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Original Article

Increased Range of Motion and Decreased Strength of the Thumb in Massage Practitioners with Thumb Pain

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Abstract: The purpose of this study was to compare the range of motion (ROM) and strength of the metacarpophalangeal (MP) and interphalangeal (IP) joints among massage practitioners with and without thumb pain and control subjects. Sixteen massage practitioners with thumb pain, 16 practitioners without thumb pain, and 16 control subjects participated in this study. ROM of flexion, extension, and abduction in the MP joint; ROM of flexion and extension in the IP joint of the thumb; strength of the flexor pollicis brevis (FPB), extensor pollicis brevis (EPB), abductor pollicis brevis, flexor pollicis longus (FPL), and extensor pollicis longus measured in all subjects. ROM of extension and abduction in the MP joint were significantly increased in massage practitioners with and without thumb pain compared with control subjects. ROM of extension in the IP joint was significantly increased in massage practitioners with thumb pain compared with those without thumb pain. The strength of the EPB and FPL muscle was significantly decreased in massage practitioners with thumb pain compared with those without thumb pain and control subjects, respectively. In addition, there was significantly increased EPB/FPB strength in massage practitioners without thumb pain compared to those with thumb pain and control subjects.

Key words: Massage practitioner, Musculoskeletal disorders, Range of motion, Strength, Work-related thumb pain

Introduction

Work-related musculoskeletal pain is widespread in many industrialized countries, and the cost related to chronic work-related pain is extremely high[1–4]. Repetitive stress on joints and tissues may cause musculoskeletal pain and loss of function, resulting in disability in several cases[2, 5]. Industry is growing, interest in beauty and cosmetics has increased, and the demand for massage practitioners has risen. The most common tasks performed by massage practitioners are body and face massage, reflexology, and aromatherapy. Because of the repetitive use of the thumb, thumb pain is the most common work-related musculoskeletal pain among massage practitioners, with an incidence of 50.3%[6]. Although some guidelines to prevent work-related musculoskeletal pain and decrease

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disability in physical therapy have been suggested[7–9], these measures are insufficient in massage practitioners.

The thumb comprises three joints: the carpometacarpal (CMC), metacarpophalangeal (MP), and interphalangeal (IP) joints[10–12]. A normal range of motion (ROM) is needed for normal thumb movement. In the MP joint, the ROM of extension and flexion is 0° to 50°, and that of the IP joint is 0° to 70°[5]. Moulton *et al.*[13] reported that increased instability in the MP joint can contribute to progressive subluxation of the CMC joint. In addition, hyperextension injury of the IP joint could be induced by rapidly applied force in hyperextension in clinical practice[13]. Although hypermobility may be related to the presence of work-related thumb pain, there has been no study of thumb mobility in massage practitioners with thumb pain.

The stability of the thumb joint depends upon the ligaments, bones, and muscles[5, 14, 15]. It has been postulated that several extrinsic muscles play an important role as dynamic stabilizers during motion[5]. A previous cadaver study reported that extrinsic muscles around the thumb [abductor pollicis longus (APL) and brevis (APB), flexor pollicis longus (FPL) and brevis (FPB), extensor pollicis longus (EPL), extensor pollicis brevis (EPB), adductor pollicis, and opponens pollicis] contribute to three-dimensional thumb joint movements[5, 12, 15, 16]. Wu *et al*.[12] demonstrated that the EPL and EPB are activated by extension motion of the MP and CMC joint, while those in the FPL are generated in response to flexion motion; in particular, the FPL muscle contributes to the maintenance of joint stability in the MP and IP flexion/extension direction. Furthermore, dynamic stability of the MP joint by the thumb muscles has been reported to prevent excessive force and subluxation in basal joints[13, 15, 17]. Therefore, balanced muscle strength in the prevention of thumb pain or injuries in massage practitioners is important.

Although excessive mobility or insufficient stability and muscle strength of the MP and IP joints in the thumb can contribute to work-related thumb pain in massage practitioners, researches has not been pursued previously in massage profession. There are many studies that related to work related thumb pain in physical therapists; however, no study has been investigated in the work related thumb pain in massage practitioner[1, 7–9]. Therefore, we compared the ROM of the thumb joint and strength of the thumb muscles between massage practitioners with and without work-related thumb pain and individuals without thumb pain who are not engaged in massage work.

Methods

Subjects

Sixteen female massage practitioners with and 16 without work-related thumb pain were recruited from 16 massage centers at Seoul and Gyungi-do. The severity and perception of the thumb pain were measured using the visual analog scale (VAS). The VAS was 100-mm line anchored at the two ends with "no pain" at 0 and "worst pain" at 100. The massage practitioners with thumb pain were asked to mark their pain level on the line. Sixteen female control subjects who did not work as massage practitioners were recruited from among the students at Yonsei University. Exclusion criteria were 1) a history of surgery or fracture in the upper extremity, 2) limitation of thumb movement by injury or inflammation, and 3) a neurologic condition in the upper extremity. The tested side was that with thumb pain or that with more severe pain if the subject had bilateral thumb pain. All subjects were provided with an explanation of the experimental procedures, and informed consent was obtained. The study was approved by the Wonju Campus Human Studies Committee. The subject characteristics were presented in Table 1.

Range of motion measurement

A digital camera and a SIMI motion analysis system (SIMI Reality Motion Systems CmbH, Unterschleissheim, Germany) were used for ROM measurement of flexion,

Table 1. Subject characteristics

	Thumb pain (n=16)	Without thumb pain (n=16)	Control (n=16)	*p*
Age (yr)	24.50 ± 2.19	25.06 ± 2.82	23.19 ± 1.17	0.052
Height (cm)	159.93 ± 4.70	161.69 ± 7.23	160.50 ± 4.23	0.351
Weight (kg)	52.61 ± 6.02	51.93 ± 7.18	53.38 ± 4.70	0.273
Work experience (months)	19.63 ± 14.33	22.69 ± 14.61	N/A	N/A
Pain duration (months)	7.43 ± 4.37	N/A	N/A	N/A
VAS (mm)	56.19 ± 19.26	N/A	N/A	N/A

Values are presented as means ± SD. VAS, visual analog scale.

extension, and abduction of the MP joint and flexion and extension of the IP joint. Red stickers with diameters of 5 mm were used to indicate each joint center. To measure ROM of the MP flexion and extension, three markers were attached at lateral aspect in center of CMC, MP, and IP joints. For MP abduction, three markers were attached at dorsal aspect in center of CMC, MP, and IP joints. Flexion and extension of the IP joint were measured using three markers in center of MP and IP joint and the lateral tip of the thumb at lateral aspect. To measure the ROM of the thumb, one investigator fixed the subject's proximal joint segment and moved their distal segments in the directions of flexion, extension, and abduction of the MP joint and flexion and extension of the IP joint while a second investigator obtained lateral and dorsal views using a digital camera. While measuring ROM of the joints, investigator carefully controlled rotation to maintain neutral position of the each segments. Tested segment was moved until investigator feel the firm end feel of the joint to apply consistent pressure during measuring ROM. Captured photographs were imported and analyzed with a computer using the SIMI motion analysis system (Fig. 1). Joint center on the red sticker was defined by intersection of the two diameters of the circle. MP flexion and extension were defined as the angle between a line connecting the CMC and MP joint markers and a line connecting the MP and IP joint markers on the lateral side. MP abduction was defined as the angle between a line connecting the CMC and MP joint makers and a line connecting the MP and IP joints on the dorsal side. IP flexion and extension were defined as the angle between a line connecting the MP and IP joint markers and a line connecting the IP and lateral tip markers on the lateral side.

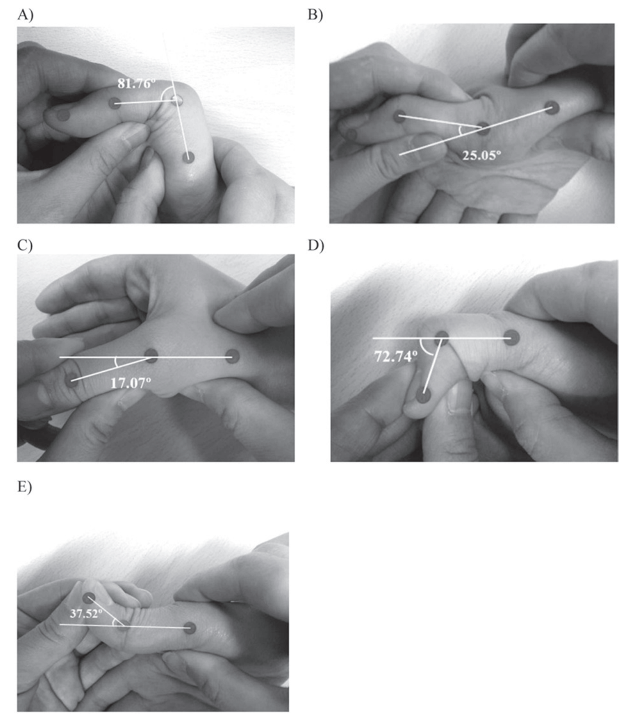

Fig. 1. Range of motion of the thumb analyzed by the SIMI motion analysis system. A) Flexion of the MP joint. B) Extension of the MP joint. C) Abduction of the MP joint. D) Flexion of the IP joint. F) Extension of the IP joint.

Muscle strength measurement

A digital dynamometer (Lafayette Manual Muscle Test System, Model 01163; Lafayette Instrument Company, North Lafayette, USA) was used to measure the muscle strength of the FPB, EPB, APB, FPL, and EPL. Muscle strength by a dynamometer was presented in kilograms. The testing method was consistent with Clarkson[18]. The dynamometer was positioned perpendicular to the tested thumb segment, and the investigator stabilized the proximal segment manually during the trials. Before muscle testing, it was confirmed that the thumb segments was always placed on the center of dynamometer's plate. The subjects maintained maximal contraction of each tested muscle group against the plate. For the familiarization, the subject practiced for 5 min to familiarize themselves with the process. Maximal isometric contraction was maintained for 5 s. Each muscle strength (FPB, EPB, APB, FPL, and EPL) and strength ratio (EPB/FPB and EPL/FPL) were used for the statistical analysis.

Statistical analysis

Data are expressed as means and SD. All statistical analysis was performed using the SPSS software ver. 12.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test was conducted to ensure normal distribution of the variables. All variables were confirmed to be normally distributed; thus, parametric statistics were used. One-way ANOVA with a Bonferroni *post hoc* test was conducted to compare ROM and strength among massage practitioners with and without thumb pain and control subjects. The level of statistical significance was set at $p<0.05$.

Results

Range of motion of the thumb

The ROM of the thumb and pairwise comparisons in massage practitioners with and without thumb pain and in the control group are presented in Table 2. In MP exten-

Table 2. Comparison of ROM of the thumb among massage practitioners with and without thumb pain and controls

Motion	Thumb pain (1)	Without thumb pain (2)	Control (3)	ANOVA	Comparison group	Mean difference (95% CI)	Post hoc *p*
MP Flexion	72.97 ± 14.21	67.79 ± 9.51	70.50 ± 16.34	F=0.576 *p*=0.566	1-2	5.18 (−6.82 to 17.19)	0.867
					1-3	2.47 (−9.53 to 14.48)	1.000
					2-3	−2.71 (−14.71 to 9.30)	1.000
MP Extension	39.27 ± 13.92	34.31 ± 13.48	18.73 ± 10.59	F=11.309 *p*<0.001*	1-2	4.95 (−6.26 to 16.16)	8.333
					1-3	20.54 (9.33 to 31.75)	0.000*
					2-3	15.59 (4.38 to 26.79)	0.004*
MP Abduction	23.83 ± 8.70	23.47 ± 10.62	12.01 ± 7.72	F=8.739 *p*=0.001*	1-2	0.36 (−7.63 to 8.36)	1.000
					1-3	11.82 (3.82 to 19.81)	0.002*
					2-3	11.46 (3.46 to 19.45)	0.003*
IP Flexion	84.83 ± 12.75	88.06 ± 14.50	92.63 ± 13.42	F=1.330 *p*=0.275	1-2	−3.22 (−15.16 to 8.71)	1.000
					1-3	−7.79 (−19.73 to 4.15)	0.335
					2-3	−4.57 (−16.50 to 7.37)	1.000
IP Extension	44.61 ± 19.54	28.75 ± 17.39	32.08 ± 11.23	F=4.143 *p*=0.022*	1-2	15.86 (1.41 to 30.31)	0.027*
					1-3	12.53 (−1.91 to 26.98)	0.109
					2-3	−3.32 (−17.77 to 11.13)	1.000

Values are means ± SD (degree). MP, metacarpophalangeal; IP, interphalangeal; CI, confidence interval. **p*<0.05.

sion and abduction and in IP extension, one-way ANOVA showed a statistically significant difference among the three groups (*p*<0.05). In *post hoc* analysis, the ROM of MP extension in massage practitioners with thumb pain was greater than that in the control group (*p*<0.001). In massage practitioners without thumb pain, the ROM of MP extension was also greater than that in the control group (*p*=0.004), however, there was no significant difference of the MP extension ROM between massage practitioners with and without thumb pain (*p*>0.05). In MP abduction, massage practitioners with and without thumb pain showed greater ROM than that in the control group (*p*<0.05). The ROM of IP extension in massage practitioners with thumb pain was greater than in practitioners without thumb pain (*p*=0.027), however, there was no significant difference between massage practitioners with or without thumb pain and control group. There was no difference in MP and IP flexion ROM among the three groups (*p*>0.05; Table 2).

Muscle strength

The muscle strength of the thumb and pairwise comparisons in massage practitioners with and without thumb pain and in the control group is presented in Table 3. One-way ANOVA showed a statistically significant difference in EPB and FPL strength among the three groups (*p*<0.05). In *post hoc* analysis, the strength of the EPB in massage practitioners with thumb pain was less than that in practitioners without thumb pain (Table 3). The strength of the FPL in massage practitioners with thumb pain was less than that in control group (Table 3). There was no difference in the strength of the FPB, APB, and EPL among the three groups (*p*>0.05).

In addition, the EPB/FPB muscle strength ratio was significantly greater in massage practitioners without thumb pain than in those with thumb pain and the controls (Table 3). There was no significant difference in the ratio of the EPL/FPL strength among the three groups (*p*>0.05).

Discussion

We compared the ROM and muscle strength of the thumb among massage practitioners with and without thumb pain and control subjects. Although some studies have investigated the prevalence and contributing factors of work-related thumb pain in massage practitioners[3, 6], we believe that this study is the first to compare ROM and muscle strength of the MP and IP joints among massage practitioners with and without thumb pain and control subjects.

The MP joint of the thumb is a ball-and-socket joint that is stabilized primarily by ligaments (radial collateral ligament and ulnar collateral ligament), the volar plate, and muscles (APB, APL, FPB, and EPB)[13, 14, 17]. The large compressive loads and shear forces acting on the articular surface can induce ligamentous laxity with progressive articular wear and contribute to the development of joint arthrosis[14]. The development of degenerative changes in

Table 3. Comparison of the strength of the thumb muscle among massage practitioners with and without thumb pain and the control group

Muscle	Thumb pain (1)	Without thumb pain (2)	Control (3)	*ANOVA*	Comparison group	Mean difference (95% CI)	Post hoc *p*
FPB (kg)	5.75 ± 2.67	5.54 ± 1.75	6.45 ± 1.89	F=0.792	1-2	0.20 (−1.68 to 2.09)	1.000
				p=0.459	1-3	−0.71 (−2.59 to 1.18)	1.000
					2-3	−0.91 (−2.79 to 0.98)	0.711
EPB (kg)	2.05 ± 0.65	2.95 ± 0.73	2.52 ± 0.60	F=7.314	1-2	−0.90 (−1.48 to −0.31)	0.001*
				p=0.002*	1-3	−0.47 (−1.05 to 0.11)	0.152
					2-3	0.43 (−0.16 to 1.01)	0.229
EPB/FPB	0.41 ± 0.16	0.57 ± 0.21	0.41 ± 0.12	F=4.773	1-2	−0.16 (−0.30 to −0.01)	0.034*
				p=0.013*	1-3	0.00 (−0.14 to 0.15)	1.000
					2-3	0.16 (0.01 to 0.31)	0.028*
APB (kg)	2.68 ± 0.67	2.45 ± 0.60	2.52 ± 0.61	F=0.560	1-2	0.23 (−0.32 to 0.78)	0.931
				p=0.575	1-3	0.16 (−3.89 to 0.72)	1.000
					2-3	−0.06 (−0.62 to 0.49)	1.000
FPL (kg)	3.85 ± 1.23	4.02 ± 1.59	5.05 ± 1.17	F=3.735	1-2	−0.16 (−1.34 to 1.02)	1.000
				p=0.032*	1-3	−1.20 (−2.38 to −0.02)	0.046*
					2-3	−1.03 (−2.21 to 0.15)	0.104
EPL (kg)	1.83 ± 0.55	1.90 ± 0.41	2.27 ± 1.52	F=0.937	1-2	−0.07 (−0.91 to 0.78)	1.000
				p=0.399	1-3	−0.43 (−1.28 to 0.41)	0.632
					2-3	−0.37 (−1.21 to 0.48)	0.861
EPL/FPL	0.48 ± 0.14	0.53 ± 0.20	0.50 ± 0.54	F=0.081	1-2	−0.05 (0.35 to 0.25)	1.000
				p=0.923	1-3	−0.02 (−0.32 to 0.28)	1.000
					2-3	0.03 (0.27 to 0.32)	1.000

Values are group means ± SD. FPB, flexor pollicis brevis; EPB, extensor pollicis brevis; APB, abductor pollicis brevis; FPL, flexor pollicis longus; EPL, extensor pollicis longus; CI, confidence interval. *$p<0.05$.

the thumb CMC joint is commonly induced by excessive mobility of the MP joint in people who perform daily hand-on techniques[13]. Manual technicians, including manual therapists, physical therapists, and massage practitioners, who use the thumb for the application of repetitive pressure to palpate and compress the soft tissue and bone can sustain excessive forces on the MP joint that promote hyperextension. Therefore, repetitive stress of the MP joint in massage practitioners may accelerate the development of thumb pain and related symptoms.

Previous studies have reported that hyperextension of the MP joint during mobilization can induce dorsal subluxation of the metacarpal shaft[7–9]. Wajon *et al.*[8] reported that physical therapists who could maintain extension of the MP and IP joints during posterior anterior mobilization showed decreased work-related thumb pain compared with physical therapists performing manual therapy on the cervical spine who displayed hyperextension or flexion of the MP and IP joints. In our study, massage practitioners with thumb pain showed greater ROM in MP extension and abduction compared with the control group. In addition, the ROM of MP extension and abduction in massage practitioners without thumb pain was greater than that in the control group. Although the thumb ROM differs among studies, our results suggest significantly increased ROM of the MP and IP joints in massage practitioners[5, 19]. We also demonstrated a greater ROM of IP extension in massage practitioners with thumb pain compared with those without thumb pain. The hyperextension of the MP joint induces shift the base of the metacarpal bone toward the dorsal side, which aggravates degeneration of the CMC joint[7]. Thus, previous studies have recommended that a neutralized thumb position may enhance stability and prevent excessive thumb stress[7, 8]. Based on the results of our study, massage practitioners with hypermobility of the thumb may have difficulty maintaining the MP and IP joints in a neutral position during massage work, resulting in work-related pain. Therefore, increased mobility during MP extension and abduction and IP extension may be a risk factor for thumb pain in massage practitioners.

Our results showed that massage practitioners with thumb pain had decreased EPB muscle strength compared with those without thumb pain. In addition, the ratio of the EPB and FPB muscle strength in the MP joint was greater in massage practitioners without thumb pain compared with that in those with thumb pain. Joint stability and balanced muscle strength are necessary for successful performance of thumb movements. Although the ligamentous structures around the MP joint commonly contribute to its stability, the APL and EPB muscles assist in stabilizing the MP joint[7, 14]. Decreased extensor strength of the MP joint can influence misdirection of the thumb tip force[20]. A high EPB and FPB muscle strength ratio may contribute to increased MP thumb joint stability and prevent dorsoradial movement of the base of the metacarpal bone with repetitive thumb use. Therefore, weakness of the EPB muscle can decrease MP joint stability, which may contribute to thumb pain in massage practitioners during work.

While we compared the ROM and strength of the MP and IP joints of the thumb among three groups, there are some limitations. First, all subjects who participated were female. There is a possibility that male massage practitioners would show different results regarding the ROM and muscle strength of the thumb. Second, when measuring the thumb ROM, we used photographic analysis with red stickers on the skin. Although a skin surface marker may not represent the true motion of the metacarpal and phalangeal bones, the SIMI motion analysis system provides valuable and informative motion analysis. Third potential limitation is measuring method of the ROM with 2D photographs. Although investigator tried to move the segment of the thumb with maintaining neutral position of the each joint during measurement of ROM, it was impossible to control the rotation completely. Future researches are needed to compare ROM of the thumb using 3D motion analysis. Forth, we cannot confirm a causative relationship between thumb pain and the ROM and/or muscle strength of the MP and IP joints. Although it is difficult to demonstrate that an increased ROM and decreased muscle strength of the MP and IP joints causes thumb pain in massage practitioners, our results suggest that an increased thumb ROM and decreased MP joint muscle strength may be a contributing factor in thumb pain. Therefore, further study is necessary to determine whether increased strength of the EPB and FPL muscles influences thumb pain in massage practitioners.

Conclusion

The purpose of this study was to compare the ROM and strength of the MP and IP joints among massage practitioners with and without work-related thumb pain and control subjects. Our study demonstrated that massage practitioners who use repeated thumb during work have greater mobility of the thumb MP than control subjects and massage practitioners with thumb pain have greater IP extension mobility than those without thumb pain. Additionally, we observed decreased strength of the EPB and FPL muscles in massage practitioners with thumb pain. These results have important clinical implication for massage practitioners that they need to be educated for safer thumb alignment and preventing hyper-stress of the thumb during work. Future study is needed to investigate whether strengthening of the EPB muscle and FPL muscle can reduce thumb pain through a longitudinal study.

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