Activity Index) and balance were strongly correlated. This finding may reflect the fact that standing equilibrium and postural fixation form an important basis for other purposeful motor activities.

Overstall, in a review of falls in the elderly, pointed out that the fear of falling may establish a pattern of immobility in older people (18). They questioned 243 elderly people between 60 and 96 years of age about their falls and measured their sway movements at the waist (17). People with falls due to giddiness, drop attacks, loss of balance, etc., had significantly greater sways.

Normally, during standing only slight muscle activity is called for to maintain equilibrium and to correct the posture. One of the important postural mechanisms during standing is the control of the centre of gravity above the area of support. This control seemed to be reduced in the patients in this study. The main component of the initiation of walking is a falling forward (5). Post-stroke patients might have a sufficient muscle strength, but the impaired central nervous control limits their possibility of standing as well as walking.

Seliktar et al. (15) found that hemiplegic patients tended to put more weight on the unaffected leg and that they displayed greater sway than normal subjects. This may agree with the present findings, but a close comparison is difficult owing to different methods of recording and to the lack of details about their patient material.

There was no significant arterial blood pressure elevation after the muscle strength tests. The same tendency was found among the healthy volunteers (only women were tested). Both ECG changes and the result of the peripheral circulation tests indicate that general cardiovascular changes are common in a sample of one-year survivors after a stroke. Twenty-six percent of the patients had test values pointing to obliterative changes in the legs.

In conclusion, the measurements of isokinetic muscle torque of the knee and of the balance capacity appear to be valid instruments for estimating functional ability in post-stroke patients. It seemed possible that special activation on the wards during the first 4 weeks after a stroke influenced the male patients in a positive way concerning the subsequent use of their affected side.

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