Original Article

PTRS Physical Therapy Rehabilitation Science

https://doi.org/10.14474/ptrs.2024.13.1.95
eISSN 2287-7584
pISSN 2287-7576

Phys Ther Rehabil Sci
2024, 13(1), 95-105
www.jptrs.org

Effects on Mechanical Properties, Joint Range of Motion, and Grip Strength of Forearm Muscles Depending on Wrapping Direction of the Floss Band

Ki Bum Jung[a], **Seohui Kim**[a], **Yongwoo Lee**[a*]

[a]Department of Physical Therapy, College of Health and Welfare, Sahmyook University, Seoul, Republic of Korea

Objective: The purpose was to investigate changes in mechanical properties, range of motion, and grip strength of the forearm muscle in 13 students depending on the wrapping direction of the floss band.

Design: A single-blind, crossover study

Methods: Subjects were randomly assigned to the wrapping direction of the flossing band and then performed a concentric exercise of the wrist flexors using a Flex-Bar. Intervention A applied the flossing band in a right spiral direction, Intervention B applied the flossing band in a left spiral direction, and Intervention C performed the exercise alone. All subjects used their dominant right hand, and pre- and post-assessments were conducted between interventions. To analyze differences in changes between groups pre- and post-, all results were subjected to one-way ANOVA, followed by Scheffe's test as a post-hoc analysis. The paired samples t-test was used to analyze the difference between pre- and post-change within groups.

Results: First, in the mechanical properties of the Flexor carpi ulnaris (FCU) muscle, interventions A and B significantly improved muscle tone and stiffness than intervention C ($p < 0.05$), and intervention A showed a significant decrease in decrement (muscle elasticity) than intervention B ($p < 0.05$). Second, interventions A and B showed significant improvement in grip strength than intervention C ($p < 0.05$).

Conclusions: The right spiral direction of the flossing band tended to increase the elasticity of the muscles compared to the left spiral direction. Therefore, in future studies, it is necessary to choose the direction of the flossing band to increase the elasticity of the muscles.

Key Words: Forearm, Blood flow restriction therapy, Proprioception, Elasticity, Hand strength

Introduction

Flossing bands are thick elastic bands that are wrapped around painful or limited range of motion joints and muscles for exercise, as opposed to Thera-Bands, which are direct band exercises [1]. It is effective in improving joint ROM by increasing fascial fluidity when performing muscle movements under compression, and the reperfusion of blood flow after the compression is removed increases catecholamines and growth hormones, which helps to improve muscle strength. The aim of these treatments is to increase mobility and strength, reduce pain and accelerate healing, and they are increasingly used in the field of physiotherapy [2].

However, previous studies of flossing bands have shown mixed results. While some studies have shown positive effects on knee joint ROM and strength [3, 4], others have reported improvements in performance but not strength, or no significant difference in joint ROM compared to foam rolling or stretching [2, 5]. This discrepancy has prompted research into intervention

Received: Mar 13, 2024 **Revised:** Mar 20, 2024 **Accepted:** Mar 20, 2024
Corresponding author: Yongwoo Lee (**ORCID** https://orcid.org/0000-0001-9978-1924)
Department of Physical Therapy, College of Health and Welfare, Sahmyook University.
815 Hwarang-ro, Nowon-gu, Seoul, Republic of Korea
Tel: +82-02-3399-1636 **Fax:** +82-2-3399-1638 **E-mail:** yongwo2@syu.ac.kr

protocols using flossing bands, with recent studies attempting to determine the effectiveness of interventions using different pressure levels of the flossing band or combining stretching and flossing bands [2]. Notably, none of these studies have investigated the effect of the direction in which the flossing band is wrapped.

Spiral-wrapped flossing bands stimulate muscles in a diagonal direction, which may affect the facilitation of proprioception [6]. Proprioception is a sensation inherent to muscles that regulates the timing of muscle contractions and is involved in balance, posture and movement. Stimulation in a diagonal pattern has been used to promote proprioception and has been shown to improve muscle strength, joint ROM and functional movement [6, 7]. Previous studies applying spiral taping have reported that applying spiral taping to the sternocleidomastoid muscle promoted proprioception and improved balance[8], and applying spiral taping to the ankle promoted proprioception and improved joint ROM [9].

In addition, recent studies have suggested that the facilitation of proprioception may vary depending on the direction of stimulation of this spiral pattern. Yang [6] measured the stiffness of the right wrist extensor when taping according to the direction of the spiral and reported that the right spiral direction improved stiffness more than the left spiral. He reported that the diagonal stimulation of the taping applied in the right spiral direction coincided with the direction of contraction of the wrist extensor, thereby facilitating proprioception. This suggests that the effectiveness of proprioceptive stimulation of the muscle may vary depending on the direction of the spiral pattern.

However, most studies have been conducted using taping and no studies have investigated the effect and direction of the spiral pattern using flossing bands, so the present study aimed to investigate the effects of two different directions.

Method

Participants

This study was conducted on 13 graduate students (8 males, 5 females) from a university in Seoul, Korea. Inclusion criteria were no history of neurological or orthopedic disorders of the upper extremities [10]. Exclusion criteria were latex allergy (flossing band), hypertension (resting systolic blood pressure > 160 mmHg or diastolic blood pressure > 100 mmHg), venous thrombosis, heart disease [4], and body mass index (BMI) > 30 kg/m^2 [11]. All subjects received a full explanation of the purpose, methods and procedures of the study before the experiment, and informed consent was obtained before the study.

Design

This was a single-blind, crossover study and the number of subjects was calculated using G*Power program (version 3.1, University of Duffledorf, Germany) [12]. An effect size of 0.7 was calculated based on a study on the effect of the spiral taping method on changes in muscle stiffness for proprioception [6], and 8 subjects were required between groups using one-way ANOVA, a significance level of 0.05, a power of 0.8, and a number of groups of 3. Considering a dropout rate of 20%, the minimum number of participants per group was 10, and subjects meeting the inclusion and exclusion criteria were selected from the recruited subjects.

Procedure

Before the intervention, the subjects' general characteristics, blood pressure, and forearm circumference and length were measured. Each subject performed three interventions — intervention A (Right spiral flossing with exercise), intervention B (Left spiral flossing with exercise) and intervention C (exercise) — on three separate days, with a one-week washout period between interventions to eliminate the effects of the previous intervention. Intervention A consisted of applying a flossing band to the forearm in the direction of the right spiral, followed by concentric exercises of the wrist flexor muscle using a Flex-Bar, while intervention B consisted of applying a flossing band in the direction of the left spiral and the same exercises. Intervention C consisted of concentric exercises using only a Flex-Bar. Subjects were randomly assigned to the interventions using a Research Randomizer program (version 4.0, Geoffrey

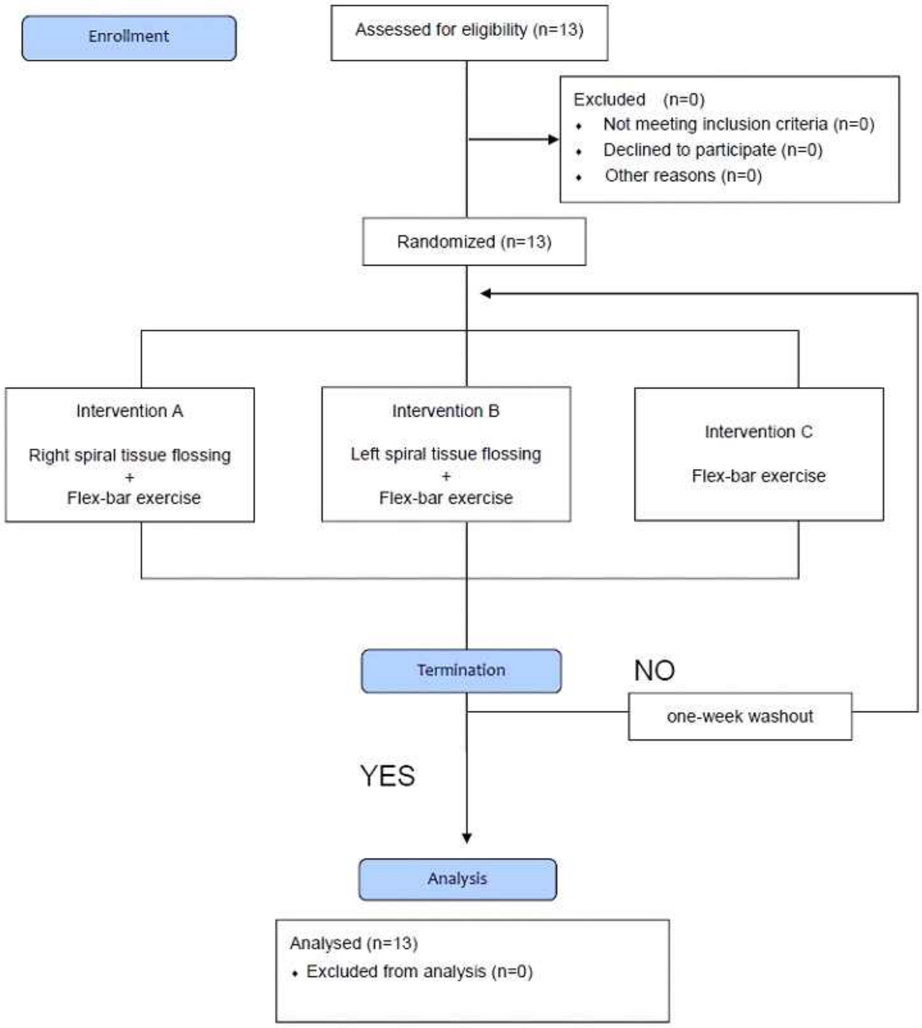


Figure 1. Flow diagram

C. Urbaniak and Scott Plous, Pennsylvania) [13]. All measurements were performed by a 7th year physiotherapist in a laboratory at a temperature of 25°C, and subjects could repeat the measurements at the same time of day as the first measurement. To prevent delayed onset muscle soreness (DOMS), subjects were also instructed not to overexert their forearm muscle in the 48 hours prior to the study [14]. Forearm muscle stiffness, wrist joint ROM and handgrip strength were measured as pre- and post-tests to determine the effectiveness of the interventions (Figure 1).

Intervention

1) The Flossing Band

The procedure for the flossing band (COMPRE Floss Band; Blueberry 2 m (L) × 5 cm (W), Sanctband, Malaysia) was as follows. First, the circumference of the forearm was measured to ensure equal tension of the flossing band between subjects. A digital tape measure (R7 Smart Tape Measure, atflee, China) was used for the measurement, and four points were measured. First, 1/2 of the length of the forearm (1/2 point between the olecranon process and the midpoint of the radial and ulnar tuberosities). Second, 2.5 cm proximal to the first measurement point. Third, 5 cm proximal to the first measurement point. Fourth, 7.5 cm proximal to the first measurement point. The flossing band was then marked with numbers at 5mm intervals, like a tape measure, and the length of the flossing band was calculated using the formula below. Each subject, while seated, held their arm out in front of them and wrapped the band tightly around the first point. The band was then wrapped around the forearm from distal to proximal, maintaining a tension of 1.5 times the length of the band, to achieve 50% overlap with the previous part of the band. A line was marked at 2.5 cm, half the width of the flossing band, to ensure accurate overlap [10]. The band was wrapped around the motor points of the ECRB and FCU [11], and the right spiral (intervention A) and left spiral (intervention B) were applied separately (Figure 2).

$x*(150/100) =$ Sum of forearm circumference
(x: Length of flossing band)

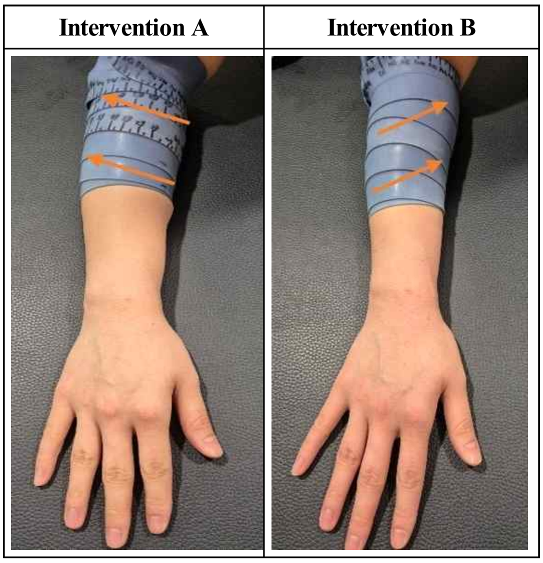


Figure 2. Intervention type

2) Flex–Bar Exercise

A Flex-Bar (Flex-Bar, Thera-Band, Germany) was used to induce a concentric contraction of the wrist flexor muscles. Exercises were performed with the Thera-Band Flex-Bar Wrist Wring-Out, provided by Thera-Band academy. The exercise was performed for two sets of four 10-second repetitions, resting 10 seconds between each repetition, with a two-minute rest between each set. The procedure of the exercise is as follows (Figure 3).

Outcome measure

1) Myotone PRO

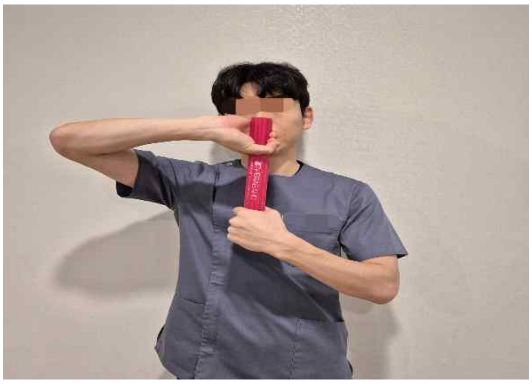
The Myoton PRO(Myoton PRO, Myoton AS., Estonia) was used to measure the mechanical properties of the forearm muscles. During the measurement, the subject was seated comfortably, and the body was positioned close to the table. The head was facing forward, the shoulders were abducted 10-20°, the elbows were positioned at the end of the table, the forearm and wrist were neutral and the fingers were fully extended. For the forearm muscles, extensor carpi radialis brevis (ECRB) and flexor carpi ulnaris (FCU) were measured at the motor point of each muscle.

To estimate the motor point of the ECRB, the examiner measured the length of the radial tuberosity and lateral epicondyle with the subject's forearm in pronation (Length of forearm lateral side). After marking an area 16% distal to the lateral epicondyle on the measured length, the motor point was identified by asking the subject to extend the wrist. The motor point of the FCU was determined by measuring the length of the pisiform and medial epicondyle with the subject's forearm in supination (Length of forearm medial side). After marking a point 32% distal to the medial epicondyle on the measured length, the subject was asked to flex the wrist to identify the motor point. Five mechanical pulses were applied to the muscle using the multi-scan mode of the Myotone Pro and the average values of muscle tone (oscillation frequency), stiffness and decrement (muscle elasticity) were derived. A 3% threshold was set for the coefficient of variation (CV) between each mechanical impulse, which was remeasured if it was exceeded. All measurements were applied to the dominant hand, which has an intra-rater reliability of ICC = 0.70-0.99 [11].

2) Wrist ROM

A goniometer app (Level Tool-Bubble Level app, Red cat studio) on a smartphone (Galaxy S21, Samsung, Republic of Korea) was used to measure wrist ROM. The subject was placed in the same position as the measurement position of the Myotone Pro. To measure wrist extension, the smartphone was placed vertically on the subject's back between the second and third metacarpal bones and the subject was asked to extend the wrist. To measure wrist flexion, the smartphone was placed vertically on the ventral side between the metacarpal bones, and the subject was asked to flex the wrist [15]. The examiner instructed the subject to keep the fingers straight during wrist extension and

First, grasp the underside of the Flex-Bar with the wrist of your non-dominant hand fully flexed.



Second, grasp the top of the Flex-Bar with your dominant wrist fully extended.

Third, as if wringing out a towel, extend your non-dominant wrist and flex your dominant wrist, simultaneously extending your elbows and holding neutral for five seconds.

Fourth, slowly flex the dominant wrist while keeping the elbow extended for 5 seconds to induce an concentric contraction of the wrist flexor muscle.

Figure 3. Process of Flex-Bar Exercise

flexion, and to say the word 'end' when the final ROM was reached. Measurements were recorded on the Y-axis of the goniometer app and averaged after three measurements. All measurements were taken on the dominant hand and the intra-rater reliability of this measure is ICC = 0.96-0.99 [16].

3) Grip strength

A K-grip dynamometer (K-grip, Kinvent, France) was used to measure grip strength using standard procedures recommended by the American Society of Hand Therapists (ASHT). Subjects were seated in a chair with the hip and knee flexed to 90° and grip strength was measured at 10° shoulder abduction, 90° elbow flexion, neutral forearm, 0° to 30° wrist flexion and 0° to 15° ulnar deviation. During the measurement, the subject was asked to squeeze the K-Grip slowly and continuously for at least 3 seconds, and the examiner gave a verbal cue to the subject to do their best. The highest peak force value was recorded after 2 measurements, with a 1-minute rest between measurements. All measurements were applied to the dominant hand and the intra-rater reliability of this measure is ICC = 0.96-0.97 [17].

Statistical analysis

This study was conducted using IBM SPSS statistical software (IBM SPSS Statistics version 22.0, IBM CO, USA). All data were tested for normality using the Shapiro-Wilk test, skewness and kurtosis [18] and were found to be normally distributed. One-way analysis of variance (ANOVA) was used to test for homogeneity between the three groups. Paired

Table 1. *General characteristics of subjects* ($N=13$)

Variable	Male(n=8)	Female(n=5)	Total(N=13)
Age (year)	27.75	27.60	27.69
Height (cm)	174.63	165.60	171.15
Weight (kg)	75.75	60.60	69.90
BMI (kg/m²)	24.83	21.97	23.73
SBP (mmHg)	124.44	114.70	120.69
DBP (mmHg)	71.31	75.30	72.85
Circumference (1) (cm)	24.58	21.82	23.52
Circumference (2) (cm)	26.43	23.22	25.19
Circumference (3) (cm)	27.19	24.18	26.03
Circumference (4) (cm)	27.75	24.60	26.54
LF(cm)	27.50	24.60	26.3
LF medial side (cm)	27.78	25.00	26.71
LF lateral side (cm)	27.50	24.90	26.50

Note. ^{a}=Mean ± standard deviation (SD)
BMI – body mass index; SBP – systolic blood pressure; DBP – diastolic blood pressure; LF – length of forearm

sample t-tests were used to compare pre-post differences by intervention method within groups, and one-way ANOVA was used to compare differences between groups. Post-hoc analyses were performed using Scheffe's test and all data were considered statistically significant at $p<0.05$.

Results

1) General characteristics

Thirteen participants, 8 males and 5 females, all right-hand dominant, were included in this study. The general characteristics of the participants are summarized in Table 1.

2) Changes in forearm mechanical properties

Flexor carpi ulnaris (FCU) muscle tone and stiffness improved significantly in interventions A, B and C ($p<0.05$) and Decrement was significantly reduced in intervention A ($p<0.05$). Interventions A and B showed significant improvements in Tone and Stiffness than intervention C ($p<0.05$), with intervention A showing a significant reduction in Decrement than intervention B ($p<0.05$). However, there were no statistically significant differences in extensor carpi radialis brevis (ECRB) muscle Tone, Stiffness and Decrement between interventions A, B and C (Table 2).

3) Changes in grip strength

Grip strength showed a significant improvement in interventions A and B, whereas no significant change was observed in intervention C. Interventions A and B showed a statistically significant improvement in grip strength than intervention C (Table 3).

4) Changes in wrist ROM

Wrist flexion ROM improved significantly in interventions A and B, whereas no significant change was observed in intervention C. There were no significant differences in wrist extension ROM between interventions A, B and C (Table 4).

Discussion

This study aimed to compare the effects of flossing band direction on the mechanical properties of the forearm muscles, wrist joint ROM, and grip strength. Intervention A and B showed significant improvement in FCU muscle Tone, Stiffness, and Grip strength than

Table 2. *Comparison of mechanical properties before and after intervention* (N=13)

			Intervention A (n=13)	Intervention B (n=13)	Intervention C (n=13)	F(p) Post hoc
FCU	Tone (Hz)	Pre	16.45±2.13[a]	16.74±2.19	17.02±2.16	0.225(0.800)
		Post	16.92±2.22	18.31±2.43	18.82±2.61	
		Post-pre	0.48±0.34	1.57±0.70	1.80±0.82	15.169(0.000)* A,B>C
		t(p)	5.065(0.000)*	8.064(0.000)*	7.890(0.000)*	
	Stiffness (N/m)	Pre	288.38±49.57	291.92±52.10	305.77±52.91	0.413(0.665)
		Post	301.38±58.36	331.23±59.55	352.08±67.51	
		Post-pre	13±13.95	39.31±17.55	46.31±26.00	10.205(0.000)* A,B>C
		t(p)	3.359(0.006)*	8.075(0.000)*	6.422(0.000)*	
	Decrement (LD)	Pre	0.86±0.08	0.86±0.11	0.92±0.14	1.144(0.330)
		Post	0.85±0.09	0.90±0.16	0.86±0.14	
		Post-pre	-0.01±0.05	0.04±0.10	-0.06±0.06	5.563(0.008)* A>B
		t(p)	-0.417(0.684)	1.365(0.197)	-3.464(0.005)*	
ECRB	Tone (Hz)	Pre	14.70±1.50	15.13±1.74	14.88±1.74	0.220(0.804)
		Post	14.44±1.42	14.98±1.60	15.22±2.20	
		Post-pre	-0.26±0.69	-0.15±0.60	0.34±0.85	2.576(0.090)
		t(p)	-1.369(0.196)	-0.930(0.371)	1.439(0.176)	
	Stiffness (N/m)	Pre	236.00±36.99	249.85±52.39	238.38±41.76	0.365(0.697)
		Post	228.08±32.54	243.62±42.46	239.92±48.86	
		Post-pre	-7.92±20.43	-6.23±19.63	1.54±20.36	0.816(0.450)
		t(p)	-1.399(0.187)	-1.144(0.275)	0.272(0.790)	
	Decrement (LD)	Pre	0.99±0.15	0.95±0.16	0.93±0.17	0.376(0.689)
		Post	0.97±0.14	0.98±0.19	0.95±0.21	
		Post-pre	-0.02±0.1	0.02±0.09	0.01±0.09	0.703(0.502)
		t(p)	-0.614(0.551)	0.954(0.359)	0.614(0.551)	

Note. [a]=Mean ± standard deviation (SD)
FCU − flexor carpi ulnaris; ECRB − extensor carpi radialis brevis
Hz - Hertz; N/m - Newton/meter; LD- logarithmic decrement. $^{*}p<0.05$

Table 3. *Comparison of Grip strength before and after intervention* (N=13)

		Intervention A (n=13)	Intervention B (n=13)	Intervention C (n=13)	F(p) Post hoc
Grip strength(N)	Pre	310.64±94.35[a]	313.50±97.70	312.88±88.52	0.003(0.997)
	Post	304.59±88.02	324.88±92.04	324.91±88.12	
	Post-pre	-6.05±12.7	11.38±14.43	12.02±15.23	6.816(0.003)* A,B>C
	t(p)	-1.717(0.112)	2.844(0.015)*	2.846(0.015)*	

Note. [a]=Mean ± standard deviation (SD)
N-newton. $^{*}p<0.05$

Table 4. *Comparison of Wrist ROM before and after intervention* ($N=13$)

			Intervention A (n=13)	Intervention B (n=13)	Intervention C (n=13)	F(*p*) Post hoc
Wrist ROM	Flexion(°)	Pre	43.35±10.75[a]	57.81±8.87	45.84±9.59	0.302(0.741)
		Post	45.17±10.29	60.11±7.35	50.31±8.01	
		Post-pre	1.82±3.8	2.95±4.23	4.47±4.19	1.377(0.265)
		t(*p*)	1.726(0.110)	2.516(0.027)*	3.840(0.002)*	
	Extension(°)	Pre	56.53±7.9	42.96±10.41	60.34±7.44	0.747(0.481)
		Post	57.07±8.07	45.91±10.36	62.13±4.86	
		Post-pre	0.54±2.99	2.29±4.93	1.78±4.83	0.563(0.574)
		t(*p*)	0.646(0.531)	1.677(0.119)	1.329(0.208)	

Note. [a]=Mean ± standard deviation (SD)
ROM-range of motion. $^{*}p<0.05$

Intervention C, and Intervention A showed significant reduction in FCU muscle Decrement than Intervention B. Intervention A and B showed significant improvement in wrist flexion ROM, but the difference between groups was not significant. There were no significant differences in the mechanical properties of the ECRB and wrist extension ROM.

The Tone and Stiffness values measured by Myotone Pro indicate muscle tone, with increasing values indicating higher tone [11]. This suggests that the contractile force of the muscle has increased, and strength gains can be expected [18]. In the present study, interventions A and B significantly improved FCU muscle tone and grip strength and were more effective than intervention C. Flossing bands have been suggested to increase strength gains by promoting catecholamines and growth hormone through reperfusion of blood flow [2]. Kaneda et al [19] reported improvements in plantar flexor strength and muscle activity of the gastrocnemius lateralis after applying the flossing band, Kaneda et al [4] reported improvements in knee flexor strength, and Matjaž et al [20] reported improvements in knee extensor strength. Therefore, it is thought that the application of the flossing band promoted hormonal changes in the forearm muscles, which contributed to the improvement in grip strength. Saldıran et al [11] showed that there is a high correlation between FCU muscle tone and grip strength, and that as FCU muscle tone increases, grip strength increases. Colomar et al [21] found that the higher the muscle tone of the gastrocnemius muscle in junior tennis players, the faster the stroke speed. This is consistent with our findings of increased FCU muscle tone and increased grip strength in this study.

However, while increasing muscle tone can be effective in improving strength, it can also increase the risk of injury. Park et al [22] reported that increased muscle tone in the infraspinatus and supraspinatus can cause cervicogenic headaches, and Kisilewicz et al [23] reported that increased muscle tone in the supraspinatus produces trigger points and impairs shoulder function. To reduce the risk of such injuries, Roch & Gaudreault [24] inserted needles into trigger points of the upper trapezius muscle to induce a decrease in muscle tone and an increase in elasticity, and Lee et al [25] reported that increasing muscle elasticity should prevent musculoskeletal disorders. Saito et al [26] reported that increased elasticity of the FCU muscle helps prevent elbow injuries by inhibiting the increase in medial elbow joint space. Therefore, it is important to consider elasticity for injury prevention.

Elasticity is expressed as a Decrement in Myotone Pro, with decreasing values indicating higher elasticity. This suggests that the muscle is more recoverable after contraction, and it can be expected that the risk of injury is reduced [11]. In order to regulate muscle elasticity, it is important to promote proprioception. Proprioception is a sensation inherent to muscles that regulates the timing of muscle contractions and is involved in balance, posture and movement. Stimulation in a diagonal pattern has been used to promote proprioception and has been shown to improve muscle strength, joint ROM and functional movement [6, 7]. Previous studies applying spiral taping have reported that applying spiral taping to the sternocleidomastoid muscle promoted proprioception and improved balance [8], and applying spiral taping to the ankle promoted proprioception and improved joint ROM [9]. In addition, recent studies have suggested that the facilitation of proprioception may vary depending on the direction of stimulation of this spiral pattern. Yang [6] measured the stiffness of the right wrist extensor when taping according to the direction of the spiral and reported that the right spiral direction improved stiffness more than the left spiral. He reported that the diagonal stimulation of the taping applied in the right spiral direction coincided with the direction of contraction of the wrist extensor, thereby facilitating proprioception. In the present study, the elasticity of the FCU muscle increased with intervention A, which applied the flossing band in a right spiral, and was significantly better than intervention B, which applied the band in a left spiral. The contraction of the FCU muscle induces a supination movement of the forearm [27]. The right spiral wrapped flossing band continuously promoted the supination stimulation of the forearm muscles, which affected proprioception, and had a significant effect on elasticity. Therefore, we believe that the right spiral wrapped flossing band increases the elasticity of the FCU muscle compared to the left spiral, and may reduce the risk of injury. These results suggest that in clinical practice, when applying a flossing band to patients with elbow pain in the dominant hand, the right spiral application may be more effective in preventing injury by increasing the elasticity of the FCU muscle than the left spiral application.

There was a significant improvement in wrist flexor ROM in intervention A and B, but there was no difference between interventions. And there was no difference between interventions in the mechanical properties of the ECRB. Stretching with a flossing band has been shown to be effective in improving ROM by improving fascial fluidity [4]. These stretching techniques reduce muscle stiffness, which follows the mechanism of improved ROM. However, previous studies have reported that stretching applications after wrapping a flossing band improved ankle ROM, but not stiffness [5, 19]. Konrad et al [2] reported that flossing bands had a positive effect on improving ROM, but the average effect size of the included studies is 0.398 (ranging from 0.01 to 0.7), indicating a small to moderate magnitude of change, and the mechanism for the improvement in ROM was reported to be an increase in neurological tolerance rather than changes in muscle stiffness. Therefore, in this study, we believe that the increase in neurological tolerance of the ECRB with flossing band wrapping and stretching contributed to the improvement in ROM, and not the mechanical properties of the muscle. In addition, the lack of difference between interventions in ROM was due to the small effect size, and future studies should consider recruiting a larger sample size.

Limitations of this study include the following. First, the short study period and small sample size, and the fact that all subjects applied the intervention to their dominant hand, the right forearm, make it difficult to generalize the results. Second, the length of the flossing band was calculated and applied to the subjects, but the tension may have been different during the winding process. Third, the difficulty level of the exercise may vary due to the different underlying muscle strength of each subject. Therefore, future studies should take these limitations into account, and should be conducted on other parts of the body other than the right forearm to confirm the effectiveness.

Conclusion

This study confirmed that the elasticity of the muscles tends to be higher when the flossing band is applied in the right spiral direction than the left, which may help prevent injuries during exercise by improving the ability of the muscles to recover after contraction. Therefore, future studies should consider the direction of the flossing band to increase the elasticity of the muscles.

Reference

1. Han S. The Effect of Theraband and Flossing Band Exercises on Ankle Range of Motion and Muscle Strength. Korean Soc Sport Phys Ther. 2022;18: 19-25.
2. Konrad A, Močnik R, Nakamura M. Effects of tissue flossing on the healthy and impaired musculoskeletal system: A scoping review. Front Physiol. 2021;12:666129.
3. Cheatham S, Martinez R, Montalvo A, Odai M, Echeverry S, Robinson B, et al. Comparison of roller massage, instrument assisted soft-tissue mobilization, and floss band on passive knee motion among inexperienced individuals. Clin at. 2020;3: 24-36.
4. Kaneda H, Takahira N, Tsuda K, Tozaki K, Kudo S, Takahashi Y, et al. Effects of tissue flossing and dynamic stretching on hamstring muscles function. J Sports Sci Med. 2020;19:681.
5. Vogrin M, Novak F, Licen T, Greiner N, Mikl S, Kalc M. Acute effects of tissue flossing on ankle range of motion and tensiomyography parameters. J Sport Rehabil. 2020;30:129-35.
6. Yang J-M. Immediate Effect of the Proprioceptive Spiral Taping Method on Changes in Muscle Stiffness. PNF & Mov. 2022;20:321-9.
7. Kim S-M, Kim Y-M. Effect of both lower extremities proprioceptive neuromuscular facilitation training with functional electrical stimulation on the balance and gait of stroke patient: A randomized controlled trial. Korean soc phys med. 2020;15: 123-32.
8. Lee BH, Lee HR, Kim KM, Lee JH, Kim KY. Effects of spiral taping applied to the neck and ankle on the body balance index. J Phys Ther Sci. 2015;27:79-82.
9. Bae Y-S. Effects of spiral taping on proprioception in subjects with unilateral functional ankle instability. J Phys Ther Sci. 2017;29:106-8.
10. Lee Y, Choi J. A Study to Identify the Optimum Forearm Floss Band Intensity in 29 Young Adults Performing Blood Flow Restriction Training. Med Sci Monit. 2022;28:e935771-1.
11. Saldıran TÇ, Kara İ, Yıkılmaz SK. Quantification of the forearm muscles mechanical properties using Myotonometer: Intra-and Inter-Examiner reliability and its relation with hand grip strength. J Electromyogr Kinesiol. 2022;67:102718.
12. Faul F, Erdfelder E, Buchner A, Lang A-G. Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. Behav Res Methods. 2009;41:1149-60.
13. Urbaniak GC, Plous S. Research randomizer (version 4.0)[computer software]. 2013.
14. Adamczyk JG, Gryko K, Boguszewski D. Does the type of foam roller influence the recovery rate, thermal response and DOMS prevention? PLoS One. 2020;15:e0235195.
15. Modest J, Clair B, DeMasi R, Meulenaere S, Howley A, Aubin M, et al. Self-measured wrist range of motion by wrist-injured and wrist-healthy study participants using a built-in iPhone feature as compared with a universal goniometer. J Hand Ther. 2019;32:507-14.
16. Surangsrirat D, Bualuangngam T, Sri-iesaranusorn P, Chaiyaroj A, Buekban C, Thanawattano C, et al. Comparison of the wrist range of motion measurement between inertial measurement unit glove, smartphone device and standard goniometer. Appl Sci. 2022;12:3418.
17. Magni N, Olds M, McLaine S. Reliability and validity of the K-force grip dynamometer in healthy subjects: Do we need to assess it three times? Hand Ther. 2023;28:33-9.
18. Jarosz J, Gaweł D, Krzysztofik M, Zając A, Tsoukos A, Bogdanis GC, et al. Effects of blood flow restriction on mechanical properties of the rectus femoris muscle at rest. Front Physiol. 2023;14.
19. Kaneda H, Takahira N, Tsuda K, Tozaki K, Sakai K, Kudo S, et al. The effects of tissue flossing and static stretching on gastrocnemius exertion and flexibility. Isokinet Exerc Sci. 2020;28:205-13.
20. Matjaž V, Kalc M, Ličen T. Acute Effects of Tissue Flossing Around the Upper Thigh on Neuromuscular Performance: A Study Using Different Degrees of Wrapping Pressure. J Sport Rehabil. 2020.
21. Colomar J, Baiget E, Corbi F. Influence of strength, power, and muscular stiffness on stroke velocity in junior tennis players. Front Physiol. 2020;11:196.
22. Park SK, Yang DJ, Kim JH, Heo JW, Uhm YH, Yoon JH. Analysis of mechanical properties of cer-

vical muscles in patients with cervicogenic headache. J Phys Ther Sci. 2017;29:332-5.
23. Kisilewicz A, Janusiak M, Szafraniec R, Smoter M, Ciszek B, Madeleine P, et al. Changes in muscle stiffness of the trapezius muscle after application of ischemic compression into myofascial trigger points in professional basketball players. J Hum Kinet. 2018;64:35.
24. Roch M, Morin M, Gaudreault N. Immediate Effect of Dry Needling on the Viscoelastic Properties of a Trigger Point on the Infraspinatus Muscle Measured with MyotonPRO. Physiother Can. 2022;74:232-9.
25. Lee Y, Kim M, Lee H. The measurement of stiffness for major muscles with shear wave elastography and myoton: a quantitative analysis study. Diagnostics. 2021;11:524.
26. Saito A, Namiki Y, Okada K. Elasticity of the flexor carpi ulnaris muscle after an increased number of pitches correlates with increased medial elbow joint space suppression. J Strength Cond Res. 2021;35:2564-71.
27. Salva-Coll G, Garcia-Elias M, Leon-Lopez M, Llusa-Perez M, Rodríguez-Baeza A. Effects of forearm muscles on carpal stability. J Hand Surg. 2011;36:553-9.