Scand J Rehab Med 2000; 32: 11–15

EFFECT OF SWALLOWING TRAINING ON SWALLOWING DISORDERS IN PARKINSON'S DISEASE

Masahiro Nagaya, MD[1] Teruhiko Kachi, MD[2] and Takako Yamada, MD[2]

From the Departments of [1]Rehabilitation and [2]Neurology, Chubu National Hospital, Obu, Japan

The purpose of the present study was to determine whether swallowing training improves swallowing function in patients with Parkinson's disease. Ten patients (5 males, 5 females) who had symptoms of dysphagia and 12 healthy volunteers were studied. The initiation time of the swallowing reflex, the "premotor time" (PMT), was calculated from an electromyogram of the submental muscles before and after swallowing training. Patients with Parkinson's disease had a significantly longer PMT ($p = 0.0014$) than did healthy controls. There was no correlation between PMT and the duration of the disease ($r = -0.146$; $p = 0.6867$) or the patient's age ($r = 0.602$; $p = 0.0653$). After swallowing training, the patients' PMTs decreased significantly ($p = 0.0051$).

Key words: Parkinson's disease, dysphagia, swallowing training, premotor time.

Scand J Rehab Med 2000; 32: 11–15

Correspondence address: Masahiro Nagaya, MD, Department of Rehabilitation, Chubu National Hospital, 36-3 Gengo, Morioka-cho, Obu 474, Japan

(Accepted March 29, 1999)

INTRODUCTION

Dysphagia is often observed in patients with Parkinson's disease (PD), especially in those at an advanced stage. Previous cineradiographic and videofluorographical studies have revealed severe impairment in the oral and pharyngeal phases, such as abnormal lingual control, piecemeal deglutition, delayed swallowing reflex, bolus pooling in the vallecular space and the pyriform fossa, as well as aspiration (1, 3, 4, 10, 11, 17, 22, 23). Leopold & Kagel (10) described dysmotility with delayed transport function during the pharyngeal stage in 39 out of 69 patients. Nagaya et al. (14) found disturbed motility in the oral phase of swallowing. There is also a delayed initiation of the swallowing reflex (1, 3, 11, 17, 22). An objective measurement of the delayed initiation of the swallowing reflex is difficult. Several reaction time (RT) measurements have shown that premotor time (PMT) tends to be prolonged in PD (2, 6, 7, 16, 18, 19, 25).

In the present study, we characterized and quantified the slowing of swallowing, based on parameters measured by electrophysiological methods. Secondly, we studied the effect of swallowing training on the delayed initiation of the swallowing reflex. We conducted a before and after trial to test whether only one session of swallowing training could improve swallowing function in patients with PD.

MATERIALS AND METHODS

Ten patients (5 males, 5 females) with PD who had symptoms of dysphagia were studied (Table I). All patients had moderate or severe PD. According to Hoehn & Yahr's disability scale (8), eight patients were at stage 3, and two were at stage 4. All patients had at least two of the four major features characterizing PD, and had no history of encephalitis or exposure to parkinsonism-inducing substances or drugs (5, 9). Patients with dementia, apparent depression, no complaints about swallowing, other neurological or internal disorders interfering with swallowing, or pulmonary function were excluded. Patients with PD at stage 1 or 2 who had no symptoms of dysphagia were excluded from the study, as were patients at stage 5 who could not follow the swallowing training. All patients were taking levodopa at the time of the examination. All examinations were performed over 90–120 minutes, after the first intake of this medication in the afternoon. We also performed the same examinations on 12 healthy volunteers (3 males, 9 females) who had no structural abnormality in the head or neck, and no history of neurological illnesses, gastrointestinal disorders, or dysphagia. They were aged from 47 to 93 years (mean ± SD 72 ± 13 years), and had not taken antidepressants, beta-blockers, or anticholinergic agents that may affect swallowing, or drugs which affect the central nervous system. Informed consent was obtained from all subjects.

In order to assess the oral and pharyngeal function in patients with PD, a modified barium swallow (13) was performed. Subjects were seated upright and asked to swallow 3, 5, 7, 10 and 15 ml of liquid barium. Recording during the fluorography was completed on a videotape running at 30 frames/second, using a videocassette recorder (Toshiba, AE52C) coupled to a counter-timer that inserted timing information on each video field. The videotapes were then analysed in slow motion and frame-by-frame to identify all abnormalities in the swallow.

The swallowing reflex was also analysed using electromyography in the submental muscles of the neck. A pair of surface Ag/AgCl electrodes were placed on the skin overlying the submental muscles of the neck, with the ground electrode sited over the external surface of the lateral epicondyle of the humerus. The muscle activity was amplified using 30 Hz low- and 3 kHz high-filter cut-offs and stored using an electromyograph (MEM 4104). The submental muscles comprise the mylohyoid, digastric, geniohyoid, stylohyoid, hypoglossal, mental, styloglossal and palatoglossal muscles.

After the electrodes were satisfactorily placed on the neck, the subject was instructed to hold 5 ml of water in his/her oral cavity and to swallow as rapidly as possible. The visual stimulus was a flash of green light. The pilot lamp flashed twice in each trial. The first flash was the signal for "ready", and the second was the signal to "start". Practice trials were administered until the subjects understood the task requirements. Three to five test trials preceded the experimental runs under the visual stimulus conditions. After we had ascertained that the subjects understood the procedure, five practice trials were performed. The PMT value was measured as the time from the imperative stimulus until the first reliably detected change in the electromyographic (EMG) activity (Fig. 1). The PMT was defined as the latency of the EMG activity when a

 ISSN 0036–5505

Table I. *Videofluorographical findings in patients with Parkinson's disease*

Case	Sex/age (years)	Stage	Course (years)	Residue in the anterior and lateral sulci	Repeated pumping tongue motion	Uncontrolled bolus/ premature swallow	Piecemeal deglutition	Vallecular residue after swallow	Residue in pyriform sinuses	Aspiration
1	F/80	3	2	−	−	−	−	+	−	−
2	M/70	3	3	−	−	−	−	+	+	−
3	M/68	3	5	−	−	+	+	+	+	−
4	F/76	3	6	−	−	−	+	+	+	+
5	F/77	3	7	−	−	+	+	+	−	+
6	F/53	3	8	−	−	−	−	+	+	+
7	M/57	3	8	−	−	−	+	−	−	−
8	M/78	3	11	−	−	−	−	−	−	−
9	M/75	4	5	−	−	+	−	−	−	−
10	M/71	4	12	+	+	+	+	+	+	+

specific movement was requested in response to an imperative stimulus, reflecting the time for information processing in the sensorimotor pathways. The maximum and minimum PMT values of the five trials were excluded. The other three PMT values were averaged.

The swallowing training consisted of five exercises (12), as listed below.

1. Range of tongue motion exercises: the subject opened his or her mouth as widely as possible and elevated the front of the tongue as high as possible, held it there for 1 second, and released it. Then the subject elevated the back of the tongue as far as possible, held it there for 1 second, and released it. This entire series of range of motion exercises was repeated 5 times.
2. Resistance exercises: the subject pushed his or her tongue up against the tongue blade, to the side against the tongue blade, or thrust forward against it.
3. Exercises to increase the adduction of vocal cords: the subject sat on a chair with the trunk upright and held his or her breath as tightly as possible for 5 seconds. After repeating this exercise five times, the subject repeated the word "ah" five times, with a hard glottal attack on each vowel.
4. The Mendelsohn manoeuvre, designed to improve the cricopharyngeal opening during swallowing by voluntarily prolonging and accentuating laryngeal upward and forward movement: the subject was instructed to feel the larynx elevate during swallowing and attempt to prolong the period of maximal laryngeal elevation that occurs during mid-swallow.
5. Range of motion exercises in the neck, trunk and shoulder joints: the subject flexed and extended his or her neck, shoulders and trunk, then rotated the neck and trunk as far as possible. This entire series of range of motion exercises was repeated five times. The swallowing training took about 20 minutes. The same EMG measurement was repeated after only one session of swallowing training.

Normally distributed continuous measures are expressed by mean values and standard deviations. The PMT measures were compared between patients with PD and healthy controls using the Mann–Whitney U test, and before and after the swallowing training using the

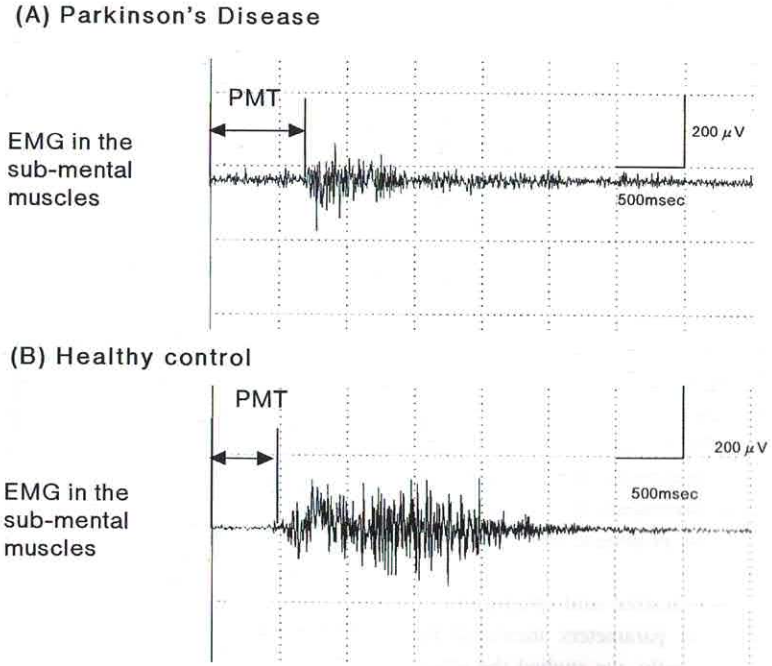

Fig. 1. Typical motor response of (*A*) a 76-year-old patient with Parkinson's disease and (*B*) a 73-year-old healthy control.

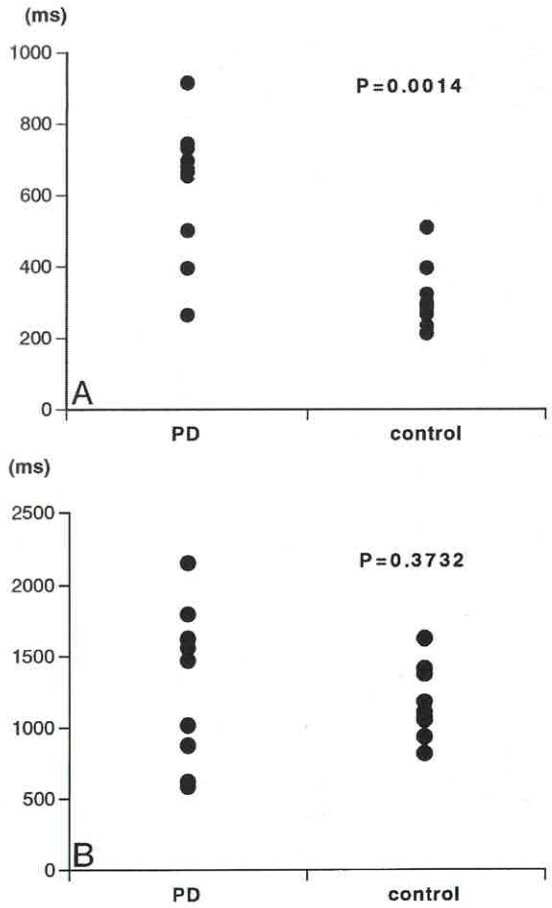

Fig. 2. (*A*) The premotor time in patients with Parkinson's disease and dysphagia, and age-matched controls before the swallowing training. (*B*) The duration of the EMG bursts in patients with Parkinson's disease and dysphagia, and age-matched controls before the swallowing training.

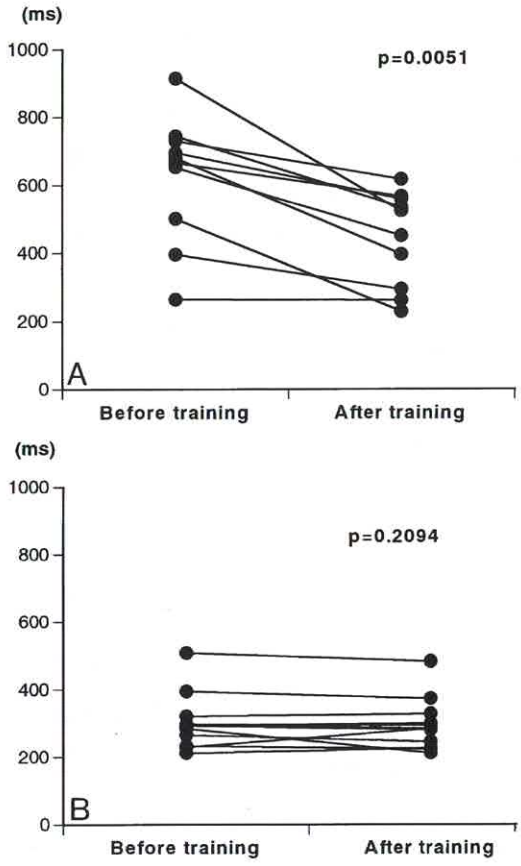

Fig. 3. Changes in the premotor time in patients with Parkinson's disease and dysphagia, and age-matched controls before and after the swallowing training. (*A*) Premotor times of the patients with Parkinson's disease. (*B*) Premotor times of age-matched controls.

Wilcoxon signed rank test (Statview 4.11). The relationship between the PMTs and patients' age or duration of PD was explored with univariate analysis.

RESULTS

Videofluorographical findings in the patients with PD

The videofluorographical findings are summarized in Table I. All patients had complaints about swallowing, whereas none of the controls had any dysphagia. Aspiration was observed in four (40%) of the patients with PD and dysphagia. Abnormal findings, such as residue in the anterior and lateral sulci, or repeated pumping tongue motion, were seen only in patients with aspiration. The most frequent features in patients with PD were piecemeal deglutition and vallecular residue after swallow.

Premotor times of patients with PD

The PMTs of the patients with PD and healthy controls were measured as the initiation time of the swallowing reflex. The motor responses of patients with PD were markedly different from those of the healthy controls. Figure 1 shows the typical motor response of a 76-year-old patient with PD (A) and of a 73-year-old healthy control (B). There was a considerable delay in the PMT. Figures 2A and B show the PMTs and the duration of the EMG burst in the submental muscles for healthy controls and patients with PD. The patients with PD had significantly longer PMTs ($p = 0.0014$) than those of the healthy controls. The duration of the EMG burst was prolonged compared with healthy controls, but these differences were not significant. The PMTs in patients with PD tended to be longer according to the patients' age ($r = 0.602$), but there was no statistically significant correlation between the PMTs and the patients' age. There was no correlation between PMTs and the duration of the disease ($r = -0.146$).

Instant effect of the swallowing training

Changes in the PMTs before and after one session of swallowing training are shown in Figure 3. After the swallowing training, the PMTs in the patients with PD decreased significantly ($p = 0.0051$). Conversely, the PMTs in healthy controls were not affected by the swallowing training. Changes in the duration of the EMG burst before and after the swallowing training are

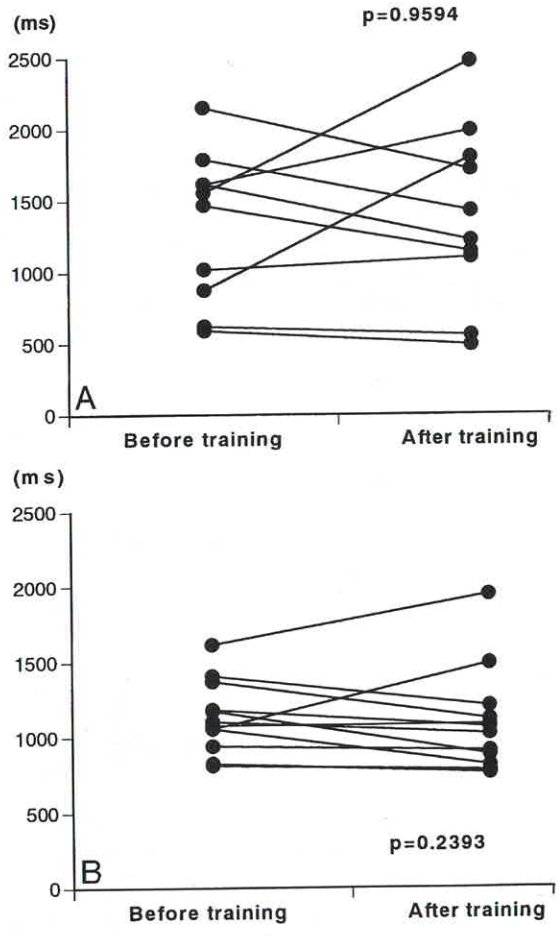

Fig. 4. Changes in the duration of the EMG bursts in patients with Parkinson's disease and dysphagia, and age-matched controls before and after the swallowing training. (*A*) Duration of the EMG bursts in the patients with Parkinson's disease. (*B*) Duration of the EMG bursts in the age-matched controls.

shown in Figure 4. The duration of EMG bursts was unchanged by the training in either the patients or the healthy controls. After only one session of training, eight patients subjectively felt it easier to swallow and two patients did not improve their swallowing function.

DISCUSSION

One of the striking features of the motor disability in patients with PD is bradykinesia. Bradykinesia includes prolonged reaction time to initiate a movement. Previous reports have shown that patients with PD have prolonged RT and PMT (2, 6, 7, 16, 18, 19, 25). However, these RT and PMT values were measured in the muscles of the extremities. Our present study evaluated the PMT in the muscles that initiate swallowing.

An important finding in the present study was the prolonged PMTs in patients with PD and dysphagia compared with those in age-matched controls. The PMT in the submental muscles may be related to the preparatory and oropharyngeal stage of swallowing. We reported that disturbed motility in the oral phase of swallowing was characteristic in PD (14). Wintzen et al. (23) reported a lack of adaptive mechanisms to create space in the oral cavity in patients with PD, and this was interpreted as a form of hypokinesia. In PD, bradykinesia and rigidity directly and adversely affect the motor function of the tongue (3). Therefore, the slowing in PMTs in the submental muscles may be caused by muscular rigidity and akinesia, which produce slowing of voluntary movements.

The PMTs of the patients with PD tended to be longer with age, although not significantly. This result suggests that older patients with PD require more time to initiate the swallowing reflex, and that age-related changes in PMT may simply be more evident in patients with PD than in the healthy controls, because slowing of movement occurs in PD as well as with normal ageing.

The main finding in the present study was that the swallowing training significantly improved swallowing performance of patients with PD by shortening the PMT, even if the training was given only once. The reduction in the PMT of the submental muscles may have hastened the triggering of the swallowing reflex. There are several possible explanations for the effectiveness of the swallowing training. First, the swallowing training in the present study may be considered indirect training, although swallowing training usually includes both indirect and direct therapies. The range of motion exercises in the neck, trunk and shoulder joints improve akinetic and bradykinetic symptoms, and increase the active range of motion. This may make it easier for patients with PD to swallow. Secondly, impaired coordination of the tongue may disturb the propelling of the bolus in the oral cavity and diminish the stimulation of swallowing receptors in the posterior oral cavity (15). Indirect therapy, such as the range of tongue motion exercises and resistance exercises, may improve the rigidity and hypokinesia of the tongue. Improved coordination of the tongue can propel the bolus in the oral cavity, and increase the stimulation of swallowing receptors in the posterior oral cavity. Thirdly, although the Mendelsohn manoeuvre is designed to prolong laryngeal elevation, improved laryngeal elevation stimulated by this manoeuvre may hasten the initiation of the swallowing reflex. Practice can improve the speed of the movement (20), and preparedness for a motor movement may be augmented with repetition (24). As a result, swallowing training may hasten the initiation of the swallowing movement.

The duration of EMG bursts did not statistically change in the present study. Once the swallowing reflex was initiated, control of these movements is largely automatic. Therefore, the duration of EMG bursts were unchanged by the training in either the patients or the healthy controls.

The results of the present study suggest that swallowing training can improve the initiation of the swallowing reflex in patients with PD and dysphagia. If patients with PD and dysphagia have symptoms of delayed initiation of the swallowing reflex, they should be given the opportunity to receive swallowing training. The swallowing training in the present study may be effective as preparatory training. Our results

suggest that the study of PMT in the submental muscles may be a useful tool for a more specific assessment of the swallowing function.

ACKNOWLEDGMENT

This work was supported by a grant from the Japan Foundation for Aging and Health, Ministry of Health and Welfare, Japan.

REFERENCES

1. Bird MR, Woodward MC, Gibson EM, Phyland DJ, Fonda D. Asymptomatic swallowing disorders in elderly patients with Parkinson's disease: a description of findings on clinical examination and videofluoroscopy in sixteen patients. Age Ageing 1994; 23: 251–254.
2. Bloxham CA, Mindel TA, Frith CD. Initiation and execution of predictable and unpredictable movements in Parkinson's disease. Brain 1984; 107: 371–384.
3. Bushmann M, Dobmeyer SM, Leeker L, Perlmutter JS. Swallowing abnormalities and their response to treatment in Parkinson's disease. Neurology 1989; 39: 1309–1314.
4. Calne DB, Shaw DG, Spiers ASD, Stern GM. Swallowing in Parkinsonism. Br J Radiol 1970; 43: 456–457.
5. Calne DB, Snow BJ, Lee C. Criteria for diagnosing Parkinson's disease. Ann Neurol 1992; 32: 125–127.
6. Evarts EV, Teravainen H, Calne DB. Reaction times in Parkinson's disease. Brain 1981; 104: 167–186.
7. Heilman KM, Bowers D, Watson RT, Greer M. Reaction times in Parkinson disease. Arch Neurol 1976; 33: 139–140.
8. Hoehn MM, Yahr MD. Parkinsonism: onset, progression, and mortality. Neurology 1967; 17: 427–442.
9. Larsen JP, Dupont E, Tandberg E. Clinical diagnosis of Parkinson's disease. Proposal of diagnostic subgroups classified at different levels of confidence. Acta Neurol Scand 1994; 89: 242–251.
10. Leopold NA, Kagel MC. Pharyngo-esophageal dysphagia in Parkinson's disease. Dysphagia 1997; 12: 11–18.
11. Logemann J, Blonsky ER, Boshes B. Lingual control in Parkinson's disease. Trans Am Neurol Assoc 1973; 98: 276–278.
12. Logemann JA. Evaluation and treatment of swallowing disorders. PRO-ED, Austin: 1983: 133–153.
13. Logemann JA. Manual for the videofluorographic study of swallowing, 2nd ed. PRO-ED, Austin, 1993: 73–111.
14. Nagaya M, Kachi T, Yamada T, Igata A. Videofluorographic study of swallowing in Parkinson's disease. Dysphagia 1998; 13: 95–100.
15. Nilsson H, Ekberg O, Olsson R, Hindfelt B. Quantitative assessment of oral and pharyngeal function in Parkinson's disease. Dysphagia 1996; 11: 144–150.
16. Pullman SL, Watts RL, Juncos JL, Chase TN, Sanes JN. Dopaminergic effects on simple and choice reaction time performance in Parkinson's disease. Neurology 1988; 38: 249–254.
17. Robbins JA, Logemann JA, Kirshner HS. Swallowing and speech production in Parkinson's disease. Ann Neurol 1986; 19: 283–287.
18. Segura MJ, Bueri JA, Gandolfo CN, Simonetti DD, Herrera GA, Sica EP. Motor reaction time in Parkinson's disease. Medicina 1995; 55: 208–212.
19. Sheridan MR, Flowers KA, Hurrel J. Programming and execution of movement in Parkinson's disease. Brain 1987; 110: 1247–1271.
20. Soliveri P, Brown RG, Jahanshahi M, Marsden CD. Effect of practice on performance of a skilled motor task in patients with Parkinson's disease. J Neurol Neurosurg Psychiatry 1992; 55: 454–456.
21. Starkstein S, Esteguy M, Berthier M, Gracia H, Leiguarda R. Evoked potentials, reaction time and cognitive performance in on and off phases of Parkinson's disease. J Neurol Neurosurg Psychiatry 1989; 52: 338–340.
22. Stroudley J, Walsh M. Radiological assessment of dysphagia in Parkinson's disease. Br J Radiol 1991; 64: 890–893.
23. Wintzen AR, Badrising UA, Roos RAC, Vielvoye J, Liauw L, Pauwels EKJ. Dysphagia in ambulant patients with Parkinson's disease: common, not dangerous. Can J Neurol Sci 1994; 21: 53–56.
24. Worringham CJ, Stermack GE. Practice effects on the programming of discrete movement in Parkinson's disease. J Neurol Neurosurg Psychiatry 1990; 53: 702–704.
25. Yokochi F, Nakamura R, Narabayashi H. Reaction time of patients with Parkinson's disease, with reference to asymmetry of neurological signs. J Neurol Neurosurg Psychiatry 1985; 48: 702–705.