The Efficacy of Self-Administered Stretching for Finger Joint Motion in Japanese Patients with Systemic Sclerosis

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ABSTRACT. ***Objective.*** To determine the efficacy of self-administered stretching of each finger in Japanese patients with systemic sclerosis (SSc).

Methods. Forty-five patients with SSc (32 with diffuse cutaneous SSc and 13 with limited cutaneous SSc) were given instructions on self-administered stretching and were directed to perform it every day. Individual fingers were maintained in a stretched position using the opposite hand for 10 seconds and this was repeated 3–10 times. To evaluate the effect of the stretching program, finger passive range of motion (ROM) was assessed using a goniometer on the first visit and after 1 month and 1 year of the stretching program. The Health Assessment Questionnaire (HAQ) was also assessed on the first visit and 1 year afterward.

Results. The total passive ROM was significantly improved in each finger after 1 month of finger stretching. The total passive ROM was further improved or maintained within 1 year after the first visit. Although ROM was less in patients with diffuse cutaneous SSc than in those with limited cutaneous SSc at the first visit, ROM increased significantly irrespective of disease duration or severity of skin sclerosis. Finger stretching may improve the finger function, since the HAQ score for hand functions such as eating and gripping was significantly decreased.

Conclusion. Our original self-administered stretching program may be useful for improving finger joint motion in patients with SSc; future studies in various ethnic populations will be needed to determine the universal efficacy of this method. (J Rheumatol 2006;33:1586–92)

Key Indexing Terms:
SYSTEMIC SCLEROSIS FINGER PASSIVE RANGE OF MOTION
FINGER STRETCHING JOINT MOTION HEALTH ASSESSMENT QUESTIONNAIRE

Systemic sclerosis (SSc) is an autoimmune disease that targets the vasculature in the skin and internal organs such as the lung, heart, and kidney, ultimately leading to fibrosis. Although SSc affects various joints, the hands in particular are involved in most patients with SSc. In the hands, thickening of the skin can result in contractures of the fingers, leading to loss of flexion at the metacarpophalangeal (MCP) joints, loss of extension of proximal interphalangeal (PIP) joints, and loss of thumb abduction. Also, the distal interphalangeal (DIP) joint may become fixed in midrange flexion, resulting in a claw-type deformity of MCP extension, PIP flexion, and thumb adduction[1,2].

Finger flexion and extension are the most impaired aspects of hand mobility in patients with SSc[3]. Loss of hand-grasp ability and hand impairment may be one of the important factors that influence the activities of daily living of patients with SSc[4]. Limitations to finger joint range of motion (ROM) in SSc are not based on arthritis, such as occurs in rheumatoid arthritis, and are caused mainly by skin thickening with edema and swelling. Passive and active stretching help the patient to maintain joint ROM and to elongate tendons and muscles, especially when fibrotic retractions are present[5]. As described in a case report, paraffin baths and stretching exercises reduced contracture and improved ROM, even in an already severely affected patient with linear scleroderma[6]. Therefore, finger stretching may prevent or delay this kind of hand deformity. Although Poole, *et al*[7] and Sandqvist, *et al*[8] described a

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series of excellent occupational and physical therapies in patients with SSc, there are no established guidelines for rehabilitation. It would be convenient if there was an easy program that could be performed by patients at home.

Objective changes in hand function are very difficult to measure and evaluate in SSc. There are 2 reliable and valid assessments of hand function for SSc: the Hand Mobility in Scleroderma Test[9,10] and the Arthritis Hand Function Test[11]. While both are excellent performance-based tests, hand function is complex, and many aspects must be considered in the evaluation of treatment efficacy. We evaluated hand function by total passive ROM and using the Health Assessment Questionnaire (HAQ)[12-15] in this study. The finger stretching program was estimated to improve finger function by increasing tissue compliance and mobility, and improving ROM. Previous studies have reported that ROM was related to some kinds of hand function in patients with SSc[4,16].

We evaluated the efficacy of self-administered finger stretching on passive ROM and HAQ in patients with SSc.

MATERIALS AND METHODS

Patients. Forty-five Japanese patients with SSc (39 women, 6 men, aged 48.6 ± 17.3 yrs) who had visited Kanazawa University Hospital between June 1, 1998, and September 30, 2004, were included in this study. All patients fulfilled the criteria proposed by the American College of Rheumatology[17]. Patients were grouped according to the classification system proposed by LeRoy, *et al*[18]: 13 patients had limited cutaneous SSc (lcSSc) and 32 had diffuse cutaneous SSc (dcSSc). Patients with dcSSc were divided into 23 early dcSSc (disease duration < 3 yrs), 4 intermediate dcSSc (disease duration 3–6 yrs), and 5 late dcSSc (disease duration > 6 yrs), as proposed by Medsger, *et al*[19]. Since numbers of cases of intermediate dcSSc or late dcSSc were low, patients in these 2 groups were pooled as intermediate-late dcSSc for this study.

Regarding autoantibodies, anti-topoisomerase I antibody was positive in 23, anticentromere Ab in 9, and anti-RNA polymerase I/III Ab in 6. The remaining 7 patients were negative or positive for other antinuclear antibodies.

The mean disease duration of SSc patients was 5.0 ± 7.6 years (lcSSc 7.9 ± 9.8 yrs, dcSSc 3.9 ± 6.4 yrs). Patients with arthritis or severe ulcers at finger joints were excluded. The skin scores were measured using the modified Rodnan Total Skin Thickness Score (mTSS, maximum 51 points)[20]. Hand skin scores calculated from 6 sites (bilateral fingers, hands, and forearms) among 17 sites used for the mTSS were also assessed (maximum 18 points), since this may reflect the skin sclerosis influencing finger motion more precisely than the mTSS.

Stretching. An occupational therapist coached the patients on a home program for stretching, which is a self-administered exercise. Individual fingers were maintained in a stretched position using the opposite hand for 10 s, and this was repeated 3–10 times (Figure 1). Patients were directed to stretch once per day. The exercise was performed carefully if aches occurred due to inflammation or skin ulcers. Since self-exercise was difficult for patients with severe contracture restrictions to perform, instructions were given to family members on behalf of the patient instead. The therapist confirmed whether the exercise was correctly performed every month, when the patient visited our hospital for treatment of SSc.

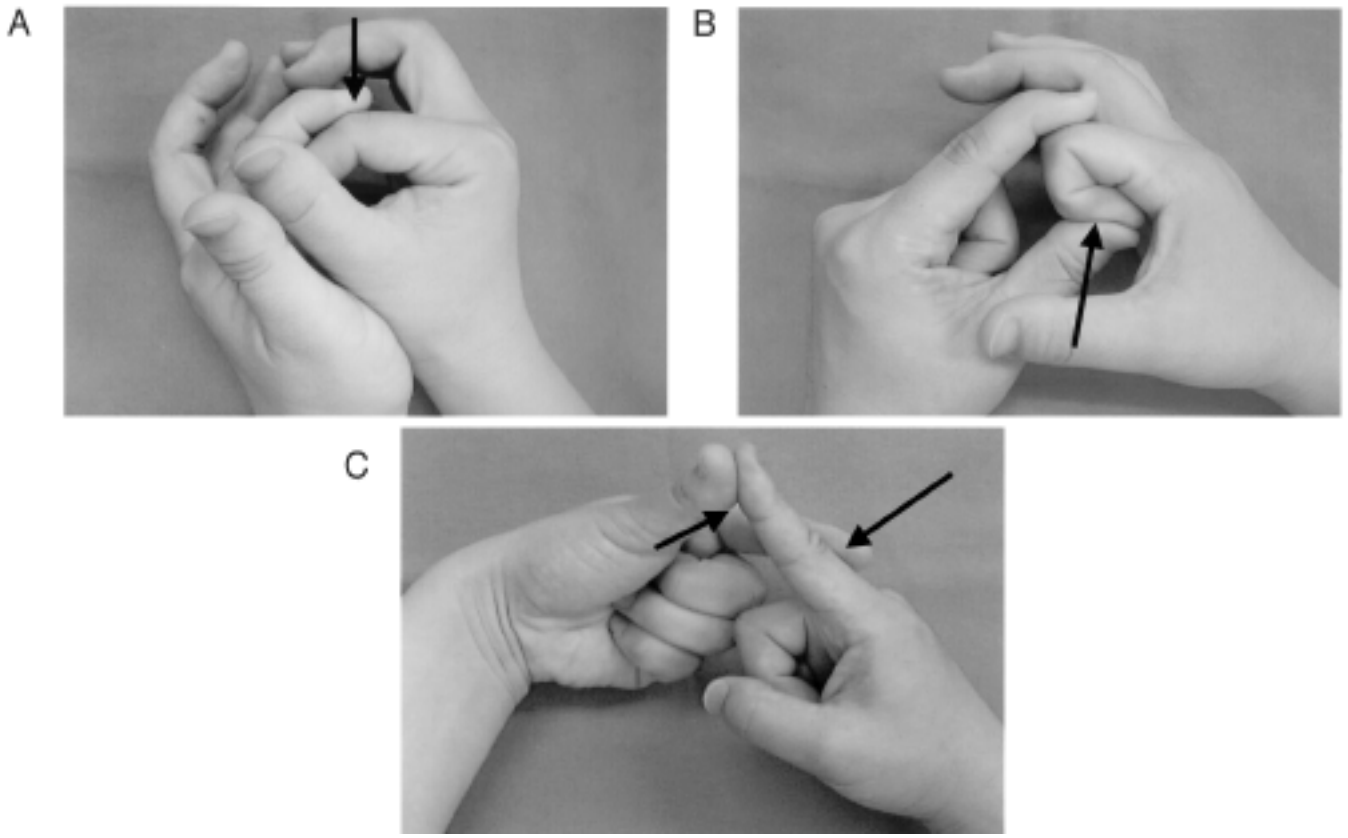

Figure 1. Methods for self-administered finger stretching. (A) Flexion of MCP joint of the right index finger. (B) Flexion of PIP and DIP joints of the right index finger. (C) Extension of PIP and DIP joints of the right index finger. Arrows indicate the direction of application of force.

Evaluation of total passive ROM. Hand impairment was assessed by the finger passive ROM test. The test was performed on each finger using a goniometer (Preston PC5050K finger goniometer). Patients were examined on their first visit, and then at followup 1 month and 1 year afterward. The same occupational therapist measured total passive ROM of each finger in all patients. ROM was measured from the angle between maximal flexion and maximal extension of each joint (Figure 2). Total passive ROM was calculated as follows: total passive ROM (°) = ROM of MCP (°) + ROM of PIP (°) + ROM of DIP (°). Therefore, the decrease in total passive ROM indicates the limitation of finger function. Decreased or increased ratio of total passive ROM in each finger was calculated as follows: [change of total passive ROM (°) divided by total passive ROM before stretching (°)] × 100%. Twenty-one healthy Japanese people (16 women, 5 men, aged 49 ± 13 yrs) were assessed for the measurement of total passive ROM to evaluate the normal range of each finger, although these healthy controls were not included in the stretching program. A single therapist evaluated every subject.

The intraclass correlation coefficient (ICC) is a statistical method for evaluating observer variability. In general, an ICC > 0.8 is considered excellent agreement. ICC of intraobserver variability of mean total passive ROM in each finger was 0.93, indicating that this measurement is a stable method.

HAQ-DI. All patients also completed the HAQ, a self-administered instrument to determine physical disability (HAQ-DI) [12-15]. One question in the HAQ was modified when translated into Japanese, as previously reported[21]: the question regarding cutting meat was changed to: "Are you able to eat with chopsticks?".

Statistical analysis. Statistical analysis was performed using the Mann-Whitney U test for comparison of intergroup differences, and the Bonferroni test was used for multiple comparisons. Spearman's rank correlation coefficient was used to examine the relationship between 2 continuous variables. A p value < 0.05 was considered to indicate statistical significance. All data are shown as means ± SD unless otherwise indicated.

RESULTS

Total passive ROM of fingers at the first visit. Twenty-one healthy persons were assessed for total passive ROM to estimate the normal range (Table 1). Total passive ROM of the fingers was examined in patients with SSc at their first visit (Table 1). Before the first visit, no patient had been treated by physical or occupational therapy for their fingers. The ROM of 13 lcSSc or 32 dcSSc patients was significantly lower than that of the controls for each finger ($p < 0.01$). Finger passive ROM was significantly decreased in dcSSc patients compared with lcSSc patients for each finger, excluding the left ring finger ($p < 0.05$). Among the dcSSc patients, intermediate-late dcSSc patients showed less passive ROM than early dcSSc patients for each finger, except the left ring or little finger ($p < 0.05$). The total passive ROM was inversely associated with mTSS ($r = –0.35$, $p < 0.01$), but not hand skin score ($r = –0.15$, $p = 0.23$), in SSc patients.

Finger passive ROM and skin score after 1 month of stretching program. The changes of total passive ROM during the first month are shown in Table 2 and Figure 3. One month after self-administered stretching, total passive ROM of the fingers was significantly improved in patients with dcSSc ($n = 32$) in each finger ($p < 0.01$). Among dcSSc patients, early dcSSc patients showed significantly increased ROM in each finger after 1 month ($p < 0.01$). Intermediate-late dcSSc patients also showed increased ROM during this period, although the change was significant in only 6 fingers ($p < 0.05$). Among 32 dcSSc patients, 50% received oral steroid therapy during this followup period. However, the mean mTSS (before 19.3 ± 7.4, 1 month after 17.5 ± 5.4) or hand skin score (before 11.3 ± 4.7, 1 month after 10.6 ± 3.9) was not significantly changed during this period. A significant increase of finger passive ROM was also found in each finger of the lcSSc patients ($p < 0.05$). No patient with lcSSc was treated with steroids during this period and the mean mTSS was not significantly different (before 6.1 ± 1.0, 1 month after 6.3 ± 0.8). Thus, finger passive ROM was improved during the first month of self-administered stretching in both dcSSc and lcSSc patients despite unchanged skin sclerosis.

Finger passive ROM and skin score after 1 year of stretching program. The changes of total passive ROM after 1 year are shown in Table 2 and Figure 3. In dcSSc patients, ROM 1 year after stretching was significantly increased in each finger

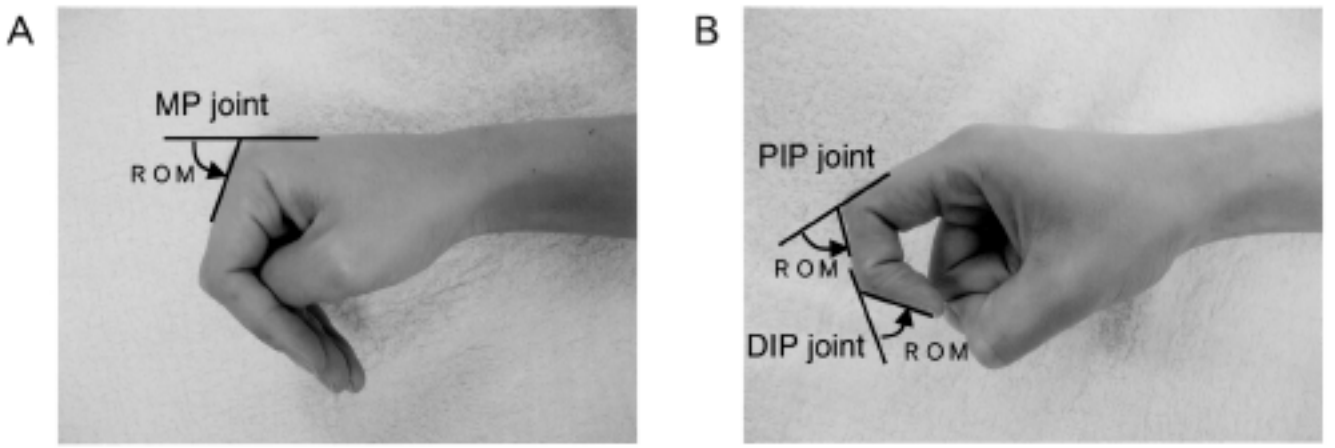

Figure 2. Measurement of total passive range of motion (ROM,°) in each finger (right index finger shown here). (A) ROM of metacarpophalangeal (MP) junction. (B) ROM of PIP or DIP joints. ROM was calculated from the angle between maximal flexion and maximal extension of each joint using a goniometer, as indicated. Total passive ROM of each finger was measured as follows: ROM of MP (°) + ROM of PIP (°) + ROM of DIP (°). Decrease of total passive ROM indicates the limitation of finger joint motion.

Table 1. Total passive range of motion in controls and SSc patients at the first visit.

Group	Right					Left				
	Thumb	Index	Middle	Ring	Little	Thumb	Index	Middle	Ring	Little
Control, n = 21										
MCP	76 ± 14	96 ± 8	103 ± 6	104 ± 6	102 ± 11	78 ± 14	96 ± 11	100 ± 7	104 ± 6	102 ± 13
PIP	94 ± 12	118 ± 5	121 ± 5	125 ± 4	115 ± 7	94 ± 7	118 ± 4	120 ± 4	122 ± 3	116 ± 4
DIP	—	89 ± 8	92 ± 9	90 ± 9	97 ± 8	—	90 ± 8	94 ± 8	94 ± 9	99 ± 9
Total	170 ± 20	304 ± 17	315 ± 15	319 ± 15	315 ± 20	172 ± 18	303 ± 19	314 ± 15	320 ± 14	316 ± 17
lcSSc, n = 13										
Total	151 ± 18**	277 ± 18**	289 ± 21**	296 ± 19**	289 ± 23**	153 ± 16**	278 ± 20**	294 ± 22	294 ± 32**	290 ± 28**
dcSSc, n = 32										
Total	135 ± 24**†	248 ± 36**††	265 ± 34**†	269 ± 35**†	260 ± 40**†	138 ± 21**†	248 ± 45**†	267 ± 38**†	274 ± 34**	267 ± 32**†
Early dcSSc, n = 23										
Total	140 ± 23**	258 ± 28**	274 ± 25**	278 ± 25**	269 ± 29**	142 ± 21**	259 ± 23**	277 ± 23**	281 ± 23**	271 ± 27**
Intermediate-late dcSSc, n = 9										
Total	120 ± 24*‡	223 ± 44*‡	240 ± 41*‡	246 ± 48*‡	235 ± 53*‡	126 ± 17*‡	221 ± 72††	242 ± 57‡	256 ± 49	256 ± 43

* $p < 0.05$ vs control, ** $p < 0.01$ vs control, † $p < 0.05$ vs lcSSc, †† $p < 0.01$ vs lcSSc, ‡ $p < 0.05$ vs early dcSSc. lcSSc: limited cutaneous; dcSSc: diffuse cutaneous systemic sclerosis.

Table 2. Change of total passive range of motion (%) in SSc patients during the finger stretching program.

Group	Finger Stretching	Right					Left				
		Thumb	Index	Middle	Ring	Little	Thumb	Index	Middle	Ring	Little
lcSSc, n = 13	Before	151 ± 18	277 ± 18	289 ± 21	296 ± 19	289 ± 23	153 ± 16	278 ± 20	294 ± 22	294 ± 32	290 ± 28
	1 mo	156 ± 18**	285 ± 16**	296 ± 15**	300 ± 18**	296 ± 21**	156 ± 15**	288 ± 17**	302 ± 17**	300 ± 21*	300 ± 23**
		(3.3)	(2.9)	(2.4)	(1.4)	(2.4)	(2.0)	(3.6)	(2.7)	(3.1)	(3.4)
	1 yr	160 ± 19**†	286 ± 18**	300 ± 18**†	304 ± 18**††	299 ± 21**††	158 ± 16**	290 ± 17**†	305 ± 15**	307 ± 21**††	304 ± 21**†
		(6.0)	(3.2)	(3.8)	(2.7)	(3.5)	(3.3)	(4.3)	(3.7)	(4.4)	(4.8)
dcSSc, n = 32	Before	135 ± 24	248 ± 36	265 ± 34	269 ± 35	260 ± 40	138 ± 21	248 ± 45	267 ± 38	274 ± 34	267 ± 32
	1 mo	142 ± 24**	261 ± 34**	279 ± 29**	282 ± 33**	273 ± 34**	145 ± 21**	260 ± 42**	278 ± 31**	285 ± 27**	279 ± 27**
		(5.2)	(5.2)	(5.3)	(4.8)	(5.0)	(5.1)	(4.8)	(4.1)	(4.0)	(4.5)
	1 yr	148 ± 23**††	266 ± 33**††	283 ± 29**††	290 ± 32**††	280 ± 36**††	149 ± 21**††	264 ± 44**	283 ± 32**††	292 ± 26**††	288 ± 27**††
		(9.6)	(7.3)	(6.8)	(7.8)	(7.7)	(8.0)	(6.5)	(6.0)	(6.6)	(7.9)
Early dcSSc, n = 23	Before	140 ± 23	258 ± 28	274 ± 25	278 ± 25	269 ± 29	142 ± 21	259 ± 23	277 ± 23	281 ± 23	271 ± 27
	1 mo	148 ± 22**	270 ± 25**	288 ± 20**	292 ± 21**	282 ± 24**	151 ± 19**	272 ± 20 **	288 ± 18**	293 ± 19**	284 ± 20**
		(5.7)	(4.7)	(5.1)	(5.0)	(4.8)	(6.3)	(5.0)	(4.0)	(4.3)	(4.8)
	1 yr	155 ± 22**††	275 ± 24**†	293 ± 18**††	300 ± 19**††	290 ± 26**††	155 ± 19**††	275 ± 22**	293 ± 17**††	299 ± 19**††	294 ± 22**††
		(10.7)	(6.6)	(6.9)	(7.9)	(7.8)	(9.2)	(6.2)	(5.8)	(6.4)	(8.5)
Intermediate-late dcSSc, n = 9	Before	120 ± 24	223 ± 44	240 ± 41	246 ± 48	235 ± 53	126 ± 17	221 ± 72	242 ± 57	256 ± 49	256 ± 43
	1 mo	127 ± 21	237 ± 41*	255 ± 34*	256 ± 44**	248 ± 43**	130 ± 18*	232 ± 66**	254 ± 45	267 ± 35	265 ± 37
		(5.8)	(6.3)	(6.3)	(4.1)	(5.5)	(3.2)	(5.0)	(5.0)	(4.3)	(3.5)
	1 yr	133 ± 18*	241 ± 41**	258 ± 36**	265 ± 43**	254 ± 46**	135 ± 17**††	235 ± 70**	256 ± 44*	273 ± 31*	274 ± 34**†
		(10.8)	(8.1)	(7.5)	(7.7)	(8.1)	(7.1)	(6.3)	(5.8)	(6.6)	(7.0)

* $p < 0.05$ vs before stretching program, ** $p < 0.01$ vs before stretching program, † $p < 0.05$ vs 1 month after stretching program, †† $p < 0.01$ vs 1 month after stretching program. (%) indicates the increased ratio of total passive ROM calculated as follows: (total passive ROM after stretching–total passive ROM before stretching) divided by total passive ROM before stretching × 100%.

compared with that at 1 month of the stretching program ($p < 0.01$). Among 32 patients with dcSSc, 63% received low-dose oral steroid therapy (~20 mg/day) and the mean mTSS was significantly decreased after 1 year (12.9 ± 3.8) compared with that before the stretching program (19.3 ± 7.4; $p < 0.05$). Similarly, hand skin score was significantly decreased after 1 year (from 11.3 ± 4.7 to 7.8 ± 3.9; $p < 0.05$). Therefore, we cannot rule out the possibility that the passive ROM was improved due to the reduced skin sclerosis. However, finger passive ROM after 1 year of stretching was significantly increased in 7 fingers, excluding the right index, left thumb, and left middle fingers, compared with ROM at 1 month in 13 lcSSc patients who did not receive steroid ($p < 0.05$). No significant change of mTSS was found in these lcSSc patients after 1 year (from 6.0 ± 1.1 to 6.3 ± 1.3). In general, the increased ratio of ROM after 1 year was more modest in lcSSc patients (2.7–6.0% in each finger) than in dcSSc patients (6.0–9.6% in each finger). A significant increase of total pas-

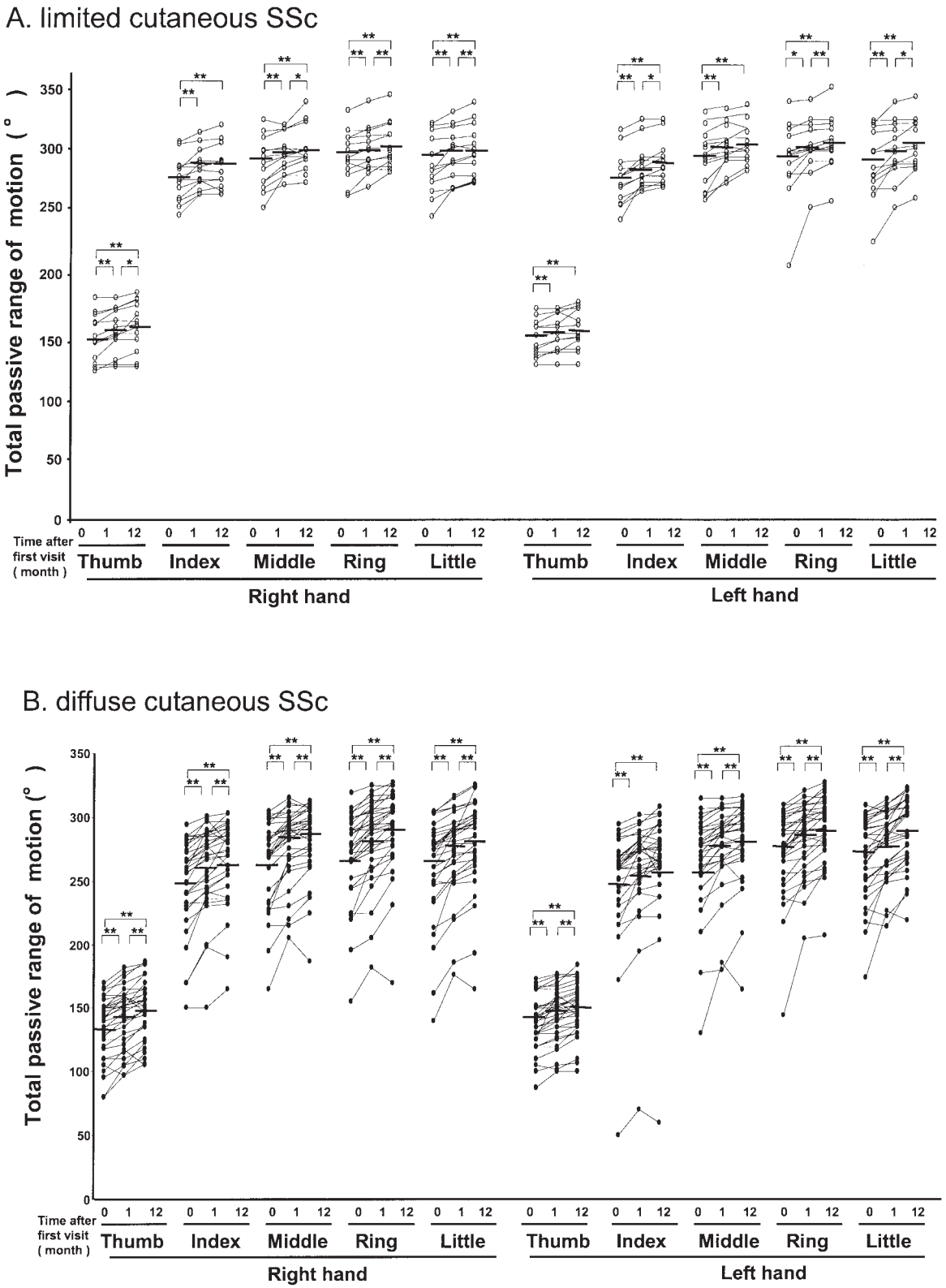

Figure 3. Change of total passive ROM in an individual patient after 1 year of the stretching program in lcSSc patients (panel A; n = 32) and dcSSc patients (panel B; n = 13). *p < 0.05; **p < 0.01.

Table 3. Change in HAQ after 1 year of finger stretching program.

Stretching	HAQ-DI	Dressing	Arising	Eating	Walking	Hygiene	Reaching	Gripping	Activities
Before	0.48 ± 0.45	0.54 ± 0.78	0.15 ± 0.44	1.04 ± 0.66	0.29 ± 0.55	0.17 ± 0.38	0.46 ± 0.88	0.75 ± 0.58	0.42 ± 0.72
1 year after	0.38 ± 0.47	0.63 ± 0.77	0.08 ± 0.28	0.71 ± 0.61*	0.29 ± 0.46	0.17 ± 0.38	0.29 ± 0.69	0.54 ± 0.35*	0.29 ± 0.55

* $p < 0.05$ vs before stretching program. HAQ-DI: Health Assessment Questionnaire Disability Index.

sive ROM of each finger was found at 1 year compared with that after 1 month of the program in early dcSSc patients ($p < 0.05$; Table 2). ROM tended to increase at 1 year when compared with ROM at 1 month in patients with intermediate-late dcSSc, although significant differences were detected in the left thumb ($p < 0.01$) and left little finger ($p < 0.05$). Nonetheless, the increased ratio of ROM was comparable between early dcSSc (5.8–10.7%) and intermediate-late dcSSc patients (5.8–10.8% in each finger). Thus, finger passive ROM was further improved or maintained after 1 year of finger stretching compared with the first month in patients with SSc.

HAQ-DI. The HAQ was assessed in 32 patients with dcSSc (Table 3). Total passive ROM was not significantly associated with the mean HAQ-DI as calculated from the 8 different components of the HAQ-DI or each component (data not shown). After 1 year of the stretching program, the mean HAQ-DI was not significantly changed (from 0.48 ± 0.45 to 0.38 ± 0.47). When individual component scores were investigated, 2 components of hand function (eating and gripping) were significantly improved after 1 year (eating: from 1.04 ± 0.66 to 0.71 ± 0.61, $p < 0.05$; gripping: from 0.75 ± 0.58 to 0.54 ± 0.35, $p < 0.05$). However, scores for the components requiring lower extremity function (dressing, arising, walking, hygiene, reaching, activities) were not significantly changed.

DISCUSSION

In Japanese patients with SSc with limitation of finger function due to skin sclerosis, the total passive ROM of the fingers was significantly improved after 1 month of easy self-administered stretching (Table 2, Figure 3). The finger passive ROM was further improved or maintained after 1 year of the stretching program (Table 2, Figure 3). Further, the HAQ-DI component scores for hand function such as eating and gripping were significantly improved after this period (Table 3).

In patients with dcSSc, severe skin sclerosis tends to reach a maximum within a couple of years after onset and then stabilizes or decreases, while patients with lcSSc show minimal or no change in their moderate skin sclerosis over a long period of time[19]. Since the mean disease duration was 3.9 years in our dcSSc patients, most dcSSc patients already had some restriction of finger joint motion. At their first visit, finger passive ROM was more significantly decreased in dcSSc patients than in lcSSc patients in each finger excluding the left ring finger (Table 1). Total passive ROM was inversely associated with mTSS at the first visit ($r = –0.35$, $p < 0.01$). Further, patients with intermediate-late dcSSc exhibited more restricted ROM than early dcSSc patients (Table 1). These results indicate that prolonged severe sclerosis leads to restriction of finger motion if beneficial exercises are not performed. Thus, some kind of exercises for the finger joints should be started early in the disease course before any observed loss of motion appears, as reported previously[22].

An increase of ROM was found in dcSSc and lcSSc patients after 1 month despite an unchanged skin score (Table 2, Figure 3). This indicates that the increased ROM during the finger stretching program was not due simply to the improved skin sclerosis. ROM was further improved or maintained after 1 year of the finger stretching in both lcSSc and dcSSc patients (Table 2, Figure 3). Importantly, patients with intermediate-late dcSSc as well as early dcSSc patients demonstrated significantly increased ROM after 1 year of the stretching program. These findings are similar to a study reported by Sandqvist, *et al*[8]. In that report, hand exercise in combination with a paraffin bath improved mobility and perceived hand problems independent of skin score and disease duration. Thus, our self-administered stretching technique may be effective for the improvement of finger joint motion independent of the severity of skin sclerosis and disease duration.

Hand involvement in both lcSSc and dcSSc leads to functional disability based on the relationship between disease status and grip strength and wrist and finger motion[12]. Ninety percent of SSc patients complain of loss of hand grasping ability because of skin retraction and musculoskeletal problems[23]. It has been suggested that SSc is manifested differently in patients of various ethnic origins, even in the relatively homogeneous subset defined by the presence of anti-topoisomerase I antibody[24]. Japanese patients with SSc may experience milder skin thickening than patients in the United States, since the frequency of TSS ≥ 20 was significantly lower in a clinical study of Japanese patients (22%)[21] relative to a study in the United States (34%; $p < 0.01$)[13]. Consistent with this, the degree of functional disability evaluated by HAQ is much less in Japanese SSc patients than in patients in the United States[21]. Japanese SSc patients experience significant functional disability, especially in the categories of eating and gripping[21], so the significant improvement of the HAQ-DI component score for eating and gripping with the stretching program may be particularly critical for Japanese patients to improve their quality of life. Thus, self-stretching of fingers may be useful for the improvement of hand function in addition to increasing finger joint motion.

Evaluation of the effectiveness of treatment for patients with SSc over an extended period of time is difficult because of the variability of progression of the disease. Skin thickening and flexion contracture of the fingers may improve spontaneously in some dcSSc patients with long disease duration. Our study was performed in a small population and it was not a control study. Despite these limitations, our results indicate that rehabilitation by stretching of the fingers may be effective for improving and maintaining hand function. Thus, the measurement of total passive ROM of the fingers and our original self-administered exercise program may be useful for patients with SSc. Larger longitudinal studies will be needed to determine the efficacy of this method in various ethnic populations.

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