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FUNCTIONAL STUDIES IN 79-YEAR-OLDS

II. *Upper extremity function*

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ABSTRACT. As part of the Gerontological and Geriatric Population Study of 79-year-old people in Göteborg, a representative subsample comprising 112 women and 93 men took part in a study of upper extremity function. Thirty-eight per cent of the women and 37% of the men had disorders in the upper extremities. The investigation included tests of co-ordination, static strength in the key-grip and the transversal volar grip, power capacity in opening jars and a bottle, basal movements in the upper extremities in personal hygiene and dressing activities, function in the kitchen e.g. reaching shelves, manual tasks including tests of pronation and supination of the forearm. In the key-grip as well as in the transversal volar grip men showed a generally larger decrease in strength with age than women compared to 70-year-olds in a previous population study. Significant correlations were found between strength in the key-grip and the performance time in the test of co-ordination. Women produced about 66% of the muscular force of the men when opening jars. Significant correlations were found between strength in the transversal volar grip and the maximal torque for opening the jars. Female and male subjects who were not capable of handling the electric plug in the manual ability test had significantly weaker strength in the key-grip. The importance of designing products and adapting the environment so as to correspond to the functional capacity of the elderly, is emphasized.

Key words: Upper extremity function, gerontology, activities of daily living, handicap, rehabilitation

An increasing part of the Swedish population belongs to the higher age-group. The proportion of persons with limited functions in Activities of Daily Living (ADL) increases with age. Ageing *per se* causes a reduction of motility (9), muscle strength (3, 7) and co-ordination (13). A reduction in physical activity accentuates the decrease of various functions (13). This means a complex of problems, full of individual variations. Old people often have several disorders in the musculoskeletal system affecting upper extremity function. Their subjective difficulties are often influenced by their personal and social circumstances.

For the individual as well as the community (human and economical reasons), it is very important that people are able to lead an independent and active life in old age. We know that even moderate physical activity has training effects on elderly persons (1). It is possible to maintain a certain basal capacity, even at high age, by adapting the physical surroundings, housing and products to the needs of the elderly. This underlines the necessity of good knowledge of the functional capacity in old age.

SUBJECTS

Sixhundred and one 79-year-old women and men were invited to participate in the population study of "79-year-olds in Göteborg" which was performed in 1980–81. These persons were drawn from the Revenue Office Register as a systematic sample comprising 30% of the 79-year-olds living in Göteborg between 1 July 1980 and 30 June 1981. The method of sampling as well as the design and performance of the general study have been described by Rinder et al. (14). The probands were numbered consecutively from 1 to 5. A systematically selected subsample (probands 3 and 5) were invited to participate in the study of upper extremity function. The subsample represented 40% of the total sample.

Altogether 112 women and 93 men took part in the study of upper extremity function, which means a response rate of 88% in women and 93% in men. The causes of non-response are given in Table I and anthropometric data on the subjects are given in Table II. Thirty-five women (31%) and 46 men (49%) had no disorder in the upper extremities.

Functional diagnostics showed that 43 women (38%) and 34 men (37%) had one or more symptoms and signs in the upper extremities, such as arthrosis in finger joints, Dupuytren's contracture and shoulder pain (Fig. 1). Moreover a number of subjects had minor disorders, e.g. impaired finger sensibility. Five of the subjects were left-handed. Thirty-four subjects (17%) reported reduced vision even with corrective glasses.

Table 1. *Causes of non-response in tests of upper extremity function in the total subsample of 79-year-old women and men*

	Women ($n=126$)	Men ($n=100$)
Refusal	3	2
Severe illness	6	2
Institutional care	5	3

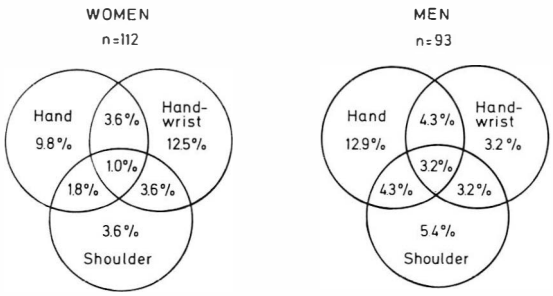

Fig. 1. Percentage distribution of 79-year-old women and men with various symptoms and signs. In addition, one woman had disorders in an elbow and shoulder, one in a wrist and shoulder and one in the four studied variables in combination.

METHODS AND PROCEDURES

Mobility in the upper extremities in hygiene and dressing activities in the seated position was tested with some basal tasks:

1. Grasping the ear-lobe on the opposite side with the arm in front of the head.
2. Grasping the ear-lobe on the opposite side with the arm behind the head.
3. Fitting a hand between the buttock and seat.
4. Placing the finger-tips on the opposite big toe.

Pronation and supination of the forearm were studied with a water-pouring test. Pronation was tested in a combined power and precision activity—pouring water from a jug to a glass. The jug contained one litre of water. Pronation and supination of the forearm were tested in a precision activity—pouring water from one glass to another and back again with the arm towards the supinated position. The tests of pronation and supination are parts of a quantitative test of upper extremity function developed by Carroll (6).

The reach of the upper extremities was tested by the subject lifting a glass and a one-kilogram packet (6 cm × 9 cm × 19 cm) on to shelves of 180, 160 and 140 cm height. The shelves, which had a depth of 30 cm, were mounted on the wall above a cupboard of 60 cm depth and 90 cm height, simulating standard Swedish kitchen fittings.

Manual ability was tested in various tasks of importance for independent ADL function (2):

1. Pulling out and inserting a key into a lock.
2. Pulling out and inserting an electric plug into a socket. (Required force 15 Newtons.)
3. Unscrewing and screwing in an electric light bulb.
4. Inserting a coin in a slot.
5. Dialling the numbers 0–9 on a telephone.

The equipment was mounted on a horizontal panel placed at chest-height with the subject sitting. Those who needed corrective glasses for carrying out the test used them. The performance time was measured and the observer registered any difficulties.

Muscular co-ordination in the hand and arm was measured with Molbech's clothes-peg test (12). This test consists of 50 clothes-pegs with metal tips which the subject is required to grasp, open and fit into 50 pairs of holes at maximum speed. The force needed to open a clothes-peg was 16 Newtons. The subject was allowed three clothes-pegs for practice.

Maximal static strength (MVC) was measured in the key-grip and the transversal volar-grip using strain gauge dynamometers (16) (Fig. 2) and a Servogor ink recorder. The contractions were performed with the dynamometers fixed at 90° elbow angle. In a pilot study of 29 elderly subjects, the force recorded with the handgrip dynamometer fixed and hanging respectively did not show any significant differences (Lundgren-Lindquist & Sperling, unpublished results 1979).

The static endurance of the transversal volar grip was measured as the time the subject could hold 50% of the maximal isometric contraction (MVC). The 50% level was marked as a target line on the paper of the recorder.

The maximal power capacity in opening jars and a bottle with screw tops was tested in the standing position. Equipment from the Swedish Packaging Research Institute was used (5). The packages were specially designed to provide readings of the torque and compressive force which people could apply when opening containers. Two jars were tested, one smaller jar (A) with a smooth lid (∅ 73 mm) and one higher jar (B) with a grooved lid (∅ 84 mm) (Fig. 3). In addition a one-litre bottle (C) with a screw top (∅ 28 mm) was tested (Fig. 3). The containers

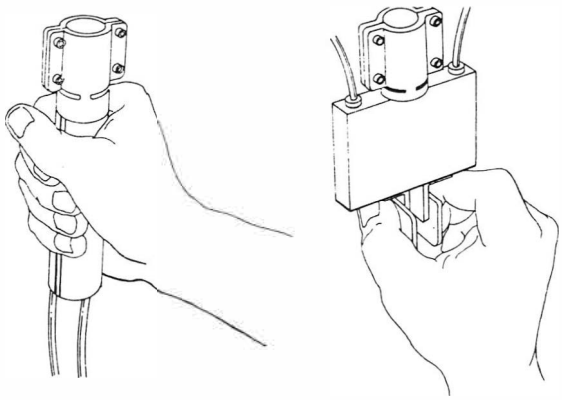

Fig. 2. Strain gauge dynamometers for static strength measurements of force of the transversal volar grip and the key-grip.

Table II. *Anthropometric data on 79-year-old women and men subjected to tests of upper extremity function*

	Women			Men		
	Mean	SD	Range	Mean	SD	Range
Body weight (kg)	64.6	10.0	40.8–92.7	73.1	9.9	46.0–99.5
Body height (cm)	158.1	6.0	138–173	171.0	6.3	156–187

were identical in size and weight to those which can be bought by consumers, but it was impossible to actually open them. In each test of static strength the subject performed three isometric contractions each of three seconds' duration with intervals of 30 sec.

For technical reasons, there was a drop-out of measurements in the test of maximal power capacity in opening jars and a bottle. This drop-out was unsystematic.

Statistics

Standard statistical methods were used to calculate means (M) and standard deviations (SD) and correlation coefficients (r).

Statistical comparison between two groups and correlation analysis were performed by means of Pitman's nonparametric permutation test. Only two-tailed tests were used. Differences and correlations were considered statistically significant for values of $p<0.05$.

RESULTS

Tests of mobility and reach of the upper extremities

Among the tests of mobility in the upper extremities in hygiene and dressing activities, the hand-to-toe test caused most difficulties (Fig. 4). Thus 7% of the women and 6% of the men were not able to reach their opposite big toe in the seated position. However, all women and men were able to reach the buttock and seat. Nine per cent or less of the women and men respectively were not capable of performing the various tests of arm elevation. In the test of reach to shelves of different heights, 6% of the women and 3% of the men were not capable of lifting the objects to the 180 cm high shelf. However, all subjects managed the 140 cm height.

Three per cent or less of the women and men respectively had difficulties in the water-pouring tests of pronation and supination.

Test of muscular co-ordination

The average time needed to perform the clothes-peg test was similar for women and men. The inter-individual variations between the subjects were large, however (Table III). This can partly be explained by variations of the strength in the key-grip. In both women and men, there was a highly significant correlation between the performance time in the co-ordination test and strength in key-grip (Table V). Women without upper extremity disorders performed the test in a significantly shorter time compared to the total group of women ($p<0.05$).

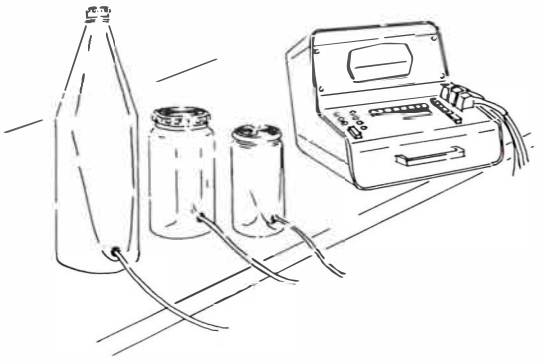

Fig. 3. Test jars and bottle for static hand torque measurements.

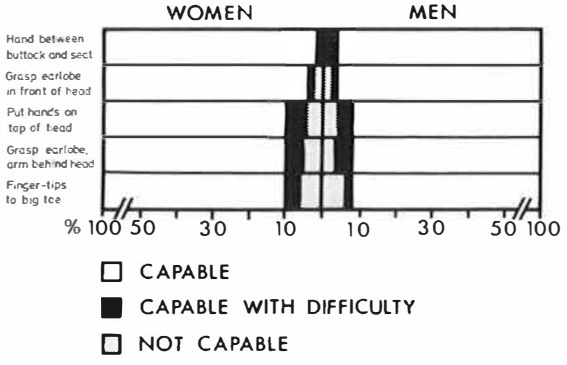

Fig. 4. Mobility of the upper extremities in hygiene and dressing activities in 79-year-old women and men.

Table III. *Evaluation of upper extremity function in 79-year-old women and men*
Mean values and standard deviations in tests of muscular co-ordination, grip strength and endurance

	All women			Women without upper extremity disorders			All men			Men without upper extremity disorders		
	n	*M*	SD	*n*	*M*	SD	*n*	*M*	SD	*n*	*M*	SD
Test of muscular co-ordination (sec)	104	298	76.1	35	273	46.1	79	282	78.7	46	264	52.9
Key-grip, MVC (*N*)	107	65	13.8	35	71	11.4	86	93	20.1	46	96	16.1
Transversal volar grip, MVC (*N*)	107	183	42.8	35	195	38.8	86	243	58.5	46	262	50.2

Static strength and endurance

In the key-grip the women produced about 70% and in the transversal volar grip about 75% of the force of the men (Table III). Women without upper extremity disorders were significantly stronger in the key-grip than the total group of women ($p<0.05$).

There were no significant differences in transversal volar grip between subjects without upper extremity disorders and the total groups of women and men respectively.

Strength in the key-grip was strongly correlated to strength in the transversal volar grip in the total female group and in the total male group (Table V). Correlations were also found in the groups of subjects without upper extremity disorders.

In the test of submaximal endurance in the transversal volar grip, the subjects were not able to keep the 50% level stable and the intra-individual variations were large.

Opening jars and bottle

In the test of power capacity in opening jars, the female subjects produced about 66% of the force of the male subjects when handling both the smaller and the larger screw lid (Table IV).

The intersubject variation was large. In the total group of women as well as men there were significant correlations between the power capacity in the transversal volar grip and the torque of both the smaller and the larger jar. Among the subjects without upper extremity disorders, this correlation was only found in male subjects when handling the smaller jar with a smooth lid (Table V).

When turning the top of the bottle, women produced about 92% of the force of the men in the same activity. The torque when turning this minor top showed a high correlation to the strength in the key-grip in the total groups of women and men. Among the subjects without disorders in the upper extremities, this correlation was found only in men.

Cumulative frequency curves (Figs. 5 and 6) show that 87% of the women and 31% of the men were not able to "open" the smooth lid of 73 mm ∅ and 71% of the women and 21% of the men were not able to "open" the grooved lid of 84 mm ∅. However, all subjects, women as well as men, were able to "open" the bottle (Figs. 5 and 6).

Test of manual ability

In the test of manual ability in various activities (Table VI), women and men used about the same performance time. The handling of the electric plug caused difficulties, especially among the women. Subjects who were not able to perform this test or had difficulty in doing so had significantly

Table IV. *Power capacity of 79-year-old women and men in opening jars and bottle*

	Women				W/M	Men			
	n	Range	*M*	SD	(%)	*n*	Range	M	*SD*
Jar (A), lid 73 mm ∅, MVC (Nm)	86	165–604	309	79	66	72	198–748	470	133
Jar (B), lid 84 mm ∅, MVC (Nm)	94	158–660	364	98	66	76	206–912	554	174
Bottle (C), top 28 mm ∅, MVC (Nm)	44	82–211	150	26	92	55	89–238	163	28

Table V. *Correlations between different variables in tests of upper extremity function in 79-year-old women and men*

	All women			All men		
	n	*r*	*p*<	*n*	*r*	*p*<
Key-grip MVC						
Transversal volar grip MVC	107	0.51	0.001	86	0.46	0.001
Test of muscular co-ordination	101	−0.31	0.001	72	−0.48	0.001
Bottle top (C) 28 mm ∅	44	0.48	0.001	53	0.42	0.001
Transversal volar gripMVC						
Lid of jar (A) 73 mm ∅	83	0.32	0.01	69	0.51	0.001
Lid of jar (B) 84 mm ∅	91	0.29	0.01	73	0.46	0.001

weaker strength in the key-grip than found in the total group (women $p<0.001$ and men $p<0.001$).

Six per cent of the women and 4% of the men were unable to handle the electric lamp bulb or had difficulty in doing so. One per cent of the women and 5% of the men had difficulties when dialling numbers on a telephone, due to fumbling. The key and coin tests caused less difficulties in the various tests of manual ability.

DISCUSSION

As the functional capacity of the arms and hands is of great importance in daily life, upper extremity disorders may reduce the ADL function considerably in old age. In this study of subjects representative of 79-year-old women and men in the general population more than a third of the women and men had one or more symptoms and signs in the upper extremities. This caused various kinds of functional limitations in the different tests used in this study.

Upper extremity function was in some of the tests also influenced by the degree of mobility in the trunk, hips and knees. Thus, in the test of mobility in the upper extremities in hygiene and dressing activities, the hand-to-toe test caused difficulties most often. This means functional restrictions especially in pedicure and in handling of shoes and shoe closures.

Only few of the subjects could not reach shelves of 180 cm height. The percentage of subjects with difficulties was lower than in a sample of 70-year-old women and men studied with the same test methods (15). One possible explanation could be the relatively small number of 79-year-old subjects with shoulder disorders (Fig. 1).

The clothes-peg test is mainly designed as a test

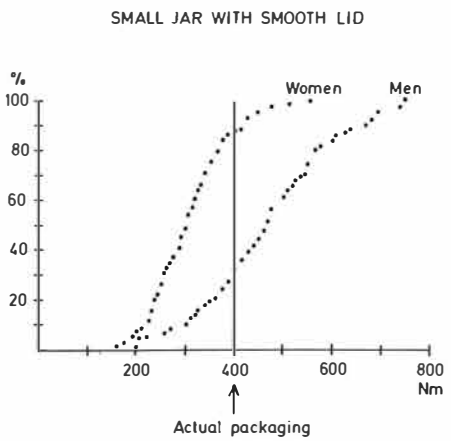

Fig. 5. Lid-opening torque in female and male subjects when handling jar A (smooth lid 73 mm ∅), cumulative frequency curve.

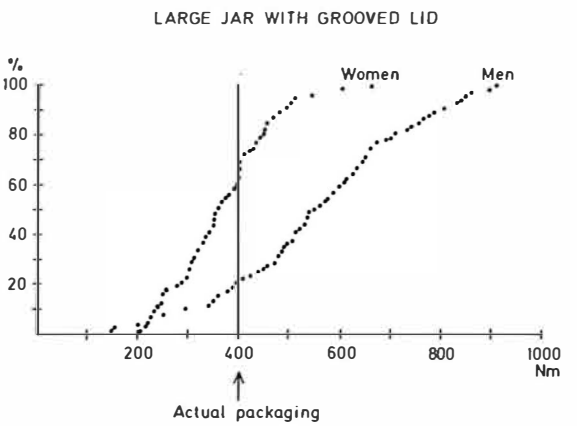

Fig. 6. Lid-opening torque in female and male subjects when handling jar B (grooved lid 84 mm ∅), cumulative frequency curve.

Table VI. *Results of various tests of manual ability in 79-year-old women and men*

	Women ($n=109$) *M* 59.8 sec, SD 17.2		Men ($n=89$) *M* 56.4 sec, SD 25.1	
	Not capable (%)	Capable with difficulty (%)	Not capable (%)	Capable with difficulty (%)
Key in lock	1	0	2	0
Plug in socket	21	25	9	7
Electric lamp bulb	0	6	1	3
Coin in slot	0	2	2	0
Numbers on telephone	0	1	1	4

of muscular co-ordination and manual dexterity. However, especially in elderly subjects, different variables influence the performance, such as motivation, vision, motility, grip strength endurance and various disorders of the upper extremities. The variation in performance time was large. A significant correlation was found to key-grip strength in both sexes. In this repetitive work, as in ordinary domestic work, grip strength and grip strength endurance certainly have importance for the performance. Furthermore, repetitive work at this force level might have a training effect in old age.

Systematic studies on grip strength of elderly people are rare. In addition, we have only found one study including both female and male subjects corresponding to the age group of this investigation. In that study Kellor et al. (8) have, among other functions, studied grip strength (transversal volar grip) and strength of lateral pinch (key-grip) of age-groups from 20–24 to 80–84 years of age. However, they do not state the number of subjects, nor are the subjects representative of persons in the general population. In grasp the dependence of strength on age was presented as linear regression lines for both sexes. In the transversal volar grip as well as in the key-grip it was shown that men are stronger than women and remain so throughout life. However, the slope of the men is steeper than that of the women.

In the present study healthy men show a much steeper decrease in strength between the age of 70 and 79 than healthy women (12). In a pilot study of 29 female and male subjects drawn from a population study in Copenhagen, essentially the same strength values were found as in the present group (10). We suppose that the degree of activity in daily life, e.g. in household work, is of great importance for retaining grip strength and that women, at least in the studied generation, have a higher manual activity with relatively better grip strength as a positive consequence. This is in contrast to the suggestion of Kellor et al. (8), who concluded that women retain a greater proportion of their grip strength than men due to lower grip strength at the age of 20. The key-grip is the most frequent type of grip in ADL (11, 17) which could explain why the decrease of strength between 70 and 79 years of age in this type of grip is consistantly less than that of the transversal volar grip in both sexes.

Very few of the 79-year-old women were able to open the jars. The norms for opening the jars which are formulated by the packaging manufacturers for nutritional and hygiene reasons are much too high in respect of strength.

It is very important that elderly people are as independent as possible as regards preparation of food. Dependence on technical aids very often means a restriction in life and it would surely be possible, by technical development, to design better standard containers instead of developing aids for opening jars, which was recommended in a previous investigation (4).

For the individual as well as for the community, it is very important that equipment is designed with consideration to the needs of the elderly, thereby making it possible for more people than today to remain in their habitual surroundings. However, we should not forget their own freedom of choice.

Home help service facilitates independent living but it is essential to be aware of the individual's functional capacity and see to it that individual activities of daily living are promoted. Standard products, tools etc. should be used as far as possible and if necessary compensated for by adapted products which do not differ in appearance from standard, e.g. improved electric plugs and sockets. Spe-

cial technical equipment should be avoided, in view of the risk of psychological disadvantages.

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REFERENCES

1. Aniansson, A. & Gustafsson, E.: Physical training in elderly men with special reference to quadriceps muscle strength and morphology. Clin Physiol *1:* 87, 1981.
2. Aniansson, A., Rundgren, Å. & Sperling, L.: Evaluation of functional capacity in activities of daily living in 70-year-old men and women. Scand J Rehab Med *12:* 145, 1980.
3. Asmussen, E. & Heeböll-Nielsen, K.: Isometric strength of adult men and women. In Communications from the Testing and Observation Institute of the Danish National Association for Infantile Paralysis, 11, 1961.
4. Berns, T.: The handling of consumer packing. Applied Ergonomics *12:* 153, 1981.
5. Berns, T., Kirk, S., Claridge, N., Jönson, G., Wahlström, G. & Ånell, M.: The handleability of different consumer packaging. Swedish Packaging Research Institute Stockholm No. 54, ID-no 141646, 1979.
6. Carroll, D.: A quantitative test of upper extremity function. J Chron Dis *18:* 479, 1965.
7. Gutmann, E.: Age changes in the neuro-muscular system and aspects of rehabilitation medicine. *In* Neurophysiologic Aspects of Rehabilitation Medicine (eds. A. A. Buerger & J. S. Tobis), pp. 42–61. Charles C. Thomas, Springfield, Ill., 1976.
8. Kellor, M., Frost, J., Silberberg, N., Iversen, I. & Cummings, R.: Hand strength and dexterity. Am J Occup Ther *25:* 77, 1971.
9. Kjerland, R. N.: Age and sex differences in performance in motility and strength tests. Proc Iowa Acad Sc *60:* 519, 1953.
10. Lundgren-Lindquist, B. & Sperling, L.: Evaluation of upper extremity function in 70- and 80-year-old men and women. Paper presented at the 8th International Congress of Physical Medicine and Rehabilitation in Stockholm, 1980.
11. Moberg, E.: Surgical treatment for absent singlehand grip and elbow extension in quadriplegia. J Bone Joint Surg *57A:* 196, 1975.
12. Molbech, S.: Methods for measuring coordination and accuracy of muscular movements. Scand J Rehab Med, Suppl. 6, 1978.
13. Potvin, A. R., Syndulko, K., Tourtellotte, W. W., Lemmon, J. A. & Potvin J. H.: Human neurologic function and the aging process. Am Ger Soc *28:* 1, 1980.
14. Rinder, L., Roupe, S., Steen, B. & Svanborg, A.: 70-year-old people in Gothenburg. A population in an industrialized Swedish city. I. A general presentation of social and medical conditions. Acta Med Scand *198:* 397, 1975.
15. Sperling, L.: Evaluation of upper extremity function in 70-year-old men and women. Scand J Rehab Med *12:* 139, 1980.
16. Sperling, L.: The perception of force in hand-grips at normal and impaired hand function. In Grip function in daily activities. Studies on subjects with normal and impaired hand function. Thesis. Department of Handicap Research, University of Göteborg, Göteborg, 1979.
17. Sollerman, C.: Grip function of the hand. Analysis, evaluation and a new test method. Thesis. Section for Hand Surgery, Department of Orthopaedic Surgery, University of Göteborg, Göteborg, 1980.

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