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CONTENTS

「The future of manual physical therapy in Asia」

The International Federation of Orthopaedic Manipulative Physical Therapists (IFOMPT), one of the lower associations of the World Physical Therapy (WCPT), is currently made up of 24 membership organizations (MOs) and 18 registered interest groups (RIGs). At present, however, IFOMPT has an image of being an association led by European countries and the U.S. because only Japan and Hong Kong have an MO and only Korea, Philippines and Pakistan have a RIG in Asia.

We wish all members to understand the organization of IFOMPT and the educational standards established by IFOMPT. As the same time, we wish to increase the number of Asian MOs, develop lots of excellent manual physical therapists, and construct a network of manual physical therapists in Asia.

We sincerely hope that the Journal of Asian Orthopedic Manipulative Physical Therapy will contribute to the development of manual physical therapy and construction of a network of manual physical therapists in Asia. We are sure that all Asian countries take this Journal as an opportunity to start to work together hand-in-hand to develop manual physical therapy in Asia.

JAOMPT President
Masao YAMAUCHI

Association between the preoperative toe grip strength and functional performance following total knee arthroplasty: A longitudinal observational study

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Abstract
The aim of this study was to investigate the association between preoperative toe grip strength (TGS) and postoperative Timed Up and Go (TUG) in patients who underwent total knee arthroplasty (TKA). Participants were sixty-seven patients who underwent TKA. Outcome measures were TGS, isometric knee extension strength (IKES), TUG, and pain during walking. TGS and IKES were measured at the affected side. Outcomes were measured at a few days before TKA and at discharge. TGS and IKES before TKA were standardized by body weight (TGSpre/wt and IKESpre/wt). Outcome measures before and after TKA were compared. The association between TUG and TGSpre/wt was analyzed using multivariate linear regression with covariates (age, sex, postoperative pain during walking, and IKESpre/wt). Significant level was set at 5%. Preoperative TUG (12.5±4.9 sec) was significantly delayed at the postoperative period (vs 14.5±5.1 sec preoperatively). In multivariate linear regression analyses, TUG had a significant association with age (standardised partial regression coefficient [β]=0.30) and TGSpre/wt (β=-0.31). Preoperative TGS was associated with postoperative TUG in patients who underwent TKA.

Key words: toe, strength, total knee arthroplasty

INTRODUCTION
Total knee arthroplasty (TKA) is one of the most common surgical interventions for knee pathologies, such as knee osteoarthritis (OA)[1)2)]. In Japan, more patients with knee pathologies underwent TKA compared with Unilateral Knee Arthroplasty or Tibial Osteotomy[3)]. TKA is effective in reducing knee pain among patients with knee OA[2)]. On the other hand, many reports described surgery-induced loss of knee extensor strength after TKA[4-7)]. In addition, physical function would also decline after TKA. For example, Timed Up and Go (TUG) is significantly delayed after

TKA in the early postoperative period[8)9)].

TUG requires multiple abilities such as standing up and sitting down, walking speed, and controlling dynamic balance. Therefore, TUG is used to evaluate functional performance[10)] and is also used for screening risk of falls in community-dwelling people[11)]. TUG has been used to evaluate functional performance among patients scheduled for TKA[12)] and those who underwent TKA[8)9)13-15)] Loss of knee extensor strength has been associated with decreased functional performance, such as TUG following TKA[15)]. In particular, the involved leg shows stronger correlations to functional performance than the non-involved leg[12)].

In addition to knee extensor strength, toe function is also associated with functional performance. Previous research demonstrated that loss of toe strength was associated with the risk of falling[16)]. Another study demonstrated that TGS was negatively associated with walking speed during fast pace walking among older Japanese[17)]. We reported that TGS had a negative association with TUG independent of age and isometric knee extension strength (IKES) in older Japanese patients[18)]. However, it is unknown whether TGS has an association with functional performance following TKA.

Strength exercise of knee extensor muscle in the preoperative period is often applied to attain better functional performance after TKA[9)]. However, knee extensor strength decreases after TKA, especially in the early postoperative period[9)]. On the other hand, toes are not influenced by surgical stress of TKA. So, we hypothesized preoperative TGS may relate to functional performance after TKA in the early postoperative period. The association between knee extensor strength and functional performance among people who underwent TKA has been reported. However, the association between TGS and functional performance among the same population is unknown. Therefore, the aim of this study was to investigate the association between preoperative TGS and postoperative functional performance, assessed by the TUG, in patients who underwent TKA for knee OA in the early postoperative period. Our hypothesis was that there was a significant negative association between preoperative TGS and postoperative TUG.

METHODS

Study design and population

This study was designed as an observational, non-interventional, longitudinal study. Participants were recruited from three hospitals located in different regions in Japan. Data were collected from July 29, 2015 to September 16, 2017. All data were collected by physical therapists. Inclusion criteria were patients who were scheduled for a unilateral TKA due to knee OA. Participants were screened to exclude those with known neuromuscular or musculoskeletal pathologies; those who undergone any other surgical treatment of the lower limbs or trunk; and those with health conditions, which could influence the function of the lower limbs including neurological or orthopaedic impairments.

Procedures

This study was approved by the local ethics committee, in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants before study inclusion.

Demographic characteristics were collected from the medical record at initial hospitalization. Outcome measures were TGS, IKES, TUG, and pain during walking. These outcomes were measured before TKA and at discharge.

Data collection

Demographic characteristics recorded included age, sex, height, and weight.

Toe grip strength (TGS) was measured on the involved side. It was measured using a toe-grip dynamometer (T.K.K. 3362, Takei Scientific Instruments, Niigata, Japan), using previously described methods[19)20)]. A previous study reported substantial to almost perfect inter- and intra-rater reliability for this device when used among people 60 to 79 years old[20)]. For measurement, participants sat upright on a chair, without leaning on the backrest, with hips and knees flexed at approximately 90 degrees; the ankles were placed in the neutral position and fixed with a strap. The first proximal phalanx was positioned on the grip bar and the heel stopper was individually adjusted to fit the heel for each participant. The first toe was used as the benchmark for establishing the testing position, because the flexor strength of the hallux has been reported to be most strongly associated with total TGS[21)]. Before the actual measurements, participants practiced the test at a submaximal effort. For the actual measurements, participants were instructed to grip the bar with their toes, exerting the greatest possible force for approximately 3 sec. Two TGS measurements were recorded and the mean value was used for analysis.

Isometric knee extension strength (IKES) was also measured on the involved side. It was measured using a hand-held dynamometer (μ-tas F1, ANIMA, Tokyo, Japan) with participants in a seated position with the knee in 90 degrees of flexion and using previously described methods[22)]. Participants were instructed to gradually increase the intensity of knee extension against the dynamometer for approximately 2 sec, avoiding an explosive contraction, and to maintain their maximal force output for approximately 3 sec. Again, two measurements were obtained, with the mean used for analysis.

TUG was measured using standard test methods[10)]. Briefly, participants were instructed to stand up from a seated position in a chair, walk as quickly and safely as possible (without running) towards a pole, turn around the pole, and then walk back to the chair and sit down. The time needed to complete the TUG was recorded using the TUG meter (T.K.K. 5804, Takei Scientific Instruments, Niigata, Japan). Each participant completed the TUG twice, with the mean time used for analysis.

Participants were asked about pain during walking. It was scaled using a visual analog scale[23)] VAS was presented as a 100-mm line, anchored by verbal descriptors, such as “no pain” and “worst imaginable pain.” Participants were asked to mark the 100-mm line to indicate pain intensity. The score was measured from the zero anchor to the patient’s mark. Using a millimetre scale to measure the patient’s score provided levels of pain intensity.

All outcomes, except IKES, were measured within a few days before TKA (preoperative) and at discharge after TKA (postoperative). Postoperative IKES was not included as an outcome because one of the facilities collaborated in this study did not measure IKES to avoid pain or other potential side effects, and postoperative IKES was not required for statistical analysis in this study. Preoperative TGS and IKES were standardized by body weight (TGSpre/wt and IKESpre/wt, respectively).

Statistical analysis

Descriptive statistics were computed as means and standard deviations. Outcome measures, except IKES, were compared before and after TKA using a paired *t* test. The Pearson's correlation coefficients between postoperative TUG and age, postoperative pain during walking, TGSpre/wt, and IKESpre/wt were calculated. The association between postoperative TUG and TGSpre/wt was analyzed using multivariate linear regression analyses with direct methods. The dependent variable was postoperative TUG and potential related factors (independent variables) were age, sex, postoperative pain during walking, TGSpre/wt, and IKESpre/wt. We also determined the adjusted R^2 value for the multivariate linear regression analyses. Statistical significance was set at 5%. Statistical analysis was performed using IBM SPSS statistics 22 (IBM Japan, Tokyo, Japan).

Statement of ethics and funding

This study was approved by the Research Ethics Committee of Kio university (H27-10). This study was funded by JSPS KAKENHI JP15K16380.

RESULTS

Participants' characteristics

Sixty-seven patients who underwent a primary unilateral TKA due to knee OA were included in this study. Details of subjects' characteristics are summarized in Table I. The age range was from 57 to 90 years old and mean age ± standard deviation was 74.4 ± 7.6 years old. Fifty-two participants (77.6%) were female and 15 participants (22.4%) were male (Table 1).

Comparison between pre and postoperative outcome measures

Outcomes were measured within a few days (2.1±1.1 days) before TKA and at discharge (18.5±3.0 days) (Table 1).

Preoperative TUG (12.5 ± 4.9 sec) was significantly delayed in the postoperative assessment (14.5 ± 5.1 sec) ($p<0.01$). Preoperative pain during walking (48.6±27.3 mm) significantly improved at postoperative assessment (20.8 ± 18.2 mm) ($p<0.01$). There was no significant change between preoperative TGS (7.7 ± 3.8 kg) and postoperative TGS (7.7 ± 3.4 kg) (Table 1).

Association between postoperative TUG and other outcomes

Postoperative TUG was significantly correlated with age (r = 0.38, $p<0.01$) and TGSpre/wt (r = −0.43, $p<0.01$). There were no significant correlations between postoperative TUG, and postoperative pain during walking and IKESpre/wt (Table 2).

In the multivariate linear regression analyses, postoperative TUG was significantly associated with age (unstandardized coefficient [B]: 0.21, 95% confidence interval [95%CI]: 0.04 to 0.38, standardized coefficient [β]: 0.30) and

TGSpre/wt (B: -26.81, 95%CI: -49.57 to -4.05, β: -0.31). The adjusted R^2 was 0.20 (Table 3).

Table 1. Participants' characteristics and outcomes

	Preoperative period (2.1±1.1 before TKA)	Postoperative period (18.5±3.0 after TKA)
Male/Female, N	15/52	
Age, years	74.4 (7.6)	
Height, cm	153.8 (8.1)	
Weight, kg	61.4 (10.8)	
Pain during walking, mm	48.6 (27.3)	20.8 (18.2)**
TGS, kg	7.7 (3.8)	7.7 (3.4)
TGSpre/wt, %	12.5 (5.8)	
IKES, kg	14.3 (6.7)	
IKESpre/wt, %	23.0 (8.9)	
TUG, seconds	12.5 (4.9)	14.5 (5.1)**

Data are expressed as mean (standard deviation), IKES; Isometric knee extension strength, TGS; Toe grip strength, TKA; Total Knee Arthroplasty, TUG; Timed up and go, **$p<0.01$

Table 2. Correlations between preoperative TUG, and age and other outcomes

	Age	Pain#	TGSpre/wt	IKESpre/wt
Postoperative TUG	0.38**	0.02	-0.43**	-0.22

#Postoperative pain during walking, IKES; Isometric knee extension strength, TGS; Toe grip strength, TUG; Timed up and go, **$p<0.01$

Table 3. Association preoperative TUG and its potential related factors

	B (95% CI)	β	p	Adjusted R^2
Intercept	2.81 (-12.12 - 17.72)		0.71	0.20
Age	0.21 (0.04 - 0.38)	0.30	0.02	
Sex	-0.17 (-3.10 - 2.76)	-0.01	0.91	
Pain#	0.03 (-0.03 - 0.10)	0.12	0.30	
IKESpre/wt	-4.51 (-18.59 - 9.56)	-0.08	0.52	
TGSpre/wt	-26.81 (-49.57 - -4.05)	-0.31	0.02	

B; Coefficient, 95%CI; 95% confidence interval, β; Standardised partial regression coefficient, #Postoperative pain during walking, IKESpre; Preoperative isometric knee extension strength, TGSpre; Preoperative toe grip strength, TUG; Timed Up and Go, wt; weight

DISCUSSION

The main finding in this study was a significant association between preoperative TGS and postoperative TUG. People with stronger TGS normalized by weight in the preoperative period presented faster TUG in the early postoperative period after TKA. This relationship was independent of age, sex, pain during walking and IKES normalized by weight. Regarding preoperative muscle strength on the involved side, TGS is more important for TUG rather than knee extensor strength.

In general, functional performance declines following TKA[8)9)], while TKA has a beneficial effect on reducing pain[2)]. The results in this study showed similar results.

Postoperative TUG (14.5 seconds) was slower than the cut off value of risk of falling (13.5 seconds)[24]. In terms of knee extensor strength, we could measure postoperative IKES amongst only a subset of participants (n=33). Based on their data, postoperative IKES (10.3 ± 5.8 kg) was significantly weaker than preoperative IKES (16.4 ± 6.8 kg) ($p<0.01$). This indicates that participants in the current study might also present with loss of knee extensor strength, in accordance with the previous reports.

Misu, et al.[17] reported that decreased TGS was correlated with slower walking speed and shorter stride length during fast-pace walking among healthy older Japanese. This suggests that TGS can affect propulsion when people are walking quickly, such as when participants in the current study performed the TUG task. In addition, TUG also requires a standing up ability. Moving ahead of the center of pressure helps forward bending and easy rising during standing up. During this phase in TUG, weight bearing is required around the toes. Therefore, TUG is also affected by TGS through standing up phase. Our previous study described the negative relationship between TGS and TUG among community-dwelling older people[18]. The results in the current study suggested that patients who underwent TKA also had similar relationship compared with community-dwelling older Japanese people.

TUG evaluates multiple abilities such as sit-to-stand motion, walking, and turning around. These movements are repeated frequently during daily life. Therefore, stronger TGS may allow people who undergo TKA a better ability to perform their activities of daily living (ADL) and may facilitate improvement in ADL in the early postoperative period. In other words, preoperative training of TGS may mitigate the decline in in the early postoperative period.

Impairment of knee extensor strength in patients with knee OA is well-known[25]. Chun, et al.[26] demonstrated that decreased knee extensor strength was the main associated factor of reduced functional performance in patients with severe knee OA[26]. That is why preoperative strength exercise of knee extensor muscles has been attempted to attain better results on functional performance after TKA[14]. However, surgical procedures applied in TKA involve trauma to the extensor mechanism and surgery-induced loss of knee extensor strength is unavoidable; as such, knee extensor strength decreases[4-7]. Meanwhile, TGS among patients with knee OA is also significantly weaker than among healthy controls[27]. However, TGS does not change before and after TKA unlike knee extensor strength according to the result in this study because toes are not invaded by surgery. Therefore, preoperative training of TGS may have a beneficial effect on postoperative TGS and may be important for postoperative function as well as preoperative training of knee extensor strength.

Based on the results in this study, TGS did not change before and after TKA. However, several previous research studies described the change of plantar loading parameters before and after TKA. Several studies reported that plantar loading parameters, such as force and pressure, were decreased in the forefoot or toe region after TKA[28][29]. These changes may influence the functional performance after TKA. Therefore, facilitation of weight bearing on the toes to exert TGS on the ground may also have to apply in therapeutic exercise in addition to strength training of TGS.

There were some limitations to this study. First, we measured toe and knee strength on only the involved side, because the involved side shows stronger correlations to functional performance than the non-involved side[12] and is influenced by surgical stress, though several previous research studies investigated both sides[9][12][30]. Therefore, we are not able to assess the influence of the non-involved side on the results. Second, we did not consider the impact of the strength of other muscles in the lower extremity, such as hip and ankle muscles. It may be relevant to investigate the impact of those muscles in future studies. Third, we were not able to determine a causal association between TGS and TUG as this study was an observational study. We have to investigate whether preoperative strength training of TGS would influence TUG after TKA to clarify its causal relationship in the future.

In conclusion, preoperative TGS was associated with postoperative functional performance assessed by TUG irrespective of age, sex, pain, and IKES. In other words, regarding preoperative muscle strength on the involved side, TGS is more associated with TUG rather than knee extensor strength. Preoperative strength training to TGS may have a beneficial effect on functional performance in the early postoperative period after TKA.

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Comparison of Muscle Activity Based on Ankle Position During Hip Abduction

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Key Words: Hip Abduction, EMG, Ankle Position

Abstract

The hip abductor muscles are considered to be more active if the motion of the distal joint is aligned with that of the proximal joint by ankle joint eversion. However, it is unclear how changes in ankle muscle activity actually affect the muscle activity of the lateral lower extremity muscles. The purpose of this study was to investigate the muscle activity of the lateral lower extremity muscles, including the lumbar muscles, depending on the ankle joint position, and to investigate an efficient activation method of the hip abductor muscles. The subjects were 9 healthy young males. The lower limbs were isolated by hanging the lower limbs with a sling device. The measurement task was to hold the hip abduction position by isometric contraction against the load in the hip adduction direction. The load was applied by a rubber band, and the length of the rubber band was adjusted to produce a loading of 5 kgf. The muscle activity of the gluteus medius, erector spinae, vastus lateralis, and peroneus longus was measured using surface electromyogram. Measurements were taken under three ankle conditions: neutral position, eversion position, and inversion position. The measured data were used to calculate the percent of integrated electromyogram (%IEMG). Statistical analysis included using a repeated-measures analysis of variance with a Bonferroni correction for multiple comparisons. In terms of %IEMG, the erector spinae and peroneus longus during ankle eversion was significantly larger than that in the neutral position. Peroneus longus during ankle inversion was significantly larger than that in the neutral position. However, the %IEMGs of the gluteus medius and vastus lateralis were not significantly different in all ankle positions. In comparison between muscles, the rate of change

of %IEMG (eversion position / neutral position) was significantly larger for ES than for GM and VL. Therefore, it is necessary to set the ankle and spine positions according to the purpose of hip abduction training.

Introduction

The muscles located outside the lower extremity, including the lumbar region, are considered to be involved in the control of motion along the sagittal, horizontal, and frontal planes[1]. Training for muscle strengthening and activation is often required after manual intervention. The hip abductor muscles, such as the gluteus medius (GM), play many roles in controlling the pelvis and the femoral head's deviation within the acetabulum while walking[1)2)], and are often susceptible to muscle weakness in hip diseases such as osteoarthritis[3]. Furthermore, it has been reported that the abductor muscles of the hip joint can also affect the other parts of the body, such as the lumbar and knee joints, due to muscle weakness[4)5)]. Although various methods of hip abductor muscle training have been researched[3)6)7)], the most efficient method to activate the hip abductor muscle has not been established, and many studies are still being carried out. The vastus lateralis (VL) is the only muscle which has its belly located in the middle of the lateral thigh, and has been reported to connect with many tissues, such as the GM, gluteus maximus, and iliotibial band, in addition to the femur and tibia[8)9)]. The patient complained of a contracting sensation mainly from the middle to the distal lateral part of the thigh during abduction, which often results in insufficient activity of the hip abductor muscles. Moreover, pelvic elevation (lumbar lateral flexion) by the erector spinae (ES) is a typical trick motion for training the hip abductor muscles. Excessive pelvic elevation during hip abduction is reported to not only reduce the training effect of hip abduction muscles but also to lead to lumbar disorders[10]. Therefore, when training hip abductor muscles, it is necessary to consider the influence of other muscles as well. Proprioceptive neuromuscular facilitation (PNF) is a known method of activating muscles using movement in other areas[11]. This technique of facilitating muscle activity by using pelvic and ankle joint movements for the hip joint is frequently used; specifically, hip abductor muscles are facilitated through posterior pelvic rotation and ankle joint eversion[12]. It has long been reported that dorsiflexion of the ankle joint during quadriceps training increases the muscle activity of the quadriceps[13]. The hip abductor muscles are also considered to be more active if the motion of the distal joint is aligned with that of the proximal joint by ankle joint eversion, such as in the case of the quadriceps. However, it is unclear how changes in ankle muscle activity actually affect the muscle activity of the lateral lower extremity muscles.

Therefore, the purpose of this study was to investigate the muscle activity of the lateral lower extremity muscles, including the lumbar muscles, depending on the ankle joint position (eversion or inversion), and to investigate an efficient activation method of the hip abductor muscles.

Method

1. Subjects

The subjects were 9 healthy young males without reported pain in activities of daily life; more specifically, the study focused on the dominant legs of the subjects that they would use to kick a ball. Mean (± standard error) age, height, and weight were 26.8±1.3 years, 172.9±1.7 cm, and 70.1±2.3 kg, respectively. None of the subjects had a history of orthopedic problems of the legs or vertebrae.

2. Ethical approval

The study was conducted in accordance with the Declaration of Helsinki. Before the study, we explained its objective and contents to the subjects and informed them that the data obtained would only be used for this study alone, assuring them that the data would be handled with strict confidence to prevent dissemination of personal information. Written informed consent was obtained from all subjects before the study.

3. Measurement positioning and tasks

The subjects underwent measurements in the supine position with the pelvis fixed, and the leg of the measured side was suspended by a sling to reduce the effect of gravity. They were given a task to maintain a position of 30° hip abduction against a load in the direction of hip joint adduction. A rubber band was used to apply this load (Figure. 1); its length was adjusted using a handheld dynamometer (Morby, Sakai Medical, Inc.) to have a force of 5 kgf at a position of 30° hip abduction. Measurements were taken three times each in 1) the neutral position, 2) the

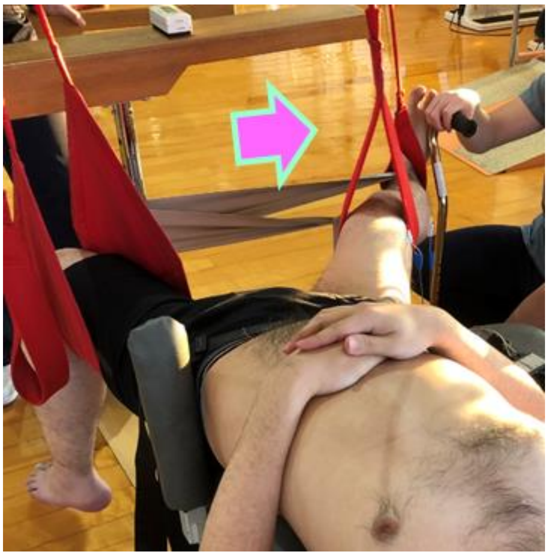

Figure1. Measurement position of EMG measurement.

eversion position, and 3) the inversion position of the ankle joint. The ankle muscles did not contract in the neutral position. Maximum eversion and inversion were maintained by subjects during the corresponding task. Considering the effect of muscle fatigue, sufficient rest time was provided between each measurement task.

4. Electromyography

The muscles measured were the GM, VL, ipsilateral ES, and peroneus longus (PL). Electrode placement was based on Shimono's criteria[14]. The GM electrode was placed 1/3 proximal to the line connecting the greater trochanter and the iliac crest. The VL electrode was placed approximately 3-5 cm proximal to the patella. The PL electrode was placed 1/4 proximal to the line connecting the peroneal head and the lateral malleolus. Lastly, the ES electrode was placed 2-3 cm lateral to the L3 spinous process. Grounding electrodes were placed on the anterior superior iliac spine. Single-use cardiac electrodes (disposable electrode L Vitorode, Nihon Kohden) were used. The distance between the electrodes was 20 mm, and the electrodes were attached parallel to the myofibrillation of each muscle. The skin was treated to keep an impedance range below 10 Kohm. The surface EMG was measured using an EMG system (MQ16 and Viatal Recorder2, KISSEI COMTEC, Inc.). The sampling frequency was set at 1000 Hz, and the activity of each muscle was measured for 5 s with the load. Electromyogram analysis was performed for 3 s, excluding 1 s at the beginning and end of the measurement task, and the integral value (IEMG) was calculated. IEMGs were calculated using a versatile bioinformation analysis program (BIMTAS II, KISSEI COMTEC, Inc.) with bandpass filtering in the range of 10 to 500 Hz and full-wave rectification. Subsequently, the value (%IEMG) relative to that of maximum voluntary contraction was calculated as an index of muscle activity. Maximal voluntary contractions of hip abduction (GM), knee extension (VL), and ankle eversion with plantar flexion (PL) were performed according to the five-level testing of the Danuels' manual muscle test[15]. Lateral flexion of the trunk (ES) was measured in the side-lying position with lateral flexion to the side.

5. Statistical Analysis

SPSS Ver.24 (IBM SPSS Statistics, IBM) was used for statistical analysis. The mean value of the three executions in each position was used as a representative value. After confirming the normality using the Shapiro-Wilk test, repeated analysis of variance and Bonferroni's test were performed to compare the %IEMG for different ankle joint positions in each muscle. The rate of change of %IEMG (eversion position / neutral position and inversion position / neutral position×100) was calculated using one-way analysis of variance and Bonferroni's test. The level of significance was set to 0.05, and all values are presented as the mean ± standard error.

Results

The %IEMGs of each muscle in the different ankle joint positions are shown in Table 1. The %IEMG of ES was significantly larger in the eversion position than for the neutral position, but not significantly different from that of the inversion position. The %IEMG of the PL was significantly larger for the eversion position and inversion position than for the neutral position, but no significant difference was observed between the eversion position and inversion position. The %IEMGs of the GM and VL were not significantly different in all ankle positions. The rates of change of %IEMG for the different ankle positions are shown in Table 2. The rate of change of %IEMG was significantly larger for ES than for GM and VL in the eversion position and neutral position.

Table 1. Comparison of %IEMG for different ankle positions (%).

Ankle position	Eversion position	Neutral position	Inversion position
Gluteus medius	36.0±5.1	35.8±5.4	40.2±6.3
Vastus lateralis	18.8±6.3	20.5±6.0	22.2±6.5
Erector spinae	44.9±7.9*	37.6±6.9	42.1±6.8
Peroneus longus	61.8±16.0*	18.8±6.4	20.1±7.5*

Data are presented as the mean ± standard error.
*: Significant dierences compared to neutral position($p<0.05$).

Table 2. Comparison of The rate of change of %IEMG in different ankle positions (%).

Muscle	Gluteus medius	Vastus lateralis	Erector spinae
Eversion position / Neutral position	101.1±2.8*	90.4±7.8*	126.5±10.9
Inversion position / Neutral position	115.5±13.2	116.8±10.0	118.5±7.1

Data are presented as the mean ± standard error.
*: Significant dierences compared to erector spinae.

Discussion

This study investigated whether lateral lower extremity muscle activity differs depending on the ankle joint positions of eversion and inversion during hip abduction. Clarifying this can help in efficient hip abductor muscle training. The results indicate that the %IEMG of PL is larger in the eversion position than in the neutral position. Therefore, the PL was more active while maintaining eversion, suggesting a difference of ankle muscle activity depending on its position. Moreover, the %IEMG of PL is also larger in the inversion position compared to the neutral position. Mengarelli et al. [16] reported that antagonist muscles are involved in joint stability and motor control by acting in coordination with their agonist muscles. Therefore, %IEMG was larger in the inversion position than in the neutral position because the PL, which is an antagonist muscle, was activated to control its agonist muscle, the tibialis posterior, during inversion. The %IEMG of the ES was larger in the eversion position than for the neutral position, and the rate of change from the eversion position to the neutral position in the ES was larger than that of the GM and VL. Since the muscle activities of the GM and VL do not decrease in the eversion position, it is suggested that the activity of the ipsilateral ES tends to increase rather than changing the ratio of the activity of the lateral lower extremity muscles during the abduction of the same level of hip abduction torque in the eversion position. Therefore, the results of this study are consistent with previous findings[12] that the activity of a proximal muscle is enhanced when the proximal and distal joints move in the same direction. However, from the perspective of hip abductor muscle training, it is not useful for the activation of the hip abductor muscle and might increase load on the lumbar spine. Cynn et al.[17] reported that lumbar stabilization during hip abduction in the side-lying position inhibits lumbar muscle activity and increases GM activity. Therefore, it is considered that hip abduction training using ankle eversion is likely to inhibit ES activity by stabilizing the lumbar spine or by suppressing the pelvis ipsilaterally, and activates the hip abduction muscles located proximal to the lumbar muscles. The influence of neurological mechanisms[18][19] has long been proposed as a mechanism through which differences in ankle muscle activity, which are not directly related to lumbar or hip motion, affect muscle activity in other joints. Moreover, it has been suggested that the myofascial system, which is connected to the muscles and is widely distributed, is involved in force transmission and the activation of specific patterns[20]. However, this study did not examine the changes in muscle activity when the pelvic position was changed or evaluate the mechanism of the changes in muscle activity due to different ankle joint positions; further studies for verification are needed. Limitations of this study include the small number of subjects, and the fact that the pattern of muscle activity due to contraction of ankle joint muscles was not constant and varied greatly. Therefore, it is necessary to increase the number of subjects and classify them according to the patterns of muscle activity in the future. Moreover, the EMG measurements were taken only at representative locations of the hip abductor and lumbar muscles. Therefore, it may be possible to obtain different results by examining each muscle in detail, such as each fiber of the GM, tensor fasciae latae, longissimus, and iliocostalis. It is also necessary to measure the antagonist muscle because of its possible effect, such as the activity of the PL in the inversion position. Lastly, in this study, although we tried to take fatigue-free measurements with sufficient rest time, we did not perform frequency analysis to determine whether the fatigue actually occurred.

Conclusions

During hip abduction, there was no difference in the muscle activity of the GM and VL in different ankle joint positions, but there was greater muscle activity of the ipsilateral ES during eversion compared to the neutral position. Therefore, it is necessary to set the ankle and spine positions according to the purpose of hip abduction training.

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A case of limited knee joint flexion improved by a sliding treatment of the quadriceps femoris after femoral shortening surgery

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Key Words: femoral shortening surgery, sliding treatment, limited knee joint flexion

Absutract:
[Purpose] The purpose of this report was to determine whether the sliding treatment of the quadriceps femoris is effective for increasing the range of motion in knee joint flexion in patient with limited knee flexion after femoral shortening surgery.
[Method] The subject was a 2-year-old girl. The diagnosis was bilateral congenital knee dislocation (tibial anterior dislocation of the tibia). Left and right femoral shortening surgeries were performed at 509 and 551 days after birth, respectively, and each leg was immobilized for 6 weeks after surgery. In the femoral shortening surgery, the skin was incised 10 cm around the knee joint, and the quadriceps femoris was shortened by 2 cm in the longitudinal direction and fixed with a metal plate insertion. Restorative positioning was also performed at the tibiofemoral joint. Physical therapy was started on day 636 after birth. The intervention was performed twice a week, for approximately 20 minutes. At the time of postoperative intervention, the palpation test revealed the extensibility limitation of both the left and right quadriceps femoris in the longitudinal direction and decreased sliding between the quadriceps femoris (particularly the rectus femoris) and adjacent soft tissues. The range of flexion of both knees was 60° on the right and 80° on the left, and the end feel at the time was more elastic. In this study, we focused on the longitudinal direction extensibility and sliding treatment with the surrounding tissues of the quadriceps femoris to expand the range of motion in knee joint flexion.
[Result] The range of motion in knee joint flexion was improved by 30° on day 818 (at the last intervention before metal plate removal) and by 90° on the right side. The range of motion of the left side was 100°, which improved by 20°.
[Conclusion] Results suggested that sliding treatment of the quadriceps femoris was effective at increasing the angle of knee flexion.

Introduction

Congenital knee dislocation occurs in 1 in 100,000 live births and is a rare condition that results in tibiofemoral joint dislocation (anterior dislocation of the tibia in relation to the femoris) [1]. It often causes problems with limited knee joint flexion, which can interfere with various activities such as walking and climbing stairs [2]. Tibiofemoral joint dislocation due to congenital knee dislocation is said to be caused by shortening of the quadriceps femoris muscle [3)4], and quadriceps femoris prolongation has traditionally been performed as a treatment method [3)5]. However, because the prolonged quadriceps femoris muscle does not function sufficiently as a knee joint extension owing to scarring of the quadriceps femoris, femoral shortening surgery, in which the quadriceps femoris muscle is relatively extended, has been used in recent years [6)7]. Femoral shortening surgery is a technique that is often performed to correct leg length differences in adults, with the leg length difference being shortened in the middle one-third of the femoris [8]. The advantages of femoral shortening surgery for congenital knee dislocations are that it minimizes the invasion of the quadriceps muscle and avoids scarring of the quadriceps femoris, thus preserving the function of the muscle as an extension of the knee joint [7]. However, limited knee joint flexion has been reported to occur after femoral shortening surgery [7].

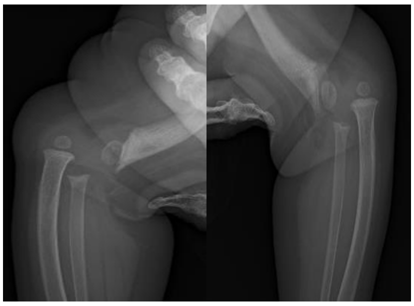
Recently, interventions that focus on the sliding of the quadriceps femoris have been reported to be effective for limited knee joint flexion [9]. The sliding of a muscle with respect to adjacent tissues is the extent to which the superficial muscle moves passively with respect to adjacent deep muscles and other soft tissues [10]. In addition, the reduction in sliding between adjacent tissues of the muscle has been shown to be largely influenced by myofascia [11]. Myofascia dysfunctions show the following three signs: densification of the collagen and elastin fibers that form the epimysium, gelatinization of the intercellular substrate, and aggregation of hyaluronic acid [12)13]. As the epimysium is continuous with the perimysium and endomysium [14], the high density of the epimysium is said to impair its sliding throughout the myofascia [15]. Myofascia is said to cause a thickened perimysium and endomysium due to immobility [16] and a decrease in extensibility and inter-tissue sliding due to inflammation [17]. Therefore, one reason for the limited knee joint flexion despite the relative quadriceps femoris prolongation caused by femoral shortening surgery may be the reduction in sliding between the quadriceps femoris and the surrounding soft tissue due to the inflammation and immobility caused by the surgery. Therefore, to improve the limited knee joint flexion after femoral shortening surgery for congenital knee dislocations, not only the expansibility but also the sliding with the surrounding tissues of the quadriceps femoris is necessary. However, no reports have described interventions that focus on the sliding of the quadriceps femoris and surrounding tissues in cases of limited knee joint flexion after femoral shortening surgery for congenital knee dislocations.

Therefore, the purpose of this report was to determine whether the sliding treatment of the quadriceps femoris is effective for increasing the range of motion in knee joint flexion in patient with limited knee flexion after femoral shortening surgery.

Subject and Methods

1. Subject

The subject was a 2-year-old girl (weight: 8100 g). The diagnosis was bilateral congenital knee dislocation (tibial anterior dislocation of the tibia; Fig. 1).



Right Left

Fig 1. X-ray image of the knee joint at birth

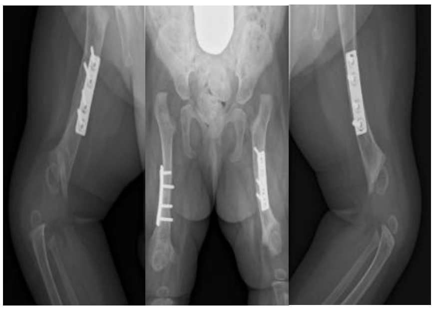
At birth, the subject weighed 755 g and had an intraventricular hemorrhage and progressive intraventricular enlargement, which were treated with a subgaleal shunt surgery 22 days after birth. On the 69th day after birth, a ventriculoperitoneal shunt surgery was performed. The subject also had a bilateral congenital hip dislocation (backward dislocation of the hip joint), and both joints were immobilized with braces since birth to prevent the progressions of the hip and knee joint dislocations. The extent of the dislocation was grade 3 (dislocated type) according to the Drehmann classification [18].

2. Ethical considerations

This study was conducted in accordance with the Declaration of Helsinki, and the patient's family's consent was obtained in writing before the start of the study, explaining the purpose and methods of the study, that the data would not be used for any purpose other than the present study, and that the data would be strictly controlled to prevent personal information from being disclosed. The study was also conducted with the approval of the Nanto Visiting Nursing Station's Ethics Review Committee (No. 2019.NHS.2).

3. Progress

Left and right femoral shortening surgeries were performed at 509 and 551 days after birth, respectively (Fig. 2).



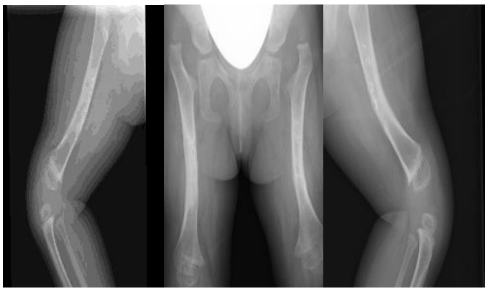
Right Front Left

Fig 2. X-ray image of Knee joint after femoral shortening surgery

※The image of the right side was

obtained 551 days after birth, that of the left side was taken 509 days after birth, and that of the front was obtained after femoral shortening surgery on the right side.

In the femoral shortening surgery, the skin was incised 10 cm around the knee joint, and the quadriceps femoris was shortened by 2 cm in the longitudinal direction and fixed with a metal plate insertion. Restorative positioning was also performed at the tibiofemoral joint. Both sides were immobilized with casts from the trunk to the lower extremities for 6 weeks after the surgery. Physical therapy was started on day 636 after birth. The intervention was performed twice a week, for approximately 20 minutes. In addition to sliding treatment of the quadriceps femoris, standing and walking exercises were also performed. On day 876 after birth, the metal plate was removed (Fig. 3).



Right Front Left

Fig 3. X-ray image of Knee joint after removal of the metal plate (876 days after birth)

4. Physical therapy assessment during intervention after femoral shortening surgery (636 days after birth)

The palpation test revealed the extensibility limitation of both the left and right quadriceps femoris in the longitudinal direction and decreased sliding between the quadriceps femoris (particularly the rectus femoris) and adjacent soft tissues. The flexion range of motion of both knee joints was 60° on the right side and 80° on the left side, and the end feel was "more elastic." Ventral displacement of the tibia from the femur was observed in the full range of motion in knee joint flexion.

5. Focus of the intervention

The tibiofemoral joint motion in knee joint flexion requires the tibia to move dorsally in relation to the femoris, according to the concave convex rule [19]. In the present case, a decrease in sliding was observed between each myofascia surrounding the quadriceps femoris and between the quadriceps femoris and the adjacent soft tissues. We hypothesized that this caused excessive ventral displacement of the tibia and restricted the dorsal motion of the tibia during knee joint flexion. In this study, we focused on the longitudinal direction extensibility and sliding treatment with the surrounding tissues of the quadriceps femoris to expand the range of motion in knee joint flexion. The sliding treatment was performed by grasping the muscle with the therapist's thumb, index finger, and middle finger in the position of full knee extension, moving it perpendicular to the course of the muscle and extending the movement between the tissues [10].

Results

The range of motion in knee joint flexion was improved by 30° on day 818 (at the last intervention before metal plate removal) and by 90° on the right side (Table 1). The range of motion of the left side was 100°, which improved by 20° (Table 1). The ventral displacement of the tibia relative to the femur in the total range of motion during knee joint flexion was reduced compared with that on day 636 after the intervention.

Table 1. Flexion angle of the knee joint

	At first intervention after femoral shortening surgery (636 days after birth)	At the time of intervention before metal plate removal (818 days after birth)
Right (°)	60	90
Left (°)	80	100

Discussion

This study investigated whether the sliding treatment of the quadriceps femoris is effective for increasing the range of motion in knee joint flexion in cases with limited knee joint flexion after femoral shortening surgery. Children with underdeveloped cognitive and verbal skills, such as our patient, have difficulty with verbal instructions and intervention to increase the range of motion of the knee joint with automatic movements. Therefore, intervention in passive movements is necessary, and evaluation of the effects of interventions that focus on sliding rather than extensibility movements is important.

Congenital knee dislocation is caused not only by the shortening of the quadriceps femoris [3)4)] but also by defects or dysplasia of the anterior cruciate ligament [20)]. In the present case, after the femoral shortening surgery, the end feel during knee joint flexion was “more elastic,” which suggests a muscle-derived loss of mobility. Therefore, we determined that the ventral displacement of the tibia in this case was of muscular origin rather than due to dysplasia or a defect in the anterior cruciate ligament. We hypothesized that in this case, inflammation of the soft tissues, including the quadriceps femoris, due to the femoral shortening surgery and immobility due to the cast fixation caused adhesions and reduced the sliding between the myofascial tissues, which resulted in limited range of motion in knee flexion. By contrast, the range of motion in knee joint flexion improved as a result of the intervention with the quadriceps femoris sliding treatment. Horiguchi et al. [9)] reported that the quadriceps femoris sliding treatment improved the sliding of the myofascia. Therefore, in this case, the sliding treatment of the quadriceps femoris may have improved the sliding between the myofascia surrounding the quadriceps femoris and the soft tissues adjacent to the quadriceps femoris, and improved the flexion angle of the knee joint by making it easier for the tibia to move dorsally during knee flexion.

The limitation of this study is that we

did not objectively assess the degree of sliding in the quadriceps femoris and adjacent soft tissues. Therefore, the degree of sliding of the myofascia of the quadriceps femoris and the soft tissues adjacent to the quadriceps femoris during flexion of the knee joint must be evaluated using ultrasonographic diagnostic equipment and other objective indicators.

Conclusions

We examined whether the sliding treatment of the quadriceps femoris is effective for increasing the flexion angle of the knee joint in subject with limited knee joint flexion after femoral shortening surgery. The results showed that it was effective for the restriction of knee joint flexion after femoral shortening surgery. In future studies, we would like to increase the number of cases and further examine the effect of the sliding treatment of the quadriceps femoris.

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The influence factor affected on the pelvic morphology for nulliparous women and men: A retrospective cohort study on 213 cases.

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Keywords: Pelvic alignment, External pelvimetry, Gender difference

【Abstract 】

Background:

Our previous research has suggested that aging and vaginal delivery after adulthood favor occurrence of pelvic torsion (PT). Therefore, etiological investigation must take gender and history of vaginal delivery into account. In addition, no previous studies have evaluated the effects of age-related changes, degree of pelvic opening and pelvic torsion in men and nulliparous women.

Purpose:

The purpose of our study was to examine the secular trend, factors influencing the degree of pelvic opening (PO), and the degree of PT in men and nulliparous women.

Methods:

The study participants were divided into two groups: group M consisted of 122 healthy men with a mean age of: 26.2±15.2 years, whereas group N consisted of 91 nulliparous women with a mean age of 25.5±12.7 years. Group M and N were further divided into three age groups. Category 1 comprised of individuals 0-19 years old, category 2 was comprised of individuals 20-39 years old and category 3 consisted of individuals over 40 years old.

Pelvic measurements in groups M and N were compared using the Student's t test. The relationship between PO and/or PT and each pelvic measurement was assessed using Pearson product-moment correlation coefficients. Next, a one-way analysis of variance (ANOVA) was conducted to compare pelvic measurement values, among each category. This study was conducted in accordance with the DECLARATION OF HELSINKI.

Results:

Student' s t-test found no significant difference in the mean values of pelvic measurements between group M and N. In groups M and N, PO was strongly positively correlated with the posterior superior iliac spines (PD) and weakly negatively correlated with the interspinous diameter (ID).

The results of the one-way ANOVA indicated significant differences in group M and N between categories 1 and 2 and between categories 1 and 3 in ID. There was a significant difference between categories 1 and 3 and between categories 2 and 3 in Group N in PO.

Conclusion:

There is no difference in pelvic measurements between group M and N, and individual variation affect pelvic morphology. Factors affecting the degree of pelvic opening in both groups were anterior widening and posterior narrowing of the pelvis, with the latter having a stronger effect. Regarding secular change in pelvic morphology over time, the only age-related change was the relatively wider anterior part of the pelvis in nulliparous women over 40 years of age. This phenomenon is unique to nulliparous women. Pelvic torsion is affected by individual differences.

【Introduction】

Pelvic girdle pain is the most prevalent symptom after delivery, and is one of the major problems during the perinatal period[1]. In particular, it hinders childcare and return to work. Postpartum pelvic alignment changes compared to early pregnancy[2], and abnormal pelvic alignment is one of the causes of pelvic pain[3]. Higher levels of women hormones produced during pregnancy results in increased laxity of the ligaments around the pelvis[4] and the pelvic girdle joint[5]. The effects of changes to the pelvic girdle that occur during the perinatal period result in a preauricular groove[6] on the facies auricularis. In addition, sclerosing osteitis, which is more common in women during childbirth, is associated with the repair of minor trauma to the subchondral bone at birth[7].

Therefore, the perinatal period is a time of abnormal stress on the pelvic girdle. The perinatal period is a time of significant changes to pelvic alignment due to the mechanical stress and the effects of women hormones on the pelvic girdle during pregnancy and delivery. Prevention of pelvic alignment abnormalities prior to delivery is important because abnormalities in pelvic alignment can interfere with normal childbirth, cause sacroiliac pain[2], and result in urinary incontinence[8]. However, there is a lack of basic data on trends in changes to pelvic alignment over time and actual measurements for different age groups.

Therefore, the purpose of this study was to determine the normal pelvic morphology and age-related changes in nulliparous women and men aged 3-77 years.

【Method】

The study participants were divided into two groups: group M consisted of 122 healthy men with a mean age of: 26.2±15.2 years, whereas group N consisted of 91 nulliparous women with a mean age of 25.5±12.7 years. The frequency distribution of age for each group is shown in Table 1.

Group M and N were further divided into three age groups. Category 1 comprised of individuals 0-19 years old (group M: n=40, mean age=12.6±3.0 years, group N: n=29, mean age=12.7 ± 3.4 years); category 2 was comprised of individuals 20-39 years old (group M: n=64, mean age=26.6±5.9 years, group N: n=49, mean age=26.9±5.3 years); and category 3 consisted of individuals over 40 years old (group M: n=18, mean age=55.3±13.0

years, group N: n=13, mean age=49.2±8.1 years).

Measurement of the pelvic morphology was performed by external pelvimetry using the Martin pelvimeter. The interspinous diameter (ID), the distance between the posterior superior iliac spines (PD), the first oblique diameter (FOD), the second oblique diameter (SOD), and the lateral conjugates were measured. The mean of FOD and SOD was the oblique distance (OD). The degree of pelvic opening (PO) was calculated by dividing PD by ID. Pelvic torsion (PT) was calculated by dividing the absolute value, which was calculated by dividing FOD by SOD by the height. We excluded women who individuals with a ≥0.5 cm difference between the lateral conjugates.

Pelvic measurements in groups M and N were compared using the Student's t test. The relationship between PO and/or PT and each pelvic measurement was assessed using Pearson product-moment correlation coefficients. Next, a one-way analysis of variance (ANOVA) was conducted to compare pelvic measurement values, between each category. The Tukey-Kramer method was used for post-hoc comparisons. SPSS version 23 was used for statistical analysis, and the significance level was set to < 5%.

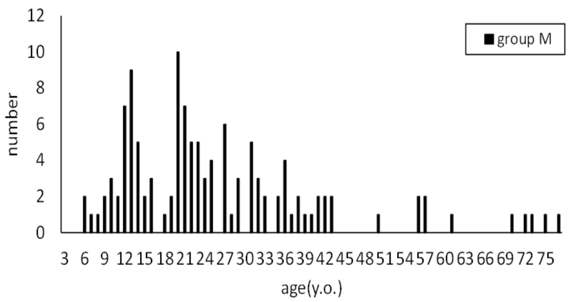
This study was conducted in accordance with the DECLARATION OF HELSINKI.

【Results】

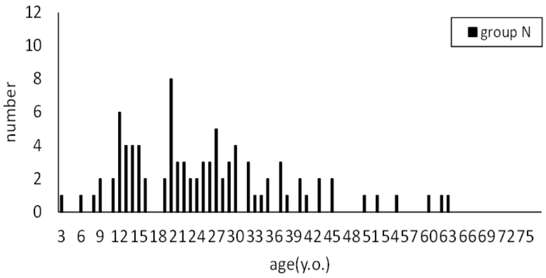
Student's t-test found no significant difference in the mean values of pelvic measurements between group M and N (Table 1).

In group M, the PO was significantly correlated with PD (r=0.86, p<0.01) and ID (r=-0.27, p=0.01) (Table 2a). In group N, the PO was significantly correlated with PD (r=0.89, p<0.01), ID (r=-0.25, p=0.02) and OD (r=0.23, p=0.01) (Table 2a). PT was not significantly correlated in both groups (Table 2b).

The results of the one-way ANOVA indicated significant differences in group M and N between categories 1 and 2 and between categories 1 and 3 in ID (Fig.2). There were differences in OD between all categories in



a: Group M



b: Group N

Fig.1 Frequency distribution

Table 1 Measurement value of Group M and N

	Group M	Group N	p value
Age(y.o.)	26.2±15.2	25.5±12.7	–
Height(cm)	165.0±1.4	155.8±12.3	–
Weight(kg)	59.1±14.8	49.5±12.3	–
BMI(kg/m2)	21.3±3.3	20.0±4.1	–
ID(cm)	23.1±2.7	23.2±2.2	p=0.60
OD(cm)	22.4±2.3	22.3±2.2	p=0.58
PD(cm)	8.3±2.0	8.1±1.9	p=0.69
PO	0.36±0.08	0.35±0.08	p=0.95
PT	0.27±0.26	0.34±0.31	p=0.17

ID : Interspinous diameter distance
OD : Mean of first obligate distance and second obligate distance
PD : Posterior superior iliac distance
PO : Pelvic opening dgree
PT : Pelvic torsion dgree

Table 2. Pearson product-moment correlation coefficient of PO and PT

	ID		OD		PD	
Group M	−0.27	p=0.01	−0.03	n.s.	0.86	p<0.01
Group N	−0.25	p=0.02	0.23	p=0.01	0.89	p<0.01

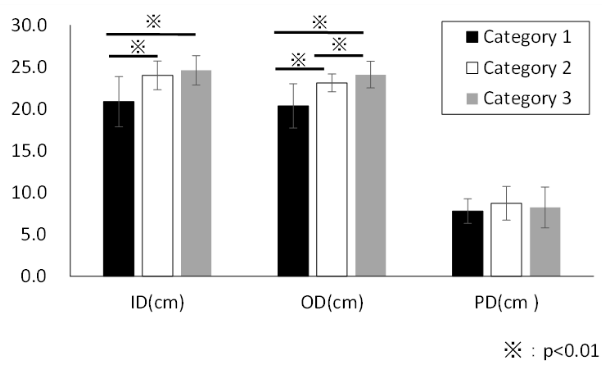
a: PO

	ID		OD		PD	
Group M	0.15	n.s.	0.13	n.s.	0.13	n.s.
Group N	0.08	n.s.	0.17	n.s.	0.09	n.s.

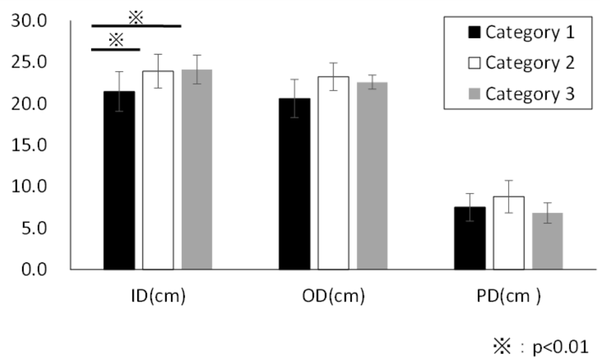
n.s. : not significant

b: PT

ID : Interspinous diameter distance
OD : Average of first obligate distance and second obligate distance
PD : Posterior superior iliac distance



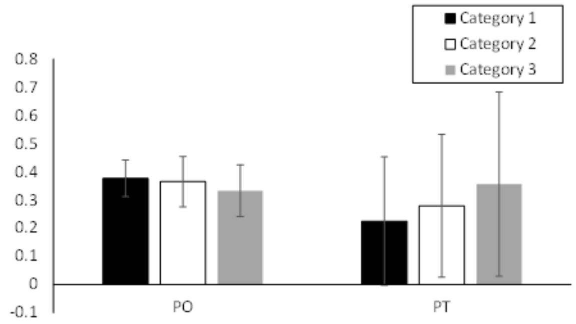
a: Group M



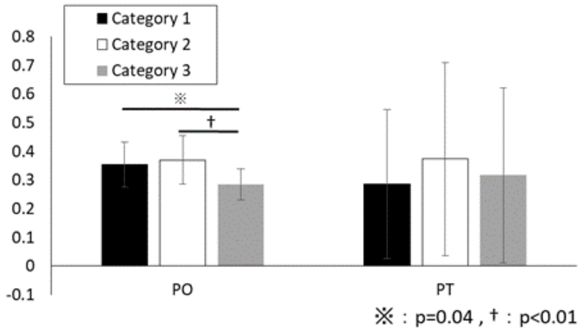
b: Group N

Fig.2 ANOVA results for External pelvimetry value among each category

group M (Fig.2a). The PD was not significantly different among the categories in both groups. There was no significant relationship between the PO categories in group



a: Group M



PO : Pelvic opening dgree
PT : Pelvic torsion dgree

b: Group N

Fig.3 One-way ANOVA results for PO and PT among each category

M (Fig.3a), but there was a significant difference among categories 1 and 3 (p=0.04) and between categories 2 and 3 (p<0.01) in Group N (Fig.3b). In addition, there was no significant relationship between each category in both groups in PT.

【Discussion】

The external pelvimetry measurements reflect the linear distance in the pelvic cavity. As a result, the external pelvic measurements indicate the distance between each index of the iliac bone. The results of external pelvimetry values, PO and PT, indicated no gender differences (Table 1). Therefore, differences in pelvic morphology were due to individual differences and not gender.

The influencing factors for PO were ID (group M: r=-0.27, group N: r=-0.25) and PD (group M: r=0.86, group N: r=0.89) in both groups (Table 2). Thus, the PO was strongly dependent on the ratio of the distance between posterior superior interosseous spines. The PD is derived from the posterior superior iliac distance and indicates the transverse diameter of the sacrum. There was substantial variation in the size of the sacrum among participants, which was the cause of the influence on the PO. The aging in pelvic morphology, the N group had significantly different PO in categories 1 and 3 and categories 2 and 3 (Fig.3b). This is a change in PO over time that was only observed in women participants over 40 years of age. This event may be related to gender differences in the iliac auricular surface and the influence of women hormones. Because, the measured parameter values for the size of the iliac auricular surface are significantly greater in men than in womens[9]. Therefore, the distance between the superior anterior iliac spines in women may be more variable than in men. Furthermore, joint laxity is higher in women than in men [10]. In addition, the hormonal changes during the menstrual cycle increases the amount of estrogen exposure over time. As estrogen exposure increases joint laxity[10,11], the distance between the superior anterior iliac spines in women may increase with age.

There was no significant difference in values of PT among the different age categories in groups M and N. In our previous study, we found that previous vaginal delivery and aging were factors associated with PT. However, the women in this study had never delivered, suggesting that aging alone may not cause PT. Moreover, in the presence of osteoarthritis, there is a progressive deformity of the sacroiliac joint surface[12], which is a factor affecting PT. However, in this study, there was no correlation between PT and age in either group. We found that PT depends on individual differences rather than on gender or age-related effects.

【Limitations】

The study is a retrospective study, and therefore, has certain limitations in assessing the relationship between pelvic morphology and each category. In addition, the relationship between the pelvic morphology and the sacroiliac joint surface morphology is unclear because the image of the sacroiliac joint surface has not been evaluated.

【Conclusion】

There was no difference in pelvic measurements between men and women, and there was substantial individual variation. Factors affecting the degree of pelvic opening in both study groups were anterior widening and posterior narrowing of the pelvis, with the latter having a stronger effect. Regarding secular changes in pelvic morphology over time, the relative anterior part of the pelvis tended to be wider in nulliparous women over 40 years of age. This phenomenon is unique to nulliparous women. Pelvic torsion is affected by individual characteristics.

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The influence of pelvic morphology to sacroiliac joint pain between young and elderly patient: A cross-sectional study.

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Keywords Pelvic alignment, External pelvimetry, Sacroiliac joint pain

【Abstract】

Background:

In Japan, the age-specific incidence of sacroiliac joint pain (SIJP) shows a bimodal distribution, with peaks observed in the 30-39 and 70-79 age groups. Abnormal pelvic positioning has been implicated as a cause, but no studies have examined the causes of SIJP in these two age groups.

Purpose:

To compare the pelvic morphology of young and elderly patients with SIJP.

Methods:

The study included patients with SIJP in the two age groups of 30-39 years (Group Y) and 70-79 years (Group E). The mean ages of patients in Group Y and E were 35.1 ± 5.0 and 73.6 ± 3.1 years with 18 and 19 patients in each group, respectively.

Physical measurements and pelvic morphology measurements were determined. Pelvic morphology was measured using a Martin pelvimeter. The following measurements were obtained: interspinous diameter (ID), posterior superior iliac spinous diameter (PD), first/second oblique diameters (FOD/SOD), and lateral distance. The degree of pelvic opening (PO) was calculated by dividing PD by ID, and pelvic torsion (PT) was calculated by dividing FOD by SOD and further dividing the absolute value of SOD/FOD by the height measured in meters. These measurements and physical measurements were analyzed using an unpaired t-test, and $p<0.05$ was considered significant. This study was conducted in accordance with the DECLARATION OF HELSINKI.

Results:

ID was significantly higher in group E than in group Y (Group Y; 24.0 ± 1.3 cm, Group E; 25.8 ± 1.5 cm) ($t = -2.39$, $p = 0.02$). PT was significantly higher in group E than in group Y (Group Y; 0.54 ± 0.41, Group E; 0.89 ± 0.38) ($t = -4.33$, $p<0.01$). There were no significant differences in the other measurement values. There was a significant gender difference bias in the two groups (Group Y: $\chi 2 = 5.56$, $df = 1$, $p = 0.02$; Group E: $\chi 2 = 6.37$, $df = 1$, $p = 0.01$).

Conclusion:

Pelvic morphology was not associated with SIJP, as there was no significant difference in PO. However, pelvic asymmetry was involved in SIJP in the elderly. As SIJP is significantly more frequent in females, there may be a female-specific effect on the sacroiliac joint.

【Introduction】

Sacroiliac joint pain (SIJP) accounts for 30% of all lower back pain in patients[1]. The causes of SIJP have been suggested to be the morphological changes in the sacroiliac joint surface and its sequelae of sacroiliac joint surface degeneration[2]. The sacroiliac joint shows superficial cartilage degeneration in the 20s, deep cartilage degeneration and osteophyte formation in the 30s, and degeneration of the subchondral bone in the 40s, followed by further degeneration over time and cartilaginous fusion[3-5]. Thus, the sacroiliac joint, like other joints, undergoes degenerative changes, and the risk of pain increases with age. Therefore, it has been reported that there is no gender difference in the occurrence of sacroiliac joint disorders[6]. In contrast, joint laxity in the sacroiliac joint after delivery[7] and preauricular grooves[8] based on the delivery experience occur as causes specific to women. Therefore, women are more likely to experience higher stresses and loads on the sacroiliac joint along with associated stresses on the ligament and distortion of the joint[9]. Asymmetry in pelvic alignment caused by sacroiliac joint distortion has been indicated as a risk factor in the development of sacroiliac joint disorders[10]. Thus, pelvic alignment changes transform the kinematic environment of the pelvic girdle and are strongly implicated in the development of sacroiliac joint disorders[11]. However, the alignment of the pelvis is different according to the sex and age, and so, the cause of sacroiliac joint disorders may differ among individuals. In general, the age of onset for

	Young group	Elderly group
Nuber	18	19
Age (y.o.)	35.1±5.0	73.6±3.1
Height (cm)	160.6±5.5	153.3±8.4
Weight (kg)	57.6±10.1	54.4±7.4
BMI (kg/m2)	22.4±4.0	23.2±3.1
Delivery experience	92.9%	93.3%

Table 1. Group characteristics

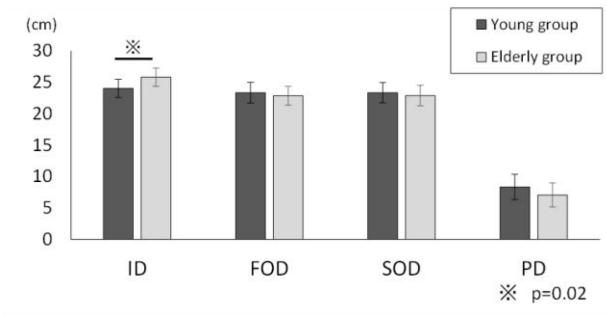

Fig 1. External pelvimetry measurement value

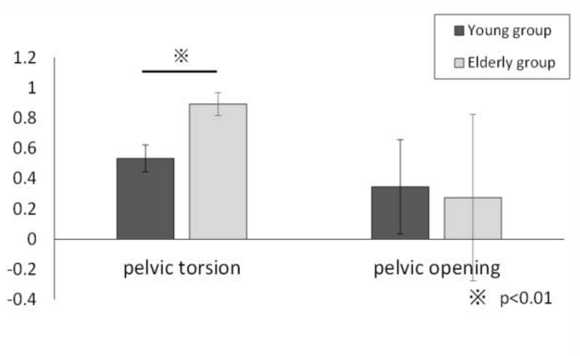

Fig 2. Pelvic torsion value and opening value

	Male	Female	
Group Y	4	14	χ^2=5.56, df=1, p=0.02
Group E	4	15	χ^2=6.37, df=1, p=0.01

Table 2. Results of Chi-square test for Group Y and E

sacroiliac joint disorders in the Japanese population is bimodal with peaks in the 30s and in the 70s. However, no previous studies have investigated the characteristics of different age groups in patients with SIJP. The purpose of this study was to compare the differences in pelvic morphology and gender between the peak ages of sacroiliac joint disorders in Japan (30s and 70s) and to investigate the relationship of these groups with SIJP.

【Method】

The subjects were 18 patients in the young group (Group Y) aged 30 to 40 years (4 males and 14 females; height: 160.6 ± 5.5 cm; weight: 57.6 ± 10.1 kg; age: 35.1 ± 5.0 years) and 19 patients in the elderly group (Group E) aged between 70 to 80 years (4 males and 15 females; height: 153.3 ± 8.4 cm; weight: 54.4 ± 7.4 kg; age: 73.6 ± 3.1 years) with a diagnosis of sacroiliac joint disorder. The delivery experience rates in the young and elderly groups were 92.9% and 93.3%, respectively. The details of each group are shown in Table 1.

Measurement of the pelvic morphology was performed by external pelvimetry using the Martin pelvimeter. The interspinous diameter (ID), distance between the posterior superior iliac spines (PD), first/second oblique diameters (FOD/SOD), and lateral conjugates were measured. The degree of pelvic opening (PO) was calculated by dividing PD by ID, and pelvic torsion (PT) was calculated by dividing the absolute value, which was calculated by dividing FOD by SOD, by the height. The exclusion criteria were an experience of abnormal delivery, and a difference of ≥0.5 cm between the bilateral lateral conjugates.

The external pelvimetry and physical measurements were compared using an unpaired t-test. In addition, a χ-square test was performed for the gender difference bias in each group. SPSS software (IBM, SPSS Statistics Version 23) was used for statistical analysis. The level of significance was set at P<0.05.

This study was conducted in accordance with the DECLARATION OF HELSINKI.

【Result】

ID was significantly higher in group E than in group Y (Group Y; 24.0 ± 1.3 cm, Group E; 25.8 ± 1.5 cm) ($t = -2.39$, $p = 0.02$) (Fig.1). PT was significantly higher in group E than in group Y (Group Y; 0.54 ± 0.41, Group E; 0.89 ± 0.38) ($t=-4.33$, $p<0.01$) (Fig.2). PO was not significantly correlated in both groups (Group Y; 0.35 ± 0.08, Group E; 0.27 ± 0.09) (Fig.2). There were no significant differences in the other measurement values.

There was a significant gender difference bias in the two groups (Group Y: $\chi^2=5.56$, df=1, $p=0.02$; Group E: $\chi^2=6.37$, df=1, $p=0.01$) (Table 2).

【Discussion】

The ID was significantly higher in Group E than in Group Y in the pelvic morphology. The posture of the elderly may also be indirectly involved in pelvic morphology. In the elderly, the activity of the transverse abdominal muscles is reduced because of the swayback posture, a common posture in the elderly[12]. The muscle power of the transversus abdominis muscle is involved in the narrowing of the anterior superior iliac spine[13]. Therefore, many elderly people in Group E with impaired transverse abdominal muscle function are more likely to develop a widening of the anterior superior iliac spine distance. In addition, more participants in this study were females. The measured parameter values for the size of the iliac auricular surface were significantly greater in males than in females[14], making pelvic alignment in females more susceptible to deformity. Therefore, the distance between the anterior superior iliac spine separates over time, even in healthy individuals. The significantly higher ID in Group E is not a finding specific to sacroiliac disorders, and can also occur in healthy individuals. Thus, ID may be a less related parameter for sacroiliac joint disorders.

The more severe the sacroiliac joint surface degeneration in sacroiliac joint disorders, the stronger the sacroiliac joint surface tilt angle[2], leading to pelvic asymmetry. PT is a parameter for pelvic asymmetry in this study. From these results, the asymmetry of pelvic morphology may be based on deformity of the sacroiliac joint and is closely related to pain. The results show that PT is significantly higher in Group E than in Group Y. The cause of the pain is most likely to occur from the degeneration of the sacroiliac joint surface[15] because of the elderly age in Group E. In contrast, Group Y had significantly lower PT than Group E. Group Y had less advanced joint degeneration than Group E, with the causes of SIJP including factors other than sacroiliac joint degeneration. In addition, pelvic asymmetry may not be the primary cause of incidence of pain in Group Y.

This study had significantly more female participants in both groups and had a higher rate of delivery experience. Pelvic girdle pain, mainly in the sacroiliac joint region, is strongly associated with SIJP, as it affects almost half of all pregnancies[15,16]. Garagiola et al. performed a computed tomography scan of the pelvis immediately after delivery and found sacroiliac joint separation in 7% of the patients and gas in the sacroiliac joint in 42% of the patients[17]. This indicates a potential change in pelvic morphology with delivery. Furthermore, the effects of the female hormones produced during delivery contribute to malalignment of the pelvis[18, 19] and pelvic instability[19]. It was not possible to determine the effect of female hormones in the present study. However, as SIJP is more common in female, changes in pelvic alignment and increased pelvic ring instability after childbirth may be involved in the development of SIJP.

【Limitation】

Pelvic ring instability and female hormones were not measured in this study. Therefore, there are limitations to the discussion regarding the relationship between SIJP and gender differences.

【Conclusion】

Pelvic morphology was not associated with SIJP, as there was no significant difference in PO. However, pelvic asymmetry was involved in SIJP in the elderly. As SIJP is significantly more frequent in females, there may be a female-specific effect on the sacroiliac joint.

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The immediate effect of neuromobilisation in stage 2 idiopathic adhesive capsulitis: a preliminary study

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Keywords: Neuromobilisation, Adhesive capsulitis, Shoulder range of motion

Abstract
Introduction: The restriction of neural mobility and neuromobilisation on adhesive capsulitis has not been paid attention in previous studies despite joint contracture via an inflammatory process in the natural history of adhesive capsulitis. We hypothesized that neurodynmics could be affected shoulder range of motion in stage 2 adhesive capsulitis due to nerve fibrosis or stiffness of non-neural tissue surrounding a nerve. This study aimed to clarify the neural restriction and the effect of neuromobilisation in patients with idiopathic adhesive capsulitis.
Subject & Method: 16 patients (four males, twelve females, 59.4 ± 11.1 years old, duration period 7.9 ± 4.8 months) were recruited in this study. Their elbow extension range of movement was measured bilaterally at their end range of the Upper Limb Neurodynamic Test1. Subjects were then randomly allocated to a neuromobilisation group, or a control group. The neuromobilisation group received neuromobilisation, whereas the control group received quasi-neuromobilisation after general physiotherapy. The elbow extension range of movement in the Upper Limb Neurodynamic Test 1 and shoulder range of motion were measured before and after general physiotherapy and neuromobilisation interventions.
Results: The elbow extension range of movement was statistically improved from -26.9 ± 29.1° (pre-neuromobilisation) to -15.0 ± 18.7° (post-neuromobilisation) in the symptomatic side in neuromobilisation group but not in control group. Shoulder extension (45 ± 10.7° to 50.6 ± 12.7°), external rotation at arm by side of the body (21.9 ± 18.1° to 27.5 ± 19.6°) and at 90° flexion (65.6 ± 26.9° to 75.6 ± 22.1°), internal rotation at 90° abduction (38.8 ± 13.8° to 45.0 ± 12.0°) were significantly improved after neuromobilisation in neuromobilisation group.
Conclusion: The results of this study might indicate the neural restriction in neurodynamic test, and the improvement of shoulder range of motion with neuralmobilisation for adhesive capsulitis. that neurodynamic assessment and neuromobilisation should be considered in the management of adhesive capsulitis.

Introduction

Adhesive Capsulitis (AC) provokes shoulder pain and restrictions in both active and passive range of shoulder motion. The restricted range of shoulder motion is improved approximately 60 to 80 % of shoulder elevation comparing with asymptomatic shoulder at the final follow-up[1]. Physiotherapy is a primary choice of conservative treatment for AC[2-4]. Joint mobilisation, capsular stretching, and muscle stretching was applied to improve shoulder range of motion (SROM) for AC due to peri- and intraarticular pathology[5-10]. Such physiotherapy intervention was based on pathophysiological evidence in AC, focused on capsuloligamentous inflammation and fibrosis or contracture with associated SROM restrictions[11-15]. An MR imaging studies reported a thickness of coracohumeral ligament in AC[16][17]. Increment of cytokines and growth factor induced in rotator interval of AC was reported in a histological study[18].

SROM restriction due to nerve involvement in AC is less knowledge despite joint contracture via an inflammatory process in the natural history of AC[1]. There was observed abnormal nerve growth factor in the glenohumeral capsule in AC[19]. Another histological study found fibroblasts in nerve tissue in chronic AC[20]. This pathophysiological process may provoke a neuro-contracture and mechanosensitivity, related to pain and movement restriction in AC as mechanical elongation and angulation of peripheral nerve during joint motion sensitizes itself after inflammation[21]. The neural restriction and its improvement by neural mobilisation for carpal tunnel syndrome, and breast cancer were demonstrated[22][23]. The clinical evidence of neural mobility and neuromobilisation (NM) on AC has not been clarified in previous studies. We hypothesized that neurodynmics could be affected SROM in stage 2 AC due to nerve fibrosis or stiffness of non-neural tissue surrounding a nerve. The purpose of this pilot study was to clarify the restriction of neurodynamics and the effect of a single session of NM in patients with idiopathic AC in stage 2.

Subject

33 patients with AC (10 men, 23 women, mean age 59.4 ± 11.1 years old, duration of symptoms 7.9 ± 4.8 months) were participated. The inclusion criteria of this study were, (i) no traumatic history of bony lesion, nor AC, (ii) no unstable neurological signs or disease, (iii) unilateral AC, (iv) more than fifteen weeks of duration of symptoms, i.e. likely to be beyond the inflammatory phase[16][17], and (v) no history of treatment. The exclusion criteria were, (i) more than 50 % loss or less than 30° external rotation at arm by side of the body (0abd)[24], (ii) more than 30° SROM restriction compare to asymptomatic side in less than one direction[16][17], or (iii) restricted passive range of elbow extension in physical examination. This study was approved by the Human ethics research committee of the Nobuhara hospital (Approval no.2401).

Method

All subjects' elbow extension range of movement (EEROM) was measured on their symptomatic and asymptomatic sides at their end range of the Upper Limb Neurodynamic Test 1 (ULNT1) (i.e. structural end range of elbow extension in ULNT1). The ULNT1 maneuver was shown in Figure 2 in appendix. Structural differentiation was undergone with cervical lateral flexion at the end of ULNT1 position by asking the change of participants' symptom. Subjects were then randomly allocated to a NM group, or a control group. The NM group received NM in ULNT1 position. They were randomly undergone 30 repetitions of through-range elbow extension into resistance (i.e. tensioner technique), or 30 repetitions of elbow extension with cervical ipsilateral flexion and wrist dorsal flexion, and elbow flexion with cervical contralateral flexion and wrist volar flexion (i.e. slider technique) after conventional physiotherapy (hot pack, soft tissue mobilisation, and passive end range glenohumeral accessory mobilisation). The control group was undergone quasi-NM (passive range of motion exercises for each component of ULNT1, 30 repetitions of through-range passive range of motion into resistance) after conventional physiotherapy. The passive range of shoulder motion exercises was undergone while elbow, forearm, wrist and fingers were held at start position of ULNT1 so as to minimize the effect of neural components during mobilizing glenohumeral joint. EEROM in ULNT1 and SROM was measured before and after conventional physiotherapy, and NM/quasi-NM respectively. SROM was measured according to the method of Macedo & Magee (2009)[25]. The profile of patients, the effects of the interventions (conventional physiotherapy versus NM) in each group and the effects of interventions between both groups were compared using Wilcoxon signed rank test.

Results

16 patients with AC recruited in this study (Table 1). Six patients excluded due to short duration period and eleven patients were excluded according to SROM criteria in this study. There was no marked difference of subjects' profile, SROM in symptomatic side, and SROM in asymptomatic side between NM and control groups ($p > 0.05$, table 1). A significant restricted SROM in symptomatic side was confirmed in both groups ($p < 0.05$).

A significant difference of EEROM between symptomatic and asymptomatic sides in both

Table 1. The profile of patients. Age and duration periods: the mean ± standard deviation.

	NM group (n = 8)			Control group (n = 8)
	Tensioner	Slider	All	
Age (yo)	56.3 ± 9.6	62.8 ± 9.5	59.5 ± 9.5	56.1 ± 9.7
Male (n)	2	1	3	1
Female (n)	2	3	5	7
Duration periods (mo)	10.0 ± 4.0	9.3 ± 9.8	9.6 ± 7.0	8.9 ± 3.4
Right-handed (n)	4	4	8	8

**: $p<0.01$

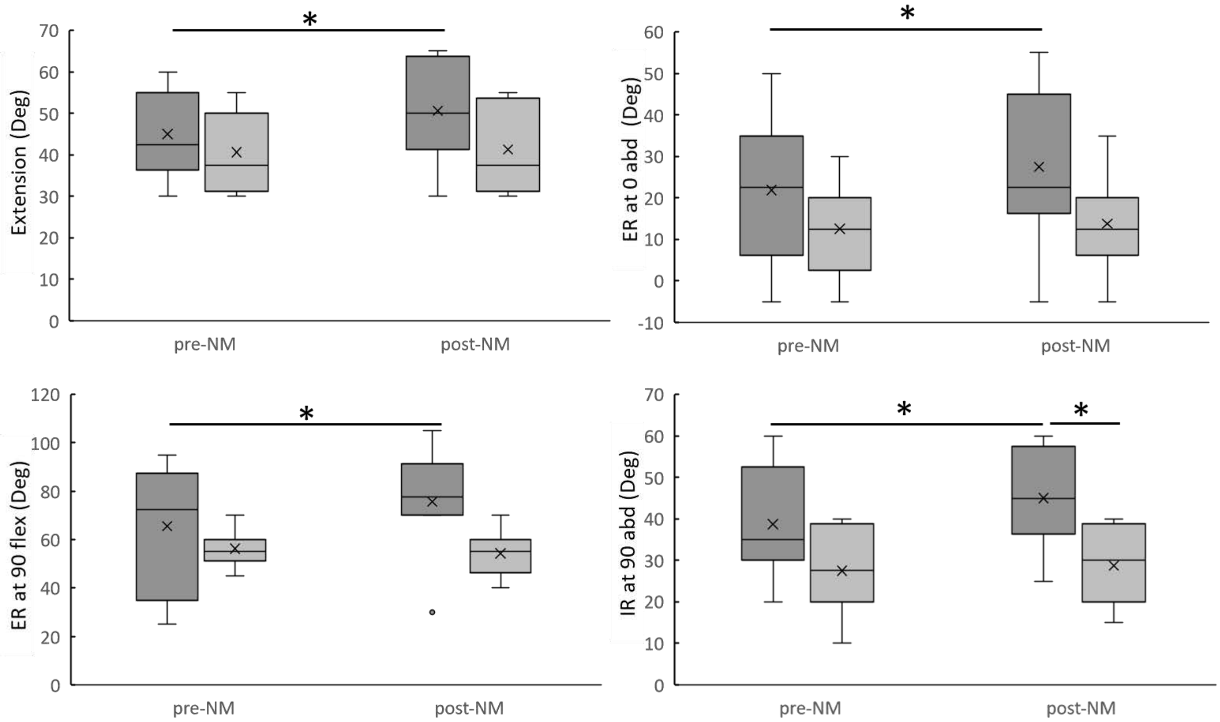

Figure 1. SROM between pre- and post-NM (Deg). ER: external rotation, 0abd: at arm by side of the body, 90 flex: at 90° flexion, 90 abd: at 90° abduction, dark grey boxes: NM group, light dark grey boxes: control group, *: $p < 0.05$. a black dot: an outlier. Cross markers indicate mean value in box-whisker graphs.

groups, with -26.9 ± 29.1º for symptomatic side, -0.6 ± 1.8º for asymptomatic side in NM group, -28.8 ± 29.5 º for symptomatic side, 0 ± 0.0º for asymptomatic side in control group (p = 0.042, 0.043), and no statistical difference of EEROM between both groups was confirmed ($p > 0.05$) in pre-conventional physiotherapy. All participants complained that their pain increased with contralateral flexion and decreased with ipsilateral flexion of cervical spine at end of ULNT1 position. A marked improvement in EEROM was found between pre- and post-NM in the symptomatic side (-26.9 ± 29º to -15.0 ± 18.7º, p = 0.043) in NM group but not in control group (-28.8 ± 29.5 º to -27.5 ± 28.7 º, p = 0.317).

Shoulder extension, external rotation at 0abd and at 90° flexion, internal rotation at 90° abduction were significantly improved in post-NM comparing with pre-NM in NM group (p = 0.024, 0.034, 0.014, 0.039, Figure 1). A statistical improvement of internal rotation at 90° abduction, and at 90° flexion in NM group were observed comparing with those in control group (p= 0.029, 0.017).

Discussion

EEROM in ULNT1 position was restricted more than 10 degrees in patients with AC whilst asymmetrical EEROM of ULNT1 in healthy subjects was within eight degrees[26]. Moreover, the symptom of subjects in ULNT1 was changed with structural differentiation, implying a positive finding of neurodynamic test[27]. These findings in this study could indicate restricted neural mobility in stage 2 AC.

SROM and EEROM in NM group further improved with NM intervention. The results of this study demonstrated that a single NM treatment can improve neural mobility and SROM in patients with AC. On the other hand, in control group, passive range of motion of ULNT1 components did not improve SROM after conventional physiotherapy although a peripheral nerve is shortened and elongated when a joint mobilized[28]. This result might indicate less effect of passive range of motion exercise for neurodynamics in AC. Our findings could indicate that neurodynamic assessment and NM should be considered in the management of AC.

To our knowledge, this study was the first challenge of NM intervention for AC. The improvement of EEROM in ULNT1 and SROM was observed after NM intervention. Several factors might lead to the improvement of them. Neurodynamic tests could detect and NM could improve surrounding tissue of peripheral nerve or the contracture of peripheral nerve per se in stage 2 AC. Induce of nerve growth factor receptor and nerve fibres were reported in AC capsule[19]. Furthermore, abnormal neovessels were observed in the rotator interval in patients with AC[29]. Nerve ingrowth with neovessels was a cause of pain[30]. NM intervention reorganized nerve collagen fibre and vessels[31]. NM intervention might reduce mechanical irritation to the capsule in AC patients.

The limitation of this study was that there was no biomechanical study to investigate the restricted neurodynamics in AC. Our hypothesis was based on previous pathophysiological studies and clinical experience that some patients with AC complaint pain along peripheral nerve at the end of motion. There might be some mechanisms that SROM improved after NM. Neural mobility could be restricted due to stiffness of neural interface or stiffness of peripheral nerve per se. This study provided the clinical evidence of that neural mobility was restricted and the NM improved ROM in patients with stage 2 AC. Future study is expected to clarify the restricted neural mobility in AC.

Conclusion

A positive finding of ULNT1 was confirmed in the symptomatic side of stage 2 AC. This finding might indicate neural restriction in AC. EEROM in ULNT1 and SROM were significantly improved after NM. The results of this study might indicate that neurodynamic assessment and NM should be considered in the management of AC.

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Appendix

Figure 2-1: Start position

Figure 2-5: Shoulder external rotation

Figure 2-2: Shoulder abduction

Figure 2-6: Elbow extension

Figure 2-3: Wrist extension

Figure 2-7: Cervvical ipsilateral flexion

Figure 2-4: Forearm spination

Figure 2-8: Cervvical contralateral flexion

Figure 2: The ULNT1 maneuver

Future challenges for JAOMPT-East, Japan clarified through the views of workshop participants and leaders

Masahiro Sakamoto Moriya Keiyu Hospital
Key words: Future challenge, Manipulative physical therapy, Disorders subject to manipulative physical therapy
【Abstract】The East Japan Branch of the Japan Academy of Orthopedic Manipulative Physical Therapy (JAOMPT-East, Japan) holds a workshop on manipulative physical therapy for physical therapists on a regular basis. Many of the workshop participants are affiliated with orthopedic clinics. The reason for this might be that manipulative physical therapy is thought to be a technique limited to orthopedics, so physical therapists who are rarely involved in orthopedics may be less likely to participate. To verify this hypothesis, I conducted a survey. The results showed that 3.0% of participants worked for a rehabilitation hospital in the recovery phase, and 9.0% were affiliated with a nursing care department. Further, 51.5% of participants and 40.0% of instructors/assistants regarded manipulative physical therapy as a special manipulation for orthopedic disorders. When asked if manipulative physical therapy was felt to be a special technique for orthopedic diseases, there was no significant difference between the participants and instructors/assistants. The problem JAOMPT-East, Japan is currently facing is that manipulative physical therapy is strongly regarded as a physical therapy specialty, and few JAOMPT-East, Japan workshop participants are physical therapists affiliated with hospitals in the recovery phase or nursing care departments. I believe that JAOMPT-East, Japan can provide even higher quality physical therapy if JAOMPT-East, Japan let all physical therapists, including those who rarely treat orthopedic disorders, acquire manipulative physical therapy skills as basic, rather than specialized, techniques. Thus, it is JAOMPT-East, Japan's duty to discuss ways to have physical therapists who are active in a range of fields participate in this workshop in the future.

Introduction

The East Japan Branch of the Japan Academy of Orthopedic Manipulative Physical Therapy (JAOMPT-East, Japan) holds a workshop on manipulative physical therapy for physical therapists on a regular basis. For each workshop, the executive office of JAOMPT-East, Japan creates a list of the participants. From these lists, a deviation in the participants' affiliations has been identified. The workshop topics involve the evaluation and treatment of various joints (for example, "evaluation and treatment of the knee joint"). For any joint disease, it is necessary to expand the joint's range of motion and strengthen the relevant muscles, which thus makes it necessary to evaluate and treat each joint as appropriate. The workshop does not focus on specific orthopedic diseases, such as "orthopedic diseases of the knee joint." However, many participants tend to be affiliated with orthopedic surgery clinics, and few tend to be affiliated with nursing care departments or rehabilitation hospitals in the recovery phase. The reason for this might be that manipulative physical therapy is thought to be a technique limited to orthopedics, so physical therapists who are rarely involved in orthopedics may be less likely to participate in the workshop. To verify this hypothesis, I conducted a survey on how participants regard manipulative physical therapy (which is the main theme of the workshop) and how they have applied it in their daily practice, as well as their affiliations. I surveyed previous workshop participants, instructors, and assistants. Based on the analysis of the results of the questionnaire, I report the challenges that JAOMPT-East, Japan must take on as part of its activities.

Conflicts of interest

No companies or organizations have a conflict of interest in association with the presentation of the results of this study.

Survey method

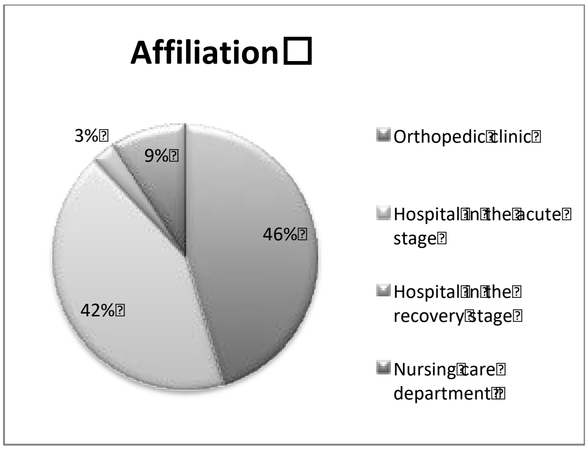
I surveyed 53 individuals who participated in the workshop more than twice and 16 individuals who were involved in the workshop as instructors or assistants. I evaluated their affiliations, their views of manipulative physical therapy, how they have applied the techniques from the workshop, the results of those applications, and their satisfaction with the workshop. All the instructors/assistants were members of JAOMPT-East, Japan, and five of them were orthopedic manipulative physical therapists. During the workshop, the instructors/assistants teach kinematics and anatomy, deliver instruction on evaluation and treatment, and teach practical skills. There have been six workshops focused on single body sites, including "Clinical reasoning, and finger and wrist," "Forearm and elbow joint," "Shoulder joint," "Hip joint," "Knee joint," and "Ankle joint."

The seating capacity of each of these six workshops was 40. I distributed the questionnaires by e-mail and collected the responses on the internet using answer forms. The answers to the questionnaire were converted to percentages and compared between the two groups (participants and instructors/assistants) using Pearson's chi-squared tests. In accordance with the Declaration of Helsinki, I explained the purpose of the survey and obtained all respondents' prior approval of the study.

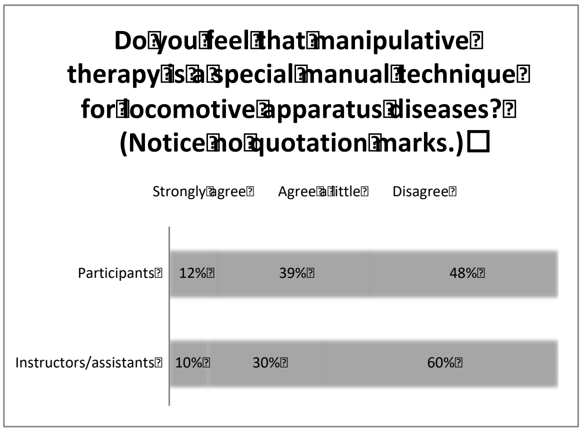
Survey results

I received valid responses from 33 participants (collection rate: 62.0%) and 10 instructors/assistants (collection rate: 63.0%). Most of the participants were affiliated with an orthopedic surgery clinic (45.5%), while 3.0% worked for a rehabilitation hospital in the recovery phase and 9.0% were affiliated with a nursing care department (Figure 1).

In addition, 51.5% of participants and 40.0% of instructors/assistants regarded manipulative therapy as a special manipulation for orthopedic disorders. There was no significant difference between the participants and the instructors/assistants



(Figure 1)



(Figure 2)

(Figure 2).

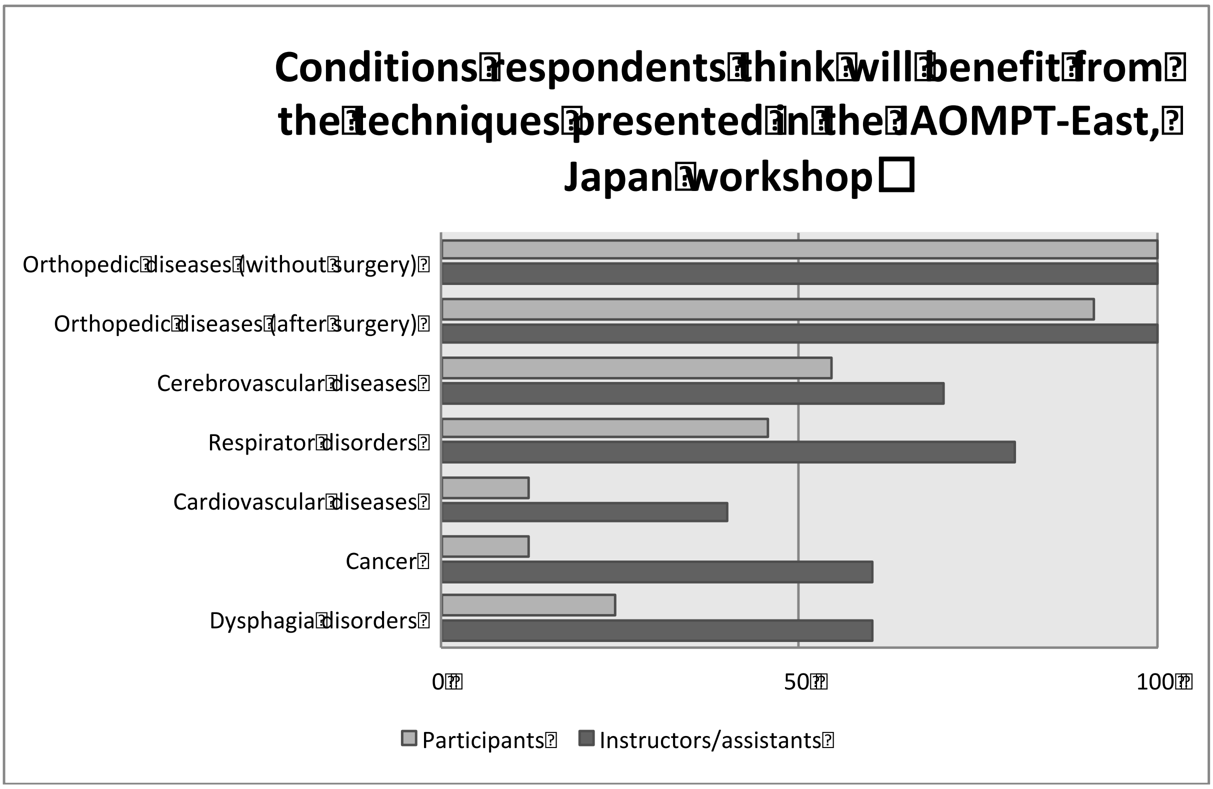
When asked which conditions they thought could benefit from the techniques learned in the workshop, the participants responded: orthopedic diseases without surgery (100.0%), orthopedic diseases with surgery (90.9%), cerebrovascular diseases (54.5%), respiratory diseases (45.5%), dysphagia disorders (24.2%), and cancer (12.1%). In response to the same question, the instructors/assistants picked: orthopedic diseases with or without surgery (100.0%), respiratory diseases (80.0%), cerebrovascular diseases (70.0%), dysphagia disorders (50.0%), and cancer (60.0%) (Figure 3).

When asked about actually applying the techniques learned in the workshop, the participants indicated orthopedic diseases with or without surgery (90.0%), cerebrovascular diseases (27.3%), respiratory diseases (24.2%), dysphagia disorders (6.1%), and cancer (3.0%). In response to the same question, the instructors/assistants picked orthopedic diseases with or without surgery (100.0%), cerebrovascular diseases (60.0%), dysphagia disorders (50.0%), respiratory diseases (10.0%), and cancer (10.0%) (Figure 4).

About 85.0% of the participants were satisfied with the workshop, and no respondents indicated dissatisfaction with the workshop (Figure 5).

Discussion

Of the respondents, 51.5% of the participants and 40.0% of the instructors/assistants had the image of manipulative physical therapy as a special technique for orthopedic diseases. Since approximately half of the physical therapists in this survey had this view, it can be inferred that physical therapists who have never participated in manipulative physical therapy workshops have an even stronger impression. However, no matter which diseases they are asked to treat, physical therapists usually provide treatments (such as pain alleviation, joint range of motion expansion, muscle building, postural regulation, and motion training) best suited to each particular disease after managing any risks. I myself work for medical facilities that do not have outpatient orthopedic surgery departments and often treat patients with dysphagia disorders and vertigo. In the course of treatment, I find that the knowledge of manipulative physical therapy techniques is very helpful for treatment. Only a few physical therapy schools



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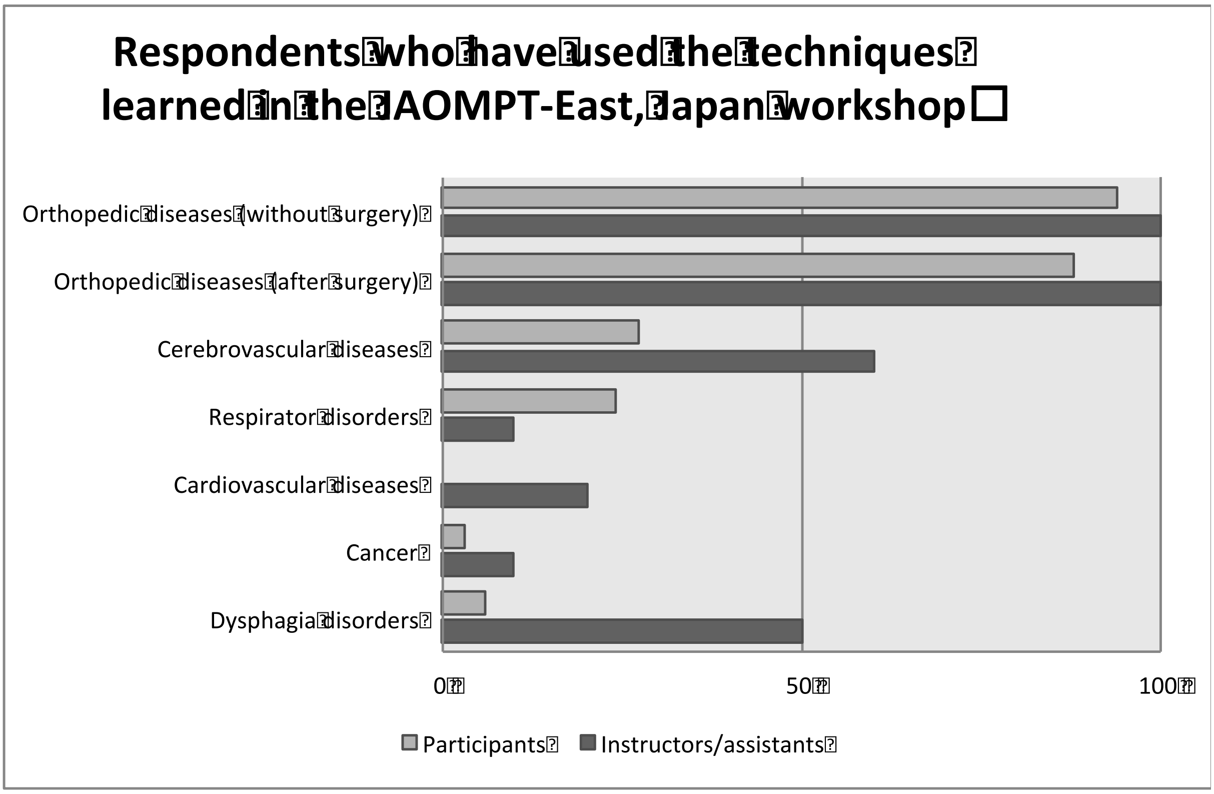

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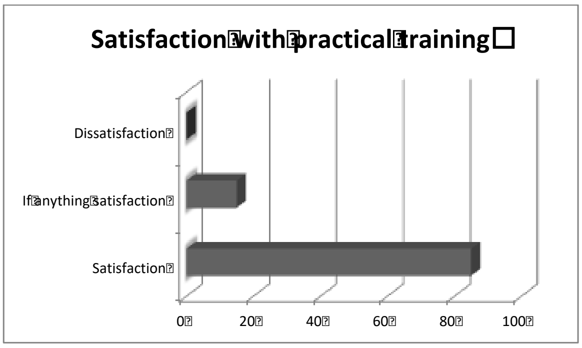

(Figure 5)

in Japan provide students with enough training on evaluation, which requires senses like end feel. I was trained in the correct usage of a goniometer in my school days, but I did not receive practical training for the end feel of a joint. I studied this in the manipulative physical therapy course and acquired the correct knowledge of the end feel technique with the proper supervision of orthopedic manipulative physical therapists. It is my opinion that knowledge of the end feel technique is indispensable in the treatment of muscles and joints. Judging from the responses given by the instructors/assistants, they seem to believe that manipulative therapy is applicable not only to orthopedic disorders but also to diverse diseases, including dysphagia disorders. When responding to the fields in which manipulative physical therapy may be applied, the instructors/assistants gave lower values than the participants. This is supposedly because the number of patients for whom they have applied manipulative physical therapy is small. Instructors/assistants plan to apply manipulative physical therapy techniques as needed when facing patients suffering from respiratory diseases. In the case of dysphagia disorders, for example, the jaw joint matters most to mastication, but the stability and position of the cervical spine are also important for normal movement. Likewise, the swallowing function is affected strongly by the jaw joint, cervical spine, and scapular arch. At the same time, these movements are caused by the contraction and relaxation of muscles epitomized by the masseter muscle, suprahyoid muscles, and infrahyoid muscles. Even the swallowing reflex, which is an involuntary movement, may be improved by postural regulation and muscle-strengthening exercises.

Dysphagia disorders are caused mainly by cerebrovascular diseases and cancer. However, the therapeutic objectives are the joints and muscles, which are the main objectives of manipulative physical therapy. Physical therapists who have studied manipulative physical therapy thoroughly can apply both technique and theory because they have learned them thoroughly. Except for the workshops authorized by IFOMPT, the workshops held in Japan mostly assign one instructor/assistant to every 20-40 participants. However, the workshops organized by JAOMPT-East, Japan assign one instructor/assistant to every 4-5 participants, without fail. In JAOMPT-East, Japan's opinion, this has allowed the instructors/assistants to teach the participants minutely and provides the participants an environment in which they can ask questions openly, which makes it possible for them to get a higher degree of understanding and satisfaction.

Conclusion

The problem we now face is that manipulative physical therapy is strongly regarded as a specialized field of physical therapy, and physical therapists who specialize in nursing care or internal diseases are not interested in studying manipulative physical therapy. JAOMPT-East, JAOMPT-East, Japan planed 11 workshops in 2 year, 6 of which were held. Participants could choose to focus only on the body sites that they have studied in detail, or they could join any of the 11 workshops along the way. However, about 70.0% of the participants have participated in the workshop without interruption, and there were standby participants in each of the past six workshops. Taking these facts into consideration, I can say that the questionnaire results are justified and that the workshops have given participants a high degree of satisfaction. JAOMPT-East, Japan needs to make efforts to let even more physical therapists specializing in nursing care and internal medicine participate in the next workshop.

I believe that JAOMPT-East, Japan can provide even higher quality physical therapy if JAOMPT-East, Japan let all physical therapists, including those who rarely treat locomotive apparatus diseases, acquire manipulative physical therapy skills as basic, rather than specialized, techniques. Thus, it is JAOMPT-East, Japan’s duty to discuss ways to have physical therapists who are active in a range of fields participate in future workshops. For this purpose, JAOMPT-East, Japan must take initiative in making presentations that treatment by manipulative physical therapy on respiratory diseases, cancer, and dysphagia disorders.

Another challenge JAOMPT-East, Japan must face is the shortage of instructors/assistants. JAOMPT-East, Japan had 50 members as of June 2019. Of these 50 members, only 15 could take on the position of an instructor/assistant. It is JAOMPT-East, Japan’s opinion that instructors/assistants can improve their presentation skills by teaching participants and enhance their practical skills by showing techniques to participants. In the future, I want JAOMPT-East, JAPAN members who are aiming for OMPT to actively experience instructors and assistants. To make JAOMPT-East, Japan’s plan a reality, I think that it is the JAOMPT-East, Japan’s duty to take on the challenge of building a system with a focus on developing orthopedic manipulative physical therapists.

Acknowledgements

The authors would like to express heartfelt gratitude to the members of JAOMPT-East, Japan and to the physical therapists who have regularly participated in the workshop for their cooperation in this survey.

THE EFFECTIVENESS OF FASCIAL MANIPULATION FOR NECK PAIN AMONG UNIVERSITY STUDENTS

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Abstract

Background. Neck pain mostly occurs at 18 years of age, then the pain gradually increases and affects the postural of the body. Frequently, university student suffered from muscle spasms around the neck mostly caused by computer activities, body posture, and sports; moreover, the evidence increased that undergraduate students have a high prevalence of musculoskeletal symptoms. However, there are not study that analyze the effects of fascial manipulation in neck pain treatment.

Purpose. This study aimed to investigate the efficacy of fascial manipulation for neck pain.

Methods. This experimental study includes 30 university students with range from 18 to 32 years old which consist of 26 males and 4 females with neck pain and two physical therapy with experiences as the examiner who were recruited between Octobers 18, 2018 until May 16, 2019. The students were randomized into the fascial manipulation group and combination therapy group. Participants in the fascial manipulation group received an intervention which treated the fascia layer, while the combination group received ultrasound treatment and transcutaneous electrical nerve stimulation (TENS) concurrently. Both groups received 30 minutes of treatment and were followed - up after one week. The outcomes were evaluated by the Neck Disability Index (NDI), numeral pain rating scales (NPRS), and the cervical range of motion (CROM) before and after treatment using the cervical range of motion. The participants get to assessment and got the physical examination first before the treatment around neck, scapula, and thoracic areas for treatment.

Result. For all measurements, there were significant differences between pre- and post - treatment values, but no significant differences between the groups. At follow-up, the NDI for the fascial manipulation group showed significantly (p = 0,039) better effects than the combination group.

Conclusion. Our study demonstrate that fascial manipulation has similar effects to combination therapy when used for neck pain.

Keyword: upper extremity, neck, fascial manipulation, combination therapy

INTRODUCTION

Based on data from the Human Health Welfare database from 2012 until 2016, neck pain is the second leading musculoskeletal problem in Japan, following lower back pain 1). Mostly affects young adults between the ages of 18 and 32 years; the occurrence gradually increases as people age or if they do not attempt to correct the pain, which is usually done through rehabilitation 2). The increased use of smartphones and computers can trigger or aggravate neck pain if these devices are used in the wrong position 13). Consequently, musculoskeletal symptoms in the neck and upper extremity are prevalent among 48 - 78% of undergraduate students 10).

There are two categories of neck pain. First is non-specific pain which is related to limited mobility in the cervical spine, neck muscle spasms, decreased movement, and pathological factors, such as stress. This kind of neck pain can be triggered pathologically, or from environment 11). The second type of neck pain is specific pain, which can be defined by a special soft tissue injury around the neck area. Some evidence suggest that the prevalence of neck pain increases steadily with the age and occurs in young adults aged 18 years and older 5).

The fascia is connective tissue layers that begins under the skin. It is not primarily composed of collagen fibers and is deeper than the epidermis; however, it is not structurally the same as epidermis layer. Recent reports address the possible involvement of the deep fascia in myofascial pain 8). The fascia also participates in mechano-transduction mechanisms, which converts the stimulus into electrical activity to interpret tension and mechanical force.

Fascial manipulation (FM) is manual therapy treatment that can be used to treat the superficial or deep fascia. It focuses on treating the deep fascia and it is dysfunction. FM examines the biomechanical and relationship between muscle and the deep fascia, which are involved in pain, disabilities, and impaired movements. The area that affected because of neck pain is retro and antero (antagonist for retro) caput area especially occiput (CP3), collum (Cl), thoracic (Th), and scapula (Sc).

The most common modalities used during physical therapy include ultrasound and transcutaneous electrical stimulation (TENS). Combining ultrasound and TENS in has been shown to describe the effect between the modalities and is thought. To enhance the effect of the treatment. A previous study demonstrated that this combination therapy provides more analgesic effects than injection and speeds up recovery 6).

Therefore, this study aimed to investigate the effects of these treatments, especially FM, disability, pain intensity, and functional movement, which involves stiffness and elasticity, among university students with neck pain.

PARTICIPANTS AND METHODS

Patients and ethical considerations

This single-blind study included a randomized controlled trial, with FM and combination therapy (ultrasound and TENS) as the patient groups. Ethical approval was given by the Research Safety Ethics Committee of Tokyo Metropolitan University Arakawa Campus (Approval no.18061). Patients were recruited between October 18, 2018 until May 16, 2019. University students who were diagnosed with chronic neck pain (> 3 months of duration with daily manifestations), aged between 18-35 years, and signed provided informed consent were included in the study. Patients with neurological problems, systemic diseases, traumatic injury around the head and neck, and those using a different therapy for neck pain were excluded from the analysis.

Definitions. Chronic pain is defined by separate criteria; these criteria include neck pain lasting longer than 12 weeks, no neurological problems, dull pain that worsens with sustained end-range spinal movements or positions, and overpressure into tissue resistance. Based on the neck pain guidelines of 2017, chronic neck pain is classified based on limited mobility or radiating neck pain. However, only students with limited neck pain were included in this study. All participants agreed to avoid any additional therapy or treatment during the study.

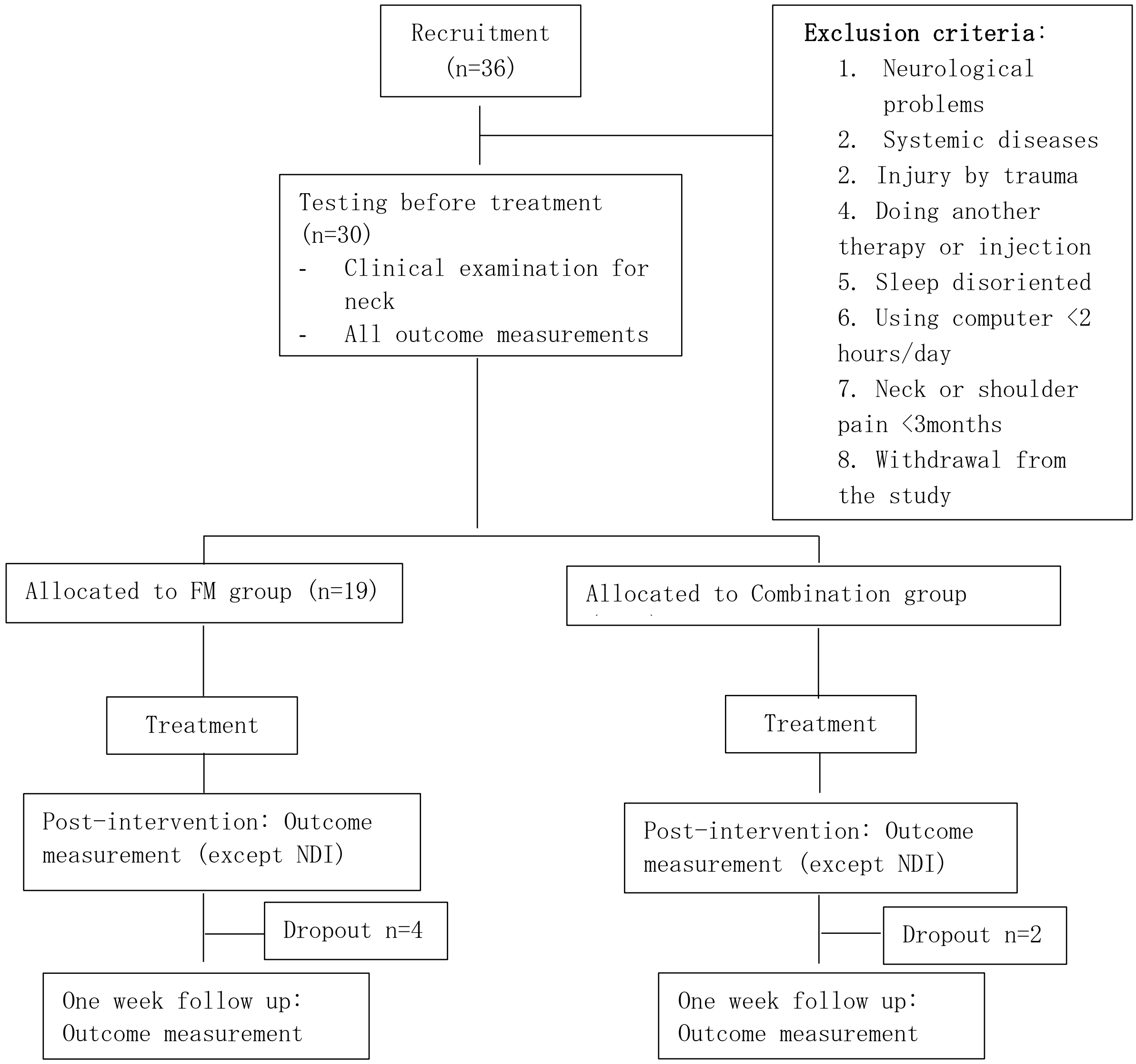

Figure 1. Flow chart describing the progress of participant through the study

Physical examination

The physical examination for selected participants conducted in the following procedures. First, there were 2 physical therapy did the assessment protocol for both groups was using standardization as movement and palpation verification in Fascial manipulation. To prepare the areas on neck and shoulder, the researcher already decided to minimize the bias; the movement verification was performed only on the most painful and compromised movement that affected the myofascial units. Second, asked the participants to do the functional movement, extension the neck to see which side that has more extended and more deviation (re-cp3 and re-cl areas), instructed to moving the scapula closer together to see the rigidity (re-th), and the last one ask to raise both scapulae moving to the posteriorly and observe for dissymmetry of symptoms (re-sc).

Palpation verification only on the neck, shoulder, and upper back to decide which anterior path which becomes Centre of Coordination (CC) of the pain. The most painful area becomes CCs and those referring to the area for treatment.

Outcome measures

The outcome was measured using the Numerical Rating Scale (NPRS), for subjective feeling using the Neck Disability Index (NDI) in Japanese and English version, and neck range of motion using the goniometer. Not only that, to make sure to check which side the most affected is with neck pain, using the Fascial manipulation assessment checked was doing. The assessment area was in retro and anterior area in *caput* 3, *collum*, *scapula*, and *thorax*.

Numerical Pain Rating Scale (NPRS) was used as the pain scale at the start and end of each treatment session, and the last follow up after one week. The physiotherapist did the NPRS for pre- and post-treatment in order to evaluate whether the pain was sharp or the pain present whenever the treatment was conducted.

The Neck Disability Index (NDI). The NDI is an instrument that using functional activities as quantifier for neck pain. The scale is composed to measure the levels of disability caused by neck pain. It has 10 sections with total points is 50 to be measured: pain intensity, personal care (washing, dressing, etc.), lifting, reading, headaches, concentration, work, driving, sleeping, and recreation. Scoring ranges from 0 to 50 with minimum scores corresponding to a higher quality of life.

Cervical Range of Motion (CROM). Neck or cervical range of motion was performed and digital measurement goniometer (DM-100) for pre-post- treatment and follow up after one week to see any significant differences before and after the treatment. The cervical movement that is assessed are flexion, extension, right and left side bending, and right and left rotation.

Randomized and treatment group

Participants come and conform to both fill the inclusion and exclusion criteria were randomized into a Fascial manipulation (FM) group or combination group using computer-generated a randomized list. Both groups have characteristic: the meeting only two days in two weeks (treatment day and follow up after 1 week), the duration of treatment both groups were 31 minutes, and each group has experienced physiotherapy for more than two years to assess the participants.

Fascial manipulation (FM). Around 30 minutes per sessions with the forces generated by a myofascial unit are considered to converge on one point which has a precise anatomical location within the muscular fascia. According to the Fascial manipulation model, musculoskeletal dysfunction is considered to occur when muscular fascia no longer slides, stretches, or adapts correctly, resulting in local fibrosis at these specific points of tension. The manual technique of Fascial manipulation will use knuckle or fingertips on the abovementioned points. This technique will do around the neck point or the point that give effect on neck pain. The point will be RE-CP3, RE-CL, RE-SC, RE-TH, (antagonist side) AN-CP3, AN-CL, AN-SC, and AN-TH.

Combination therapy. Ultrasounds perform almost at the same area as Fascial manipulation and will be done at 9 minutes. (1 watt/cm^2 dose, 1 MHz frequency, continuous mode). Ultrasound will be doing in trigger point on shoulder and neck areas. TENS using two electrodes to deliver a current premixed amplitude-modulated with <100 Hz frequency/pulse 60ms width and intensity adjusted according to the threshold for each participant without emerging pain or contractions. The electrodes are placed crosswise in the cervical paravertebral region.

Procedures

In this study, at first do a questionnaire about personal and professional characteristics as well as specific questions regarding the Neck Disability Index, was developed for the students. This study will use the Neck Disability Index (NDI) in Japanese and English language. We used this questionnaire to get information about neck pain that affects the daily active life among students. The eligibility criteria are the students had neck pain more than three months with a maximum NDI score is 10, using the computer for more than 2 hours per day and had not responded to conventional conservative treatment. Active neck range of motion assessment is conducted in flexion, extension, rotation, and lateral rotation using goniometer. At the starting position, each participant looked forward with the neutral position then asked to move the heads towards each direction as far as possible, and the degree of neck motion would be recorded. Participants were followed in after first treatment and assessment for collecting data. It measured by goniometer for range motion. Then it would be doing another evaluation a week after the treatment. The allocation will be done with simple random sampling.

Outcome measurement	Group	Pre-treatment	Post-treatment	One-week follow-up
NDI	FM	7.2 ± 2.0	-	3.0 ± 2.7*
	Combination	8.3 ± 4.7	-	6.3 ± 4.6
NPRS	FM	3.8 ± 1.3	1.8 ± 1.0	1.5 ± 0.9
	Combination	3.3 ±1.4	1.9 ± 1.1	1.8 ± 1.0
Flexion	FM	47.2 ± 14.7	58.7 ± 12.5	52.5 ± 12.6
	Combination	44.9 ± 12.9	49.8 ± 14.0	58.9 ± 15.5
Extension	FM	53.6 ± 13.7	63.8 ± 10.2	59.8 ± 13.0
	Combination	54.8 ± 11.0	60.7 ± 11.0	59.9 ± 15.8
Side bending (T)	FM	40.1 ± 10.0*	50.9 ± 14.5*	46.6 ± 8.3*
	Combination	30.5 ± 6.1	37.6 ± 9.7	38.7 ± 9.1
Side bending (NT)	FM	40.2 ± 14.7	43.9 ± 11.6	44.2 ± 9.8
	Combination	37.2 ± 11.5	39.4 ± 10.6	40.0 ± 13.3
Rotation (T)	FM	51.0 ± 14.0	59.7 ± 12.0	61.0 ± 12.2
	Combination	55.4 ± 9.5	63.5 ± 8.8	66.3 ± 10.4
Rotation (NT)	FM	55.9 ± 13.8	61.8 ± 13.4	61.4 ± 13.4
	Combination	62.5 ± 8.9	65.8 ± 9.0	63.0 ± 10.6

Table 1. The measurements results testing for effects of intervention

Variable	Time (F value)	Group (F value)	Time x group (F value)
NDI	0.408 (p = 0.001)	40.56 (p = 0.092)	4.7 (p = 0.039)
NPRS	36.84 (p = 0.001)	0.004 (p = 0.949)	1.63 (p = 0.215)
Flexion	23.35 (p = 0.001)	0.56 (p = 0.46)	10.5 (p = 0.001)
Extension	13.89 (p = 0.001)	0.019 (p = 0.89)	1.097 (p = 0.348)
Side Bending Treat	22.11 (p = 0.001)	10.19 (p = 0.003)	1.59 (p = 0.222)
Side Bending Non-treat	3.29 (p = 0.53)	0.918 (p = 0.346)	0.196 (p = 0.823)
Rotation Treat	19.21 (p = 0.001)	1.5 (p = 0.23)	0.158 (p = 0.854)
Rotation Non-treat	6.79 (p = 0.004)	1.066 (p = 0.311)	1.285 (p = 0.293)

Table 2. Two-way repeated ANOVA results for analyzing the effects of each intervention

Data Analyses

To analyze the data, we were using SPSS statistical software version 26 (IBM Corp., Japan version) for Windows. Descriptive statistics were calculated for all parameters. At first, divided the participants using the SPSS. Secondly, for each outcome parameter, a linear factors "time" (pre, post, and follow up) and the research group (FM and combination) to found out if there were significant differences between time and treatment. The dependent variables were analyzed using two-way repeated ANOVA. There was one between factor (group) within a factor of time (pre, post, and follow up) p-value was set at 0.05.

RESULTS

Participants

Thirty university students (26 males and 4 females) with a mean age were 27 years (standard deviation: 4.429) were randomly recruited between October 18, 2018 to May 16, 2019. Demographic features of participants in both treatment groups are summarized.

Outcome measurements

Numerical Pain Rating Scale. (NPRS). Based on the table 1, the interaction effect between the groups and the time (pre-treatment and at the follow - up) was statistically significant $p = .039$. there was a significant differences between time ($p = .001$) but the difference between the groups was not significant ($p = .092$) *it* shown there were no significant different in baseline with has improvement in NDI, pain, and range of motion. Both treatments showed the same good result after the treatment. But, on FM group there were no improvement after one week not like the combination group. And on the table 2, the result talked about the relation between time, relation of group, and the differences between time and group. It showed that both groups did affect the process after the treatment ($p < .001$). However, between the treatment, there are no significant different since both of group result gave the same effectivity for the neck pain. In the other hands, the FM has the main significant effect on ROM of side bending comparing two types of intervention ($p < .003$). Only that measurement gave the different because since the beginning on the side bending treatment side already have differentiation based. Suggesting there are difference in the effectiveness between two interventions only for side bending in treatment area even there were no significant different between two treatment.

Neck Disability Index (NDI). The interaction effect between the groups and the time (pre-treatment and at follow-up) was statistically significant ($p = .039$). There was difference between the treatment time ($p = .001$), but the differences between groups was not significant ($p = .092$).

Cervical Range of Motion (CROM). *Flexion.* The differences between the two treatments and the times (pre-, and post-treatment, and follow up) were statistically significant ($p = .001$), with the most substantial differences being between the treatment times (p<0.001).

Extension. There was a significant difference in extension between the two-time groups (p< 0.001). The differences in extension for analyzing the effects of each movement between the two intervention groups was not significant.

Side bending. The interaction between the group intervention and time groups (pre-treatment and at follow-up) in the treatment side was not significant (p= .22). there was a significant difference between the time groups (p< .001). Additionally, there was a significant difference between the interventions (p= .003)

DISCUSSION

The results showed that Fascial manipulation has the same effect as combination treatment in reducing pain and improving neck ROM. However, the result in neck disability index (NDI) showed better than combination group.

The NDI was evaluated before the treatment and followed up after one week the treatment was performed. Mostly, when interview before re-evaluation, they feel no different whenever the interview asked what the feeling after one week without any treatment with doing the usual activity just like before the treatment was performed. But the participants feel the immediate effect after the treatment but no different after one week. Based on the result on the questionnaire, showed the different result. It showed better than before even they feel the same.

According to *Picelli A* 12), participants with the sub-acute whiplash who received FM for 30 minutes showed significant improvement in neck flexion after treatment; no differences were found between the groups for other primary outcomes after treatment or during follow - up. Compared to almost two weeks of neck exercise, functions of the neck significantly improved over time. Our study demonstrated that FM therapy improves neck flexion movement result after treatment, even though the results were similar to that of the combination group. Decrease in pain immediately following combination therapy; comparatively, ischemic compression treatment did not significantly improve pain. This study also demonstrated therapeutic effects after the first intervention. Similarly, in our study, both intervention groups demonstrated a decrease in the NDI and side bending on the treatment side an improvement in non-specific chronic pain. Our results suggest that there are no significant differences in the effects between FM and combination therapy. Both treatments have the same immediate effect after the first intervention and there were no significant prolonged effects measured one week after treatment. The present study is limited in that there are no control groups for comparison and NDI was not measured post - treatment. Despite these limitations, this study demonstrates the efficacy of combination treatment ultrasound and TENS for neck pain treatment. More studies are warranted to fully elucidate the potential of combination therapy and FM among participants with neck pain.

The movement in FM and combination group showed the good result before and after treatment but there were no changes on both group after the follow up. In Fascial manipulation, it can be the effected due to restoration of fascial mobility and the quality of sliding motion between fascia layers 7). Because the concept of fascial manipulation it must be in the specific area and segmental of anatomical path; which may restore optimal motor unit recruitment 15). The movement in flexion became rising after the treatment change it until 10 degree even after finished the treatment. But the result did not stand too long because there were decrease after one week. It might be the effect of psychology that participants feel after the treatment. In the real time, participants that join the FM group, got pain at the beginning but not long after that they feel better. However, the combination group showed differently because after following up for one week the range of motion became increased. The combination just like mixing the effected of ultrasound and TENS. Ultrasounds have function as repair the soft tissue and TENS have stimulation for central nerve system. So that have combined the effected the soft tissue and stimulate the nerve to reduce the pain stimulus and make people condition calm and relaxed. But there is not clear evidence showed that combination treatment using ultrasound and TENS in musculoskeletal problem, especially chronic neck pain, as one of the treatments. Because mostly therapist still using separately between ultrasound and TENS. Not only that, there are not many published studies that have analyzed the effects of combination therapy.

Even though, the result of this study revealed that the effects of FM and combination of TENS and ultrasound for non-specific chronic neck pain can be used.

Limitation

Limitation of the current study includes no control groups to compare, no post-treatment measurement on the NDI. This including the evidence of combination treatment ultrasound and TENS for neck pain treatment.

First limitation is this study is the absence of control group. The problem appears because of the limited number of participants and no matched schedule. Since there were no natural comparison with the natural condition of chronic neck pain.

Secondly, the evidence of combination treatment using ultrasound and TENS for neck pain intervention remains unclear. There are not many researchers talked about combining those two interventions for neck pain.

Lastly, the NDI score only has two measurements time (pre and follow up only). In this study, the NDI questionnaire talked about the participant daily life activity and it was not possible to measure it for immediate effect after the treatment. Accepting these limitations, the study may be more provide the participant and the information further about combination therapy with ultrasound and TENS.

CONCLUSION

There is no different effect between Fascial manipulation and combination treatment. Both interventions have the same immediate effect after the treatment on the first meeting. However, there is no significant prolonged effects measured one week after treatment.

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Examination of training effect on low back pain using the center of gravity in unstable sitting.

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Keywords: Motor control exercise, Low back pain, Center of gravity

Abstract

[Background] Low back pain(LBP) occurs widely, with a lifetime prevalence ranging from 80% to 85%. According to the physical therapy guidelines, exercise therapy is effective for the improvement of pain and function in patients with chronic LBP. Previously, individuals with back pain have been demonstrated to have an obstacle to the control of local muscles involved in maintaining the cooperativeness and stability of the spinal column. On the basis of this finding, motor control exercise (MCE) has been developed for adjustment, control, and ability recovery.

[Purpose] In this study, we aimed to examine the effect of MCE in subjects with nonspecific chronic LBP and compare it with that of core stability exercise (CSE), focusing on the center of gravity(COG) sway while sitting on an unstable surface.

[Target] Twenty-two subjects with nonspecific chronic LBP (age, 21.5 ± 0.9 years) and 14 healthy subjects (age, 21.6 ± 0.8 years) were included in this study.

[Methods] The subjects were divided into two groups; one group performed CSE and the other performed MCE at home for 6 weeks. They performed home exercise for 6 weeks, one group performed a CSE and the other performed an MCE. Their COG sway was measured before and after the intervention. The severity of LBP was assessed over time using a questionnaire for subjects with LBP.

[Outcome] A significant decrease was observed in the intensity of LBP in both groups. And a significant decrease in COG sway was observed in both groups of subjects with LBP and in the CSE group of healthy subjects.

[Conclusion] Both MCE and CSE led to improvements in spinal stability and LBP after 3 weeks, but CSE was more effective.

Introduction

Low back pain(LBP) occurs in a wide range of people, from general adults to athletes. The prevalence of LBP in Japan (multiple responses, population per thousand, 2016) was 91.8 for men and 115.5 for women[1). LBP was more prevalent than other subjective symptoms in both men and women. LBP is a serious health problem worldwide, with a lifetime prevalence of 80-85%. The causes of LBP can be broadly classified into five categories as follows: spinal, neurological, visceral, vascular, and psychogenic[2]. However, 85% of LBP cases are nonspecific chronic LBP. Thus far, studies have focused on abnormal cortical processing of the central nervous system, including cognitive, sensory, and motor disorders[3].

With respect to the treatment of LBP, the physical therapy guideline, 1st edition, back pain physical therapy practice guideline indicates that exercise therapy is recommended as grade B or evidence level 2, and is slightly effective for improving bodily function and reducing pain in patients with chronic LBP. Active rehabilitation reduces pain in patients complaining of non-specific chronic LBP and has long-term effects (up to a year later)[4]. We focused on motor control exercise (MCE) in active rehabilitation. Subjects with LBP may present with impaired control of the deep trunk muscles (local muscles), which are involved in maintaining spinal coordination and stability. On the basis of this principle, MCE has been developed to restore coordination, control, and activity of the trunk muscles[5]. Moreover, MCE increases spinal stability[6].

In a previous study, core stability exercise (CSE) increased lumbar spinal stabilization mechanisms and decreased center of gravity (COG) sway[7]. CSE reduced back pain by improving spinal stability and decreasing COG sway during loaded seated holding.

In this study, we hypothesized that CSE and MCE would reduce LBP and decrease COG sway. The purpose of this study was to investigate the effect of MCE in subjects with non-specific chronic LBP and to compare its effect with that of CSE, focusing on the COG sway while sitting on an unstable surface.

Methods

1. Participants

Twenty-two subjects with nonspecific chronic LBP (12 men and 10 women, aged 21.5 ± 0.9 years) and 14 healthy subjects (10 men, 4 women, aged 21.6±0.8 years) were included in this study. The subjects with LBP had only back pain for >3 months and had no history of orthopedic diseases such as lumbar disk herniation. Both the subjects with LBP and the healthy subjects were randomly divided into two groups, the CSE and MCE groups. Both groups were required to perform home exercises for 6 weeks. This study was approved by the Research Safety and Ethics Committee of Tokyo Metropolitan University, Arakawa Campus(approval no.18039).

2. COG sway measurement

All the study subjects were assessed for COG sway during seated holding at the beginning of the experiment (pre – intervention) and at 3 weeks (intermediate) and 6 weeks after the intervention (post-intervention). COG sway was measured with a COG sway meter (Gravicorder GS-11, Anima) at a sampling frequency of 20 Hz. The following parameters were measured: total trajectory length (LNG), unit trajectory length (LNG/TIME), left-right trajectory

Fig. 1 Unstable sitting position with the shoe sole above the ground. The subject is seated on a balance cushion.

length (MEAN OF X:MX), and front-back trajectory length (MEAN OF Y:MY). A wooden board and gravimeter were placed on a liftable bed, and COG sway was measured while sitting. One side of the gravimeter was placed in line with the edge of the bed. The subjects were seated in the mid-pelvic sitting posture with both upper limbs folded in front of the chest. The bed height was adjusted to set the subject' s hip and knee angles to the right angles, with their soles in contact with the ground. In the unstable sitting posture, a balance cushion was placed on the gravimeter, and the subject was held in the sitting posture with the sole ungrounded (Fig. 1). The end of the balance cushion was aligned with the bed end and the edge of the gravimeter, and the sitting posture was such that the ischium was in the posterior quarter of the balance cushion. For all the measurements, the subjects looked at the target with a 3-cm diameter placed 2 m away and held the position for 30 seconds. The target was adjusted to the height of subject' s eyes. Measurements were taken for the last 20 seconds. COG sway was measured twice each for plantar-grounded, ungrounded, and unstable sitting, with a 2-minute rest period after each measurement. Before the measurement in the unstable sitting position, a practice period of 1 minute was allowed to enable the subjects to sit for 1 minute, and then a 2-minute rest period was given. The measurement method was based on that reported by Suzuki et al[8].

3. Pain intensity assessment

Pain was assessed using the scores in the functional assessment questionnaire (Japan Low Back Pain Evaluation Questionnaire[JLEQ][9]) for subjects with chronic LBP. The JLEQ is a self-administered questionnaire developed to evaluate the effectiveness of exercise and conservative treatment for subjects with chronic LBP, with a maximum score of 120 and lower values indicating a better status. As a subjective pain assessment, this rating scale was used to investigate the extent to which LBP affects daily life. The participants were asked to fill out a questionnaire about their most recent life situation, and the scores were compiled and compared.

4. Home exercises

MCE was performed, as shown in Fig. 2. The subjects stood 90 cm from the wall, with their feet shoulder-width apart and a laser pointer attached to their waist (anterior superior iliac spine) with a band. They traced the figure attached to the wall with the light of a laser pointer for 1 minute, followed by a rest period of 1 minute; 3 such sets were performed per day. The following three types of target figures were prepared: (1) a star-shaped target, (2) a flower-shaped target with only curves, and (3) a target with a mixture of straight and curved lines. The subjects performed the exercise randomly. The subjects were instructed to trace the line as slowly as possible without going beyond the line, and to control the light not by flexion of the knee joint but by pelvic tilting.

With respect to the CSE group, CSE was performed, as shown in Fig. 2. One set of exercises involved raising the right and left legs horizontally from a four-crawl position

Fig. 2 Posture assumed by the subjects when performing the home exercise.
(1) Posture during motor control exercise (2) Posture during core stability exercise

for 15 seconds, followed by immediately switching the sides and holding for 15 seconds. The subjects then rested for 30 seconds, and 5 such sets were performed per day. The subjects were instructed regarding the posture to be maintained during the exercises when measurements were recorded at the pre-intervention and intermediate time points; they were also instructed to minimize the performance of compensatory movements such as trunk and lumbar extension and pelvic rotation.

The participants were asked to perform the exercises 4 days a week for 6 weeks and to record the days of their performance on a training record sheet. They sent us the record sheet every week to track their progress. For MCE, the subjects recorded the number of figures used for the exercise on the sheet.

5. Statistical analysis

A statistical analysis was performed between the CSE and MCE groups using two-way repeated-measures analysis of variance for the JLEQ score, followed by the main effect and multiple comparison tests for items that were significantly different.

Regarding the measurement of COG sway, the differences between the mean values of the LBP and healthy groups before the intervention were tested, and whether the two groups had a significant difference was assessed. In addition, a correlation analysis was performed using the JLEQ scores of each COG sway measurement in the LBP group before the intervention to determine whether a correlation exists between pain intensity and COG sway. A three-way analysis of variance (ANOVA) was performed on three time COG sway measurements in the healthy and LBP groups, and simple main effect and multiple comparison tests were performed on the items that showed significant differences in main effect.

The statistical procedures were performed using IBM SPSS Statistics 24 at a 5% significance level.

Results

1. JLEQ score

We observed a significant decrease in the scores and subjective LBP in the pre-intervention, intermediate, and post-intervention (Fig. 3). The scores were not significantly different between the two groups ($p = 0.597$). A gradual decrease in the scores between the three measurements was observed, but the rate of change was greater between the pre-intervention and intermediate measurements than between the intermediate and post-intervention. The main effect test for the time factor was significant only in the CSE group (CSE: $p = 0.010$, MCE group: $p = 0.066$). A multiple comparison test for the time factor in the CSE group revealed a significant difference between the pre-intervention and intermediate measurements ($p = 0.004$; intermediate vs. post-intervention: $p = 0.332$).

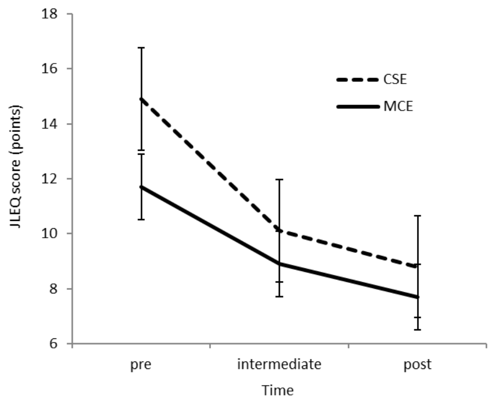

Fig. 3 Rate of change in the JLEQ score
There was no difference between two groups ($p>0.05$). But both groups show significantly decrease ($p<0.05$).

		CSE				MCE			
		pre	intermediate	after		pre	intermediate	after	
LBP	LNG(cm)	19.67±6.00	15.58±5.14	14.42±5.25	*1*2	21.28±6.74	17.85±6.01	17.46±6.39	*1*2
	LNG/TIME(cm/s)	0.98±0.30	0.78±0.26	0.72±0.26	*1*2	1.06±0.34	0.89±0.30	0.87±0.32	*1*2
	MX(cm)	13.58±4.09	10.37±4.09	9.45±3.16	*1*2	13.49±4.61	11.72±4.25	11.15±4.33	*1*2
	MY(cm)	11.30±3.54	9.49±2.95	8.94±3.61	*2	13.10±4.08	10.97±3.43	11.05±4.10	*1*2
healthy subjects	LNG(cm)	20.24±5.61	17.26±4.25	15.55±4.59	*2	14.10±5.06	13.44±5.00	13.70±3.73	
	LNG/TIME(cm/s)	1.01±0.28	0.86±0.21	0.78±0.23	*2	0.71±0.25	0.67±0.25	0.69±0.19	
	MX(cm)	13.44±3.72	11.97±3.23	10.17±3.18	*1*2	9.06±3.73	8.89±4.12	8.88±2.57	
	MY(cm)	12.30±3.52	9.93±2.24	9.59±2.72		8.96±2.91	8.21±2.42	8.55±2.27	

Table. 1 COG sway measurements during unstable sitting (mean value ± SD)
*1: significant difference between pre and intermediate ($p<0.05$), *2: significant difference between pre and after ($p<0.05$)

We found no correlation between the JLEQ score the pre-intervention, intermediate, and post-intervention.

2. Center of gravity sway

The COG sway measurements are shown in Table. 1. The SD of each pre-intervention measurement was large in both the healthy and LBP groups, indicating large individual differences. No significant differences in the mean values of each measurement and all measurements were found between the LBP and healthy groups.

Three-way ANOVA was performed for the three measurements of all the subjects, and the main effects of the time factor were significant in MX and RMS in the stable sitting position. The main effect of the time factor was significant in LNG, LNG/TIME, MX, and MY in the unstable sitting position. No interaction effect was found for any of the items.

When a simple main effect test was conducted on the time factor of the item that was significant as described above, many items were significant in the CSE group of subjects with LBP and healthy subjects and in the MCE group of subjects with LBP. We found no significant items in the MCE group of healthy subjects.

When multiple comparison tests were performed for the time factor in the above-mentioned items, significant differences were observed between the pre-intervention and intermediate measurements and between the pre-intervention and post-intervention, but no significant difference was found between the intermediate and final measurements. Both groups showed significant differences between the subjects with LBP and healthy subjects. Especially in the case of LNG, LNG/TIME, and MY of the CSE group and the MCE group of subjects with LBP, the effect of time was significant in the pre-intervention and final measurements.

Discussion

Effectiveness based on the JLEQ score is judged differently. Some researchers judge effectiveness based on a decreasing rate, and others judge it based on a decrease in the score by >1 point[8, 10]. In this study, the rate of decrease in the JLEQ scores from the pre-intervention to the post-intervention was 40.9% in the CSE group and 34.2% in the MCE group. On the basis of the studies in which subjects were considered to have the same level of LBP severity as subjects in the present study, this decrease in JLEQ score was not considered a significant improvement[8]. However, as the score significantly decreased, we considered that both exercises contributed to the decrease in LBP severity. The rate of change between the pre-intervention and intermediate measurements was greater than between the intermediate and post-intervention in both groups, which suggests that both exercises were effective in improving the LBP within 3 weeks and that further improvement was observed with continuation of the exercises. In terms of the effects of muscle strengthening training, the initial maximum increase in muscle strength is largely due to the activity of the central nervous system, including an increase in the number of active motor units and synchronization of the activities of multiple motor units, and the muscle cross-sectional area increases with prolonged training[11]. The improvement in LBP at 3 weeks suggests that the LBP improved owing to the activity of the local muscles. This was not a result of the muscle strengthening in the CSE group, but the effect of the activation of muscle activity. The test results for the main effect of the time factor were significant only between the pre-intervention and intermediate measurements in the CSE group. However, the rate of change between the intermediate and final measurements was 12.9% in the CSE group and 13.5% in the MCE group, which was not significantly different between the two groups. This is because the subjects in the CSE group experienced slightly more severe LBP based on the mean JLEQ scores at the pre-intervention time point; therefore, the rate of decrease in the JLEQ score may have been greater in the CSE group. Considering this, the degree of improvement of LBP is expected to be the same in the two groups.

We found no correlation between the JLEQ score and pre-intervention measurement of COG sway or a significant difference in each pre-intervention measurement of COG sway between the two groups of healthy subjects and subjects with LBP. The standard deviation of each pre-intervention measurement was large in both the healthy and LBP groups, which suggests that individual differences are largely responsible for the difference in the magnitude of COG sway. Regarding the fact no relationship was observed between COG sway and pain intensity, the mean pre-intervention JLEQ score in the LBP group in this study was 14.9 ± 8.1 in the CSE group and 11.7 ± 8.1 in the MCE group. Considering the 120-point scale, the JLEQ score was severe enough to be significantly different from that of the healthy subjects. In a few individuals, LBP is considered to have no effect on COG sway, unless the LBP was severe. Pain intensity was scored subjectively, and the influence of individual differences in pain perception may be significant.

Regarding the changes in COG sway measurements, MCE had no significant effect on spinal column stabilization in the healthy subjects. However, in the healthy subjects, the COG sway before the intervention was smaller in the MCE group, and it is presumed that many subjects had high spinal stability as well. Therefore, the decrease rate in COG sway was considered small, and no significant differences were found.

Bergmark et al.[12] classified muscles into superficial (global system) and deep muscles (local system) according to their functional role in joint stabilization. Global muscles are not directly attached to the vertebrae but are located superficially across the multi-segment and generate torque for spinal movement. On the other hand, initiation or cessation of local muscles in the lumbar spine refer to those muscles whose origin or cessation is in the lumbar vertebrae, which are involved in the stiffness and intervertebral relationship of the spinal segment and the postural control of the lumbar segment and spinal stability. Regarding the relationship between COG sway and spinal stabilization, Zadka et al.[13] stated that in the unstable sitting position, the right and left lumbar dorsal muscles, which are considered global muscles, break the forward tilt of the seat, and the right and left abdominal oblique muscles break the backward tilt of the seat. Zadka et al.[13] and Preuss et al.[14] reported that both the lumbar and contralateral lumbar dorsal muscles (the external and internal abdominal obliques and erector thoracic spinal muscles) break the lateral tilt of the seat in an unstable sitting position. In addition, Suzuki et al.[15] investigated trunk muscle activity in the unstable sitting position and found significant positive correlations between the global rectus abdominis and thoracolumbar spine muscles and COG sway. Conversely, no significant correlation was observed between the COG sway of the local muscles and that of the internal oblique and lumbar multifidus muscles. These results suggest that the activation of local muscle activity and static contraction improved spinal stability, and decreased COG sway during unstable sitting by breaking the tilt of the local muscle to the front and back, and to the left and right.

With respect to the effect of local muscle activity on COG sway, Hodges et al.[16] reported that afferent input from peripheral mechanoreceptors and other sensory systems must be interpreted, and then a coordinated response of the trunk muscle must be generated so that the muscle activity occurs at the correct time, with the correct amplitude, in response to unexpected challenges such as sitting on an unstable surface. Tanemoto et al.[17] stated that deep trunk muscles are more involved in somatosensory functions such as intrinsic receptor sensations. They stated that the activation of the deep trunk muscles may trigger a feedback system that provides information regarding intersegmental motions and positional changes of the spine, which may facilitate postural control and reduce COG sway.

In summary, the local muscles may be involved in improving spinal stability owing to their muscle contractile activity and may also contribute to the reduction of COG sway by acting as intrinsic receptors.

On the basis of these considerations, we have discussed the differences in exercise effectiveness between CSE and MCE. Ito et al.[18] described the lumbar spine stabilization system as being, composed of the following three subsystems: (1) a passive lumbar stabilization system (PS) that focuses on the vertebral body, intervertebral disks, intervertebral joints, and ligaments; (2) an active subsystem (AS) that focuses on a group of flexors such as the abdominal muscles and a group of extensor muscles such as the erector spinae, which stabilizes the lumbar spine; and (3) a neural subsystem (NS), which efficiently coordinates the activities of these systems. The transverse abdominis and internal oblique muscles are essential for lumbar spinal stability. According to Yoon et al.[19], CSE involving raising the limbs from a four-crawl position, which was used in this study, activates the medial obliques, external abdominal obliques, multifidus, and erector thoracic spinal muscles. The dorsal and trunk muscles showed greater activity when the unilateral lower limb was raised than when only the unilateral upper limb was raised. In this study, while raising the unilateral lower limb or the unilateral and contralateral upper limbs, the CSE may have increased the muscle activity of the back and trunk muscles, especially the medial and external abdominal obliques, lumbar multifidus, and thoracic erector spinae, which resulted in lumbar spinal stability. On the other hand, MCE is performed to coordinate, control, and restore the ability of the trunk muscles, but as Hodge et al.[16] stated, a coordinated response of the trunk is required to maintain unstable sitting; thus, MCE may affect the reduction of COG sway in terms of improving trunk coordination.

Both CSE and MCE were effective in improving LBP and reducing COG sway, but the differences in their effects were small. In the present study, we found no significant difference in the effect of the exercises in the patients with mild LBP because of the small difference in COG sway between them, and healthy subjects. In addition, the intervention period was only 6 weeks, and the effect of muscle strengthening was not significant. To investigate the difference in exercise effectiveness in the future, it is necessary to conduct a similar study with a longer intervention period in subjects with more severe LBP.

Conclusion

The effects of both CSE and MCE improved spinal stability and subjective LBP in 3 weeks. CSE and MCE showed approximately the same degree of efficacy in reducing LBP and COG sway while sitting on an unstable surface, indicating that spinal stability and trunk muscle coordination were involved in the reduction of LBP and COG sway. The results showed that CSE improved spinal stability and trunk muscle coordination in the subjects with LBP and reduced COG sway in the subjects with and without LBP. To further investigate the differences in exercise effectiveness in the future, studies must include subjects with severe LBP and longer intervention periods.

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Survey on Skills Education for Physical Therapists in Japan

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Keywords: Registered physical therapist, Skills education, Survey

ABSTRACT: [Background] Japan has a super aging society, and, thus, the activities of physical therapy should be improved in their qualities, besides the quantities demanded so far, to meet the needs of the times. Therefore, the skills of physical therapists need to be improved. However, in recent years, the techniques and qualifications of physical therapy have deteriorated in Japan. Therefore, good quality education for physical therapists is required before and after graduation. [Purpose] The purpose of the present study was to conduct a survey on attitudes toward physical therapy skills and to help ensure that effective technical education is practiced. [Participation and Methods] Subjects comprised 100 working physical therapists (6.54 ± 3.02 years) working on-site. Subjects completed a web-based questionnaire, which consisted of nine questions with a multiple-choice, 10-step, and free entry method. [Results] Self scores for palpation and physical therapy skills were low, with means of 3.85 and 3.66 out of 10 points. Regarding the acquisition of physical therapy techniques, 53% of subjects indicated that they were learned at seminar workshops, while 45% stated that a stronger focus on 'knowledge of basic medicine' was needed at training schools. Furthermore, 64% responded that they started studying hard in the first year. As a reason, 34% responded "Helplessness and lack of ability". [Discussion] The present results showed that subjects felt that they lacked knowledge of basic medicine as well as palpation and evaluation skills in self-assessments. Therefore, training school education and the lifelong learning system of the Japanese Physical Therapy Association may be insufficient. [Implications] The results of this survey indicate that basic medical education at training schools and educational opportunities in the first year are important for future physical therapy education.

[Background]

Japan is a super aging society, and the abilities and roles required of physical therapists (PT) are not only in the medical field, but also in the field of health care, such as the extension of healthy life expectancy, participation in nursing care prevention activities, and industrial PT. The activities of physical therapy should be improved in their qualities, besides the quantities demanded so far, to meet the needs of the times 1).

However, in recent years, the abilities and qualifications of PT in Japan are considered to be inadequate 2). One of the reasons for this is the increase in the number of students enrolled in training schools. The number of students enrolled in training schools, which was less than 4,000 in 1999, increased to 13,635 in 2016 3). Therefore, the development of an appropriate training and education system for new PT, which markedly exceeds the number of experienced PT, is warranted. Furthermore, high-quality PT education in the pre- and postgraduate periods is needed.

In the present study, a survey was conducted on PT techniques to improve the technical education for PT.

[Methods]

Subjects were PT for musculoskeletal diseases. They were asked to complete a web-based questionnaire (SurveyMonkey). One hundred subjects (average years of experience, 6.54 ± 3.02 years) who agreed with the purpose of the present study after written and oral explanations completed the questionnaire on the designated questionnaire page. The average response time required to complete the survey was 4 minutes and 8 seconds. The collection period was one year, from December 2017 to December 2018.

Table 1. Question items

1	Acquisition of palpation skills (Fig. 1)
2	Elements of own palpation skills (Fig. 2)
3	Acquisition of therapy skills (Fig. 3)
4	How PT skills were learned (Fig. 4)
5	Skills to improve in the workplace (Fig. 5)
6	Minimum instructor-to-student ratio for skills acquisition (Fig. 6)
7	What should have been done during your school days? (Table 2)
8	Changes in approaches to learning as a student and professions (Fig. 7), and reasons and time periods for changes (Table 3)

The questionnaire involved a multiple-choice, 10-step, and free entry method. The following questions were asked (Table 1): 1. Acquisition of palpation/treatment techniques; 2. How PT skills were learned; 3. Skills to improve in the workplace; 4. Ratio of instructors to students for skills acquisition; 5. What should have been done during your school days? 6. Changes in approaches to learning as a student and profession and the underlying reasons. Each question item was tabulated and averaged. Responses to free entry questions were categorized by keywords.

The present study was conducted with the approval of the Research and Ethics Committee of Nihon Institute of Medical Science (No. 2017027).

[Results]

The results obtained for the questions listed in Table 1 were as follows.

Figure 1 shows the acquisition of palpation skills at 10 levels. The average was 3.85.

Figure 2 shows the elements of their own

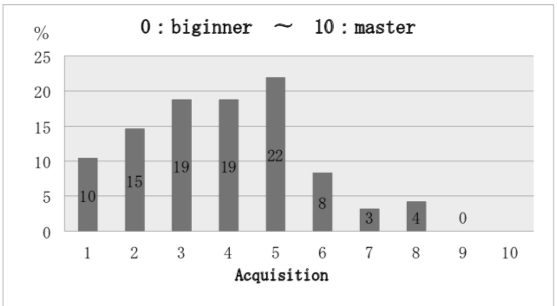

Fig. 1. Question1: Acquisition of palpation skills (Ave3.85)

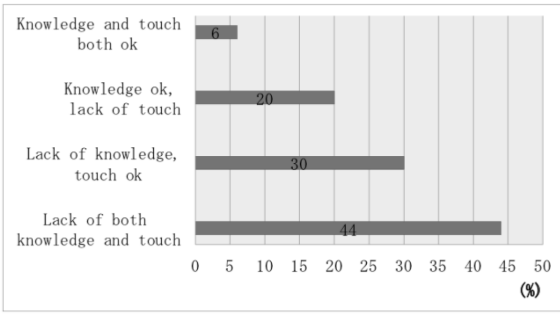

Fig. 2. Question2: Elements of own palpation skills

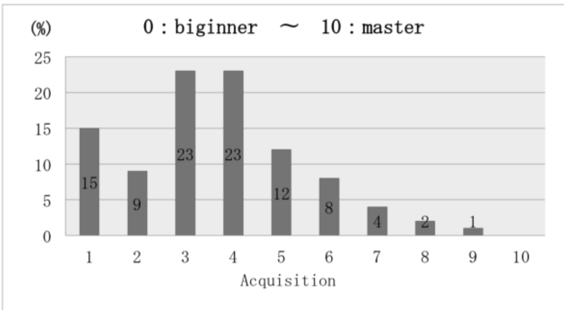

Fig. 3. Question3: Acquisiton of therapy skills (Ave3.66)

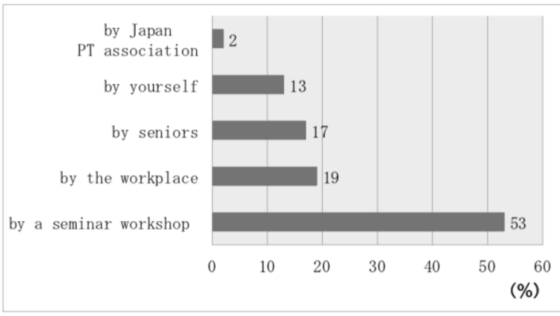

Fig. 4. Question4: How PT skills were learned

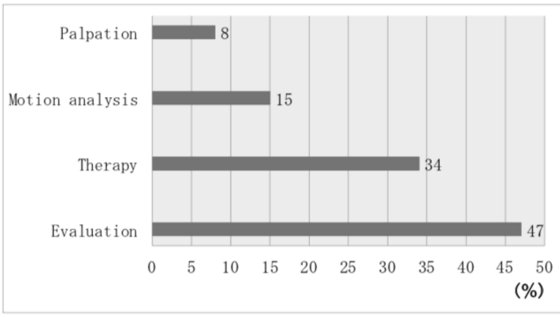

Fig. 5. Question5: Skills to improve in the workplace

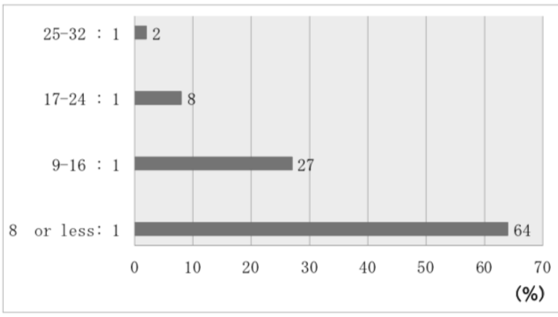

Fig. 6. Question6: Minimum instructors-to-student ratio for skills acquisiton

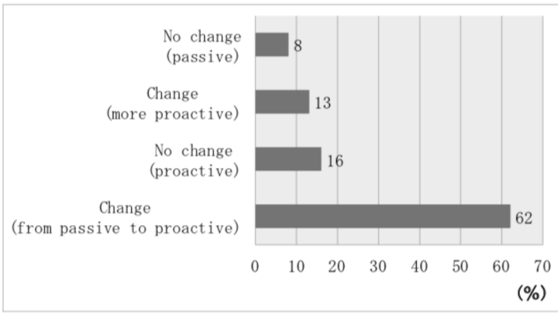

Fig. 7. Question8: Changes in approach to learning at a student and professional

Table 2. Question 7: What should have been done during your school days? (n=92)

Item	Number (%)
Knowledge of basic medicine	42 (45.7%)
PT evaluation ability	23 (25.0%)
Palpation	16 (17.4%)
Therapy & handling	7 (7.6%)
Motion analysis	4 (4.3%)
Social courtesy	5 (4.3%)

palpation skills, with 70% of subjects responding that their palpation skills were inadequate.

Table 3. Reasons and time periods for “changes” in Question 8 (n=73)

Reason	Number (%)
Helplessness and lack of ability	25 (34.2%)
Responsibility to patients	14 (19.2%)
Emergence of a role model	8 (11.0%)
Environmental changes (e.g., work place)	8 (11.0%)
Opportunities to educate students	7 (9.6%)
Participation in seminar workshops	7 (9.6%)

Timing	Number (%)
Intern	4 (5.6%)
1st year	46 (63.9%)
2nd year	15 (20.8%)
3rd year	6 (8.3%)
5th year	1 (1.4%)

Figure 3 shows the acquisition of therapy skills at 10 levels. The average was 3.66.

Figure 4 shows how PT skills were acquired; 53% of subjects learned PT skills at seminar workshops, followed by the workplace, and from senior therapists.

Figure 5 shows the results of skills to be improved in the workplace, with approximately 50% of subjects indicating a desire to increase their evaluation ability.

Figure 6 shows the minimum instructor-to-student ratio for skills acquisition. This result also shows the limits of skills education in training school education.

Figure 7 shows changes in approaches to learning as a student and professional; 60% of subjects became active learners in the workplace, whereas approximately 10% were “passive”.

Table 2 shows a summary of answers to Question 7, ‘What should have been done during your school days?’ Approximately 50% of subjects reported a lack of knowledge. Other answers are shown in Table 2.

Table 3 shows the results of subjects who responded ‘There was a change’ to question 8, with 50% citing ‘a lack of ability’ and ‘a sense of responsibility to patients’ as the underlying reasons and the most common time period for this change being in the first year (63%).

[Discussion]

Among PT with 6.54 ± 3.02 years of experience, the results of Questions 1 and 3 were high at 3.85 and 3.66, respectively, on a 10-point scale (FIG. 1, FIG. 3). The reason for this may be a lack of knowledge and perceived lack of tactile and evaluation skills in the self-assessment (FIG. 2, FIG. 5).

This can be seen in the responses to Question 8 “Changes in the attitudes of learning between school days and today”. Specifically, more than 60% responded “passive to positive changes” after being qualified (FIG. 7). As shown in Table 3, the perceptions by subjects of their own lack of competence and perceived responsibility to patients appeared to change in the first year of becoming a qualified PT. These results suggest that subjects with 6.54 ± 3.02 years of experience have no confidence in acquiring and practicing the techniques of physical therapy, resulting in a low value. Regarding the acquisition of PT skills, the majority of subjects learned these skills through seminar workshops, suggesting that similar to knowledge, education in training schools and the lifelong learning system of the Japanese

Physical Therapy Association are insufficient (FIG. 4). In the results shown in Table 2, nearly 50% of subjects indicated their lack of knowledge of basic medicine as students. Unsurprisingly, we believe that this is a result of recognizing that even if they have enough knowledge to pass the national examinations, they still need to have a deeper knowledge in order to practice effective PT in clinical setting. Many subjects indicated that evaluation and palpation methods were essential. These results suggest a significant gap between training school education and the skills needed in clinical practice. The ratio of one lecturer to 40 students is common in skills education at training schools in Japan.

In 2020, the designated rules for training physical and occupational therapists were revised for new students for the first time in 20 years. Specifically, the current educational contents of physical therapy were improved and the problems in clinical practice were resolved. The results of our survey revealed the need for further improvement in the Japanese curriculum regarding the knowledge of physical therapy and the methods of technical education for PT to play an active role in clinical practice. The need for post-graduate education for PT has been widely reported, and the training of new PT in clinical practice is common 1) 4) 5). Therefore, it is important to provide effective educational opportunities in the early stages of the career of PT, such as post-graduate training in the workplace and participation in training sessions.

JAOMPT was admitted to the IFOMPT in 2008 6). In training sessions held by JAOMPT, a curriculum of lectures on basic medical knowledge and practical training is implemented in accordance with the educational standards developed by the IFOMT. Responses by more than 60% of subjects to question 8 revealed that the number of students per instructor needs to be less than 8 in order to facilitate the learning of skills (FIG. 6). Therefore, effective education is provided by experienced instructors in JAOMPT’s training sessions. Exemplary responses to Question 9 include emergence of a role model (Table 2). Instructors with OMT serve as role models for would-be PT.

The results of this survey suggest that basic medical education at training schools and educational opportunities in the first year are important for future PT education.

This survey had some limitation, such as the lack of detailed demographic information on subjects and specific definitions of knowledge and skills in the questions asked.

Further studies are needed on a larger sample number, with a focus on less experienced PT, such as those in their first year, the relationship between the number of years of experience and responses, and the impact of the revisions to the Japanese designated rules.

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Measurement of scapulo-humeral rhythm and related factors

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Keywords
Scapulo-humeral rhythm, simple measurement, related factors

Abstract
The purpose of this study was to investigate the relationship between conventional reports and to investigate factors related to scapulo-humeral rhythm using a simple method to measure scapulo-humeral rhythm. The study included 10 subjects (10 shoulders) with no disorder of or past medical history involving the shoulder joint (mean age: 25.2 ± 2.8 years). For the measurement of scapulo-humeral rhythm, subjects performed scapular plane elevation in a sitting position according to a previous study, and the distances between each landmark on the scapula and spine were measured at 0°, 30°, 60°, 90°, 120°, and 150° shoulder joint abduction angles. Furthermore, we measured factors such as scapular upward rotation angle and the wall acromial distance with the upper limb hanging downwards and the distance between the acromion and floor in a lateral position with thoracic spine rotation and evaluated their relationships with scapulo-humeral rhythm. In this study, we reported the average scapulo-humeral rhythm to be 3.12:1. Analysis of related factors showed that scapulo-humeral rhythm was positively correlated with the wall acromial distance ($r = 0.64$, $p<0.05$) as well as the distance between the acromion and floor in a lateral position with thoracic spine rotation ($r = 0.78$, $p<0.05$). The study suggests that scapula malposition caused by anterior tilting of the scapula is involved in the reduction in scapular upward rotation angle related to scapulo-humeral rhythm.

【Introduction】
Optimal function of the shoulder is reliant on the coordinated movement of the scapula and the humerus. A humerus in the elevation movement of the shoulder joint and the scapular sense of cooperation are made the definition as scapulo-humeral rhythm (SHR)[1)], and it is reported that the scapular movement for the humerus moves by a constant ratio of 2:1[2)]. It is reported

that the disorder of this SHR is associated with the dysfunction of shoulders such as the subacromial impingement disorder, and the like[2]. The factors that effect SHR such as decline of scapular function due to aging[3], the posture of the thoracic kyphosis rank[4], and diseases such as frozen shoulder[5] or rotator cuff injury[6] have been reported. However, there are few reports about the relationship between scapular malposition and stiffness of the scapular muscles. In addition, common, but, as for the measurement of the SHR, the studies such as X-rays or the three-dimensional motion analysis[7)8)], and the like cannot measure those studies by problems such as the involvement to a body and the gap of the skin marker position, the measurement environment, and the like easily. Therefore we cannot measure SHR in many subjects using conventional methods. For the rating system of simple scapula malposition, Kibler scapula lateral slide test[9] and Diveta test[10] to measure distance from a spinal column to inferior angle of the scapula are reported as a physical therapy evaluation now, there are few reports evaluating the ratio of the SHR. Therefore in this study, we devised a procedure to evaluate SHR that can be easily performed of the shoulder scapula aspect elevation from each scapular landmark and distance between the spinal column that we could perform easily, and demanded SHR at the shoulder elevation and examined the investigation of the relationship with the conventional report and a factor related with the SHR.

【Methods】

The study included 10 shoulders of 10 healthy adults (mean age: 25.2 ± 2.8 years) with negative findings in the impingement tests by Neer and Hawkins. We explained the purpose and significance of this study to subjects and obtained their written consent. For the measurement of SHR, subjects performed scapular plane elevation in a sitting position, and the distances between each scapular landmark and the spine at 0°, 30°, 60°, 90°, 120°, and 150° shoulder joint abduction angles were measured using a carpenter’s square (Fig. 1).

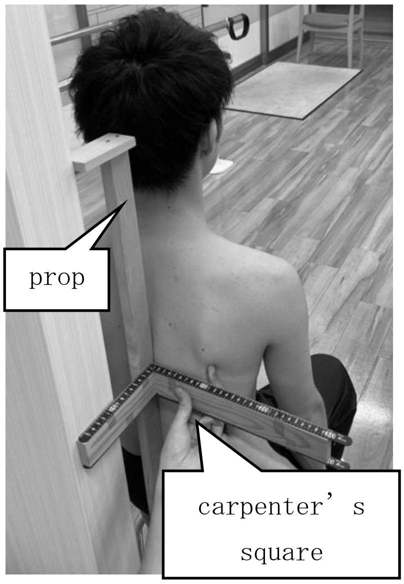

Fig. 1 Setup for measuring scapulo-humeral rhythm

The setup was carefully designed to avoid pelvic retroversion.

During the measurement, we carefully avoided lateral bending of trunk movement and pelvic retroversion rank using a prop. It prescribed the line which linked the middle point of bilateral posterior superior iliac spines from the seventh cervical vertebrae spinous process with trunk axis O and put it together to a prop and rearranged it.

We designated the medial border of the spine of the scapula as point A, the inferior angle of the scapula as point B, the intersection point of a perpendicular line from point A and a horizontal line from point B as point C, and the angle between AB and BC as θ. We measured the distances between the trunk axis and point A (OA), and the trunk axis and point B (OB); the difference between OB and OA was considered as the distance between point B and C (BC). We also calculated the distance between point A and B (AB), and $\cos\theta$ was calculated using the formula (1) (Fig.2).

$$\underline{\cos\theta = BC/AB} \cdot \cdot \cdot \cdot (1)$$

Next, we determined the arc degree using the formula (2).

$$\underline{\text{radian} = \cos^{-1}(\cos\theta)} \cdot \cdot \cdot \cdot (2)$$

The measured numerical values were converted into degrees using the formula (3).

$$\underline{\text{degree} = \text{radian} * 180/\pi} \cdot \cdot \cdot \cdot (3)$$

After converting the values in degree into positive values, and the upward rotation angle (θ') was calculated using the formula (4).

$$\underline{\text{scapular upward rotation angle } (\theta') = 90 - \angle ABC} \cdot \cdot \cdot \cdot (4)$$

The upward rotation angle of each elevation angle was calculated using the above formula. Next, the movement of the humerus in SHR was calculated based on the change in the upward rotation angle at each elevation angle. All distances were measured twice, and the average value was used for analysis.

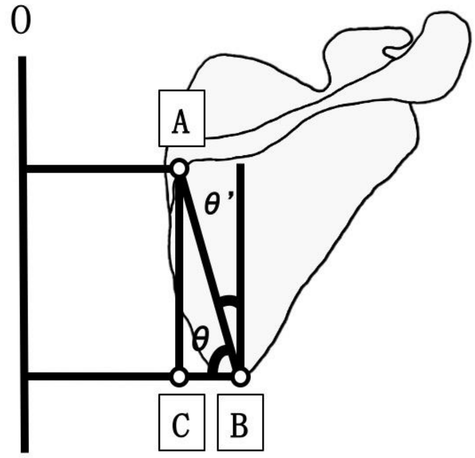

Fig.2 Analysis method

O: the human trunk axis that linked the middle point of the posterior superior iliac spine on both sides and the seventh cervical vertebra transverse process,

A: the medial border of the spine of the scapula,

B: the inferior angle of the scapula,

C: the intersection point of a perpendicular line from point A and a horizontal line from point B.

a

ICC (1, 1)	OA	OB
0°	0.99	0.99
30°	0.98	0.99
60°	0.99	0.97
90°	0.93	0.88
120°	0.93	0.89
150°	0.87	0.83

b

ICC (2, 1)	OA	OB
0°	0.99	0.99
30°	0.98	0.99
60°	0.99	0.96
90°	0.92	0.86
120°	0.92	0.89
150°	0.87	0.81

Table.1 Intraclass correlation coefficients

a: Intraclass reliability,

b: Interclass reliability,

OA: Distance from human trunk axis O to the medial border of the spine of the scapula,

OB: Distance from human trunk axis O to

the inferior angle of the scapula.

Both the intraclass and interclass reliability of this method were as high as 0.81 or higher in the intraclass correlation coefficient (Table.1).

The factors related to SHR, such as scapular upward rotation angle with the upper limb hanging downwards, the wall acromial distance[11] (WAD) in the sitting position, and the distance between the acromion and floor in a lateral position with thoracic spine rotation (TR-AFD) in the lateral decubitus position, were measured (Fig.3).For the measurement of WAD, the spinal column was in close contact with the wall in the sitting position, and the distance between the acromion posterior horn and the wall was measured in 1 cm units. For the measurement of TR-AFD, the compensation of the lumbar spine was minimum at 90° flexion of the hip joint; the shoulder girdle was passively twisted towards the dorsal side, and the distance between the posterior angle of the acromion and the bed was measured in centimeters.

The relationships between SHR and related factors were analyzed using Pearson's correlation coefficient. In addition, related factors were treated as dependent variables, whereas the changes in scapular upward rotation angle at each elevation angle were considered as explanatory variables. Multiple regression analysis was performed using a stepwise method, and the related of the extracted factors on changes in scapular upward rotation angle were investigated. All statistical analyses were performed using SPSS software version 23.0. The level of significance was set at $P<0.05$. This study was conducted according to the principles of the Declaration of Helsinki.

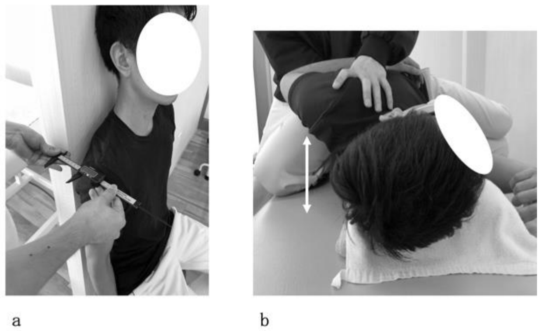

Fig.3 Measurements of wall acromial distance and acromion floor distance with thoracic spine rotation

a: Wall acromial distance,

b: acromion floor distance when thoracic spine rotation.

【Results】

The average SHR measured in this study was 3.12±0.36:1.

In our study, SHR was positively correlated with WAD ($r = 0.64$, $p<0.05$) and TR-AFD ($r = 0.78$, $p<0.05$) (Fig. 4). However, there was no correlation between SHR and the scapular upward rotation angle with the upper limb hanging downwards. Then, the relationships between WAD and the changes in scapular upward rotation angle at each elevation angle were analyzed using multiple regression analysis. The changes in the scapular upward rotation angle at each elevation angle were analyzed using multiple regression analysis. The Changes in scapular upward rotation angle at 90° to 120° abduction were measured as the factors related to WAD ($B = 0.71$, $p<0.05$). No factor related to the changes in scapular upward rotation angle was extracted at any elevation angle ($B = 0.58$, $p>0.05$).

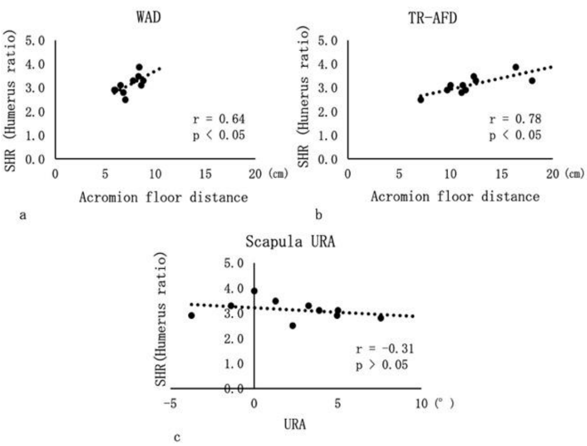

Fig.4 The Influence of related factors on scapulo-humeral rhythm

a: Relationship with WAD and the SHR,
b: relationship with TR-AFD and the SHR,
c: relationship with scapula URA and the SHR,
WAD: wall acromial distance,
TR-AFD: acromion floor distance when thoracic spine rotation,
URA: upward rotation angle,
SHR: scapulo-humeral rhythm.

【Discussion】

Previously, SHR has been reported to be between 3.2:1 and 4.3:1[8] as well as 2.89:1[12]. In this study, SHR was 3.12:1, which was similar to the previous reports using three-dimensional motion analysis. Therefore, we recommend the simple method developed in this study as one of the methods to measure SHR.

We found that SHR was positively correlated with WAD ($r = 0.64$, $p<0.05$) and TR-AFD ($r = 0.78$, $p<0.05$). WAD is one of the tools used to evaluate scapular anterior tilting[11], and TR-AFD comprehensively estimates the mobility of thoracic spine extension/rotation and scapular posterior tilting/adduction. Therefore, increasing the angle of scapular anterior tilting and decreasing the flexibility of the thoracic vertebra may increase the humeral movement ratio and decrease the scapular movement ratio in SHR. The high values of scapular malposition and TR-AFD, such as scapular anterior tilting, limit scapular posterior tilting during shoulder elevation. Furthermore, the restrictions of scapular anterior tilt and scapular posterior tilt during shoulder elevation are closely related to the stiffness of the pectoralis minor muscle[13], and it is speculated that the stiffness of the pectoralis minor muscle is related to SHR disorder.

Clinically, many diseases involving the shoulder joints, such as impingement syndrome[2)14], are associated with SHR disorder. In subacromial impingement syndrome, it has been reported that scapular upward rotation and posterior tilt angle significantly reduced at 90° abduction[15], and the changes in WAD and scapular upward rotation angle observed in this study were similar to the related angle. Therefore, it is clinically possible that mechanical stress, such as impingement, can be reduced by improving scapula malposition of the scapular anterior tilt in diseases involving the shoulder joints caused by SHR disorder.

【Limitation】

Measurement procedure of the SHR of this study is two-dimensional measurement and cannot prove a related factor and the relationship with the three-dimensional scapular movement.

【Conclusion】

Although the method described in this study is based on two-dimensional measurement, it is one of the methods that can easily measure SHR clinically. This study suggests that the scapular malposition of the scapular anterior tilt might contribute to the reduction in the change in scapular upward rotation angle in SHR.

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Effects of rotator cuff muscle training

～ pre-exercise vs post-exercise, baseline vs one month of training ～

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Key words：shoulder, warm-up, injury prevention

Abstract

This study aimed to investigate the effects of immediate and periodic low-intensity RCM (rotator cuff muscle) training on the IR (internal rotation) torque of the shoulder. Twenty-six healthy men with no previous shoulder injuries were divided into training (n=13) and control (n=13) groups. In both groups, IR torque were significantly decreased in six positions by the single RCM training ($p<0.05$). After the one-month training, the IR torque significantly increased at all positions in the training group ($p<0.01$).

Introduction

Low-intensity internal/external rotation leads to adequate activation of the RCM (rotator cuff muscle)[1)]. RCM training may be beneficial for throwers during their pre-throwing routine[2)]. The effects of RCM training are still unclear[3-7)]. This study aimed to investigate the effects of immediate and periodic low-intensity RCM training on the IR (internal rotation) torque of the shoulder.

Subject & Method

The experimental procedures are summarized in Figure 1. Informed consent was obtained from all subjects. Twenty-six healthy men with no previous shoulder injuries were randomly and equally divided into training (n=13) and control (n=13) groups. First, we measured the isometric IR torque for 3 seconds using isokinetic dynamometer (Biodex system 4, SAKAI Medical) in the dominant shoulders of all subjects (n=26) (Ba-pre (Baseline-pre)) . Isometric IR in a seated position with the elbow flexed at 90° were measured in these eight positions randomized: 90 ° of shoulder abduction ((1)90 ° ER (external rotation), (2)60° ER, (3)30° ER, (4)0° ER, (5)30° IR) and 0° of shoulder abduction ((6)30° ER, (7)0° ER, (8) 30° IR). Muscle activation was assessed in the clavicular portion of the PM (pectoralis major), latissimus dorsi, and anterior

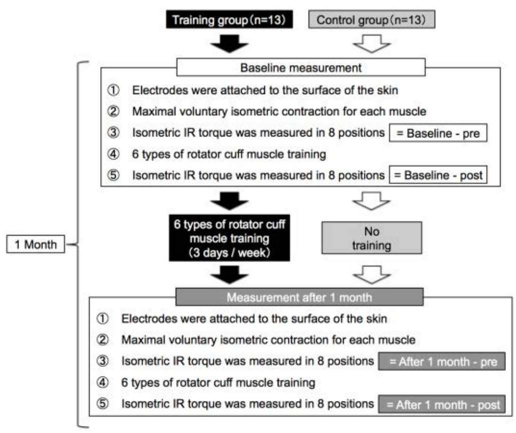

Figure 1. Experimental procedures

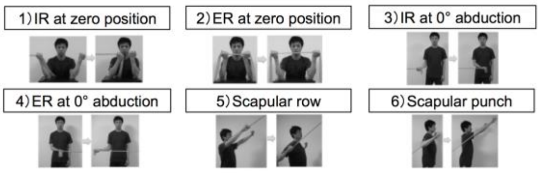

Figure 2. Six types of RCM training

deltoid by surface EMG (electromyogram) (MQ Air, KISSEI COMTEC). The surface EMG was attached in line with the muscle fibers, with an interelectrode distance of approximately 2.0 cm. The subjects rested for a minimum of 2 minutes between trials. Ten minutes after finishing all measurements, six types of RCM training protocols were performed (Figure 2)： 1) IR at zero position, 2) ER at zero position, 3) IR at 0° abduction, 4) ER at 0° abduction, 5) Scapular row, 6) Scapular punch. These are commonly introduced in training textbooks and are often practiced for baseball player. We provided a 2 minutes rest period between exercises to control for any fatigue effect. The subjects performed 1 set each of the six types of RCM training protocols, and the elastic band (THERABAND-yellow, SAKAI Medical) loads were described as "feeling fatigued deep in the shoulder". After every RCM training was completed, we measured the isometric IR torque in eight positions for all the subjects (Ba-post (Baseline-post)). After the baseline measurements, subjects in the training group performed six types of RCM training 3 days per week for 1 month. In both groups, we measured the isometric IR torque in eight positions after one month (Af-pre (After 1 month-pre)). After the isometric IR torque was measured in the eight positions, six types of RCM training protocols and isometric IR torque measurements were performed; these measurements were recorded using a process similar to that used for recording the baseline measurements (Af-post (After 1 month-post)). We calculated mean IR torque and integrated EMG data for 250 ms before and after the maximum IR torque at each position (total of 500 ms). All muscle activation data were normalized to the mean activation of the 500 ms MVC (maximal voluntary contraction), and the results were expressed as %IEMG. To evaluate the immediate training effect, paired t-test was used to compare differences in Nm and %IEMG data between Ba-pre and Ba-post for all subjects (Baseline-pre vs Baseline-post). To evaluate the immediate training effect after the one-month program, the paired t-test was used to compare the differences between the Af-pre and Af-post values in the training group (After 1 month-pre vs After 1 month-post). Furthermore, to evaluate the periodic training effect after the one-month program, paired t-test was used to compare differences in Nm and %IEMG data between Ba-pre and Af-pre in both groups (Baseline-pre vs After 1 month-pre). The level of significance used was $p < 0.05$. Statistical analysis were performed using the SPSS version 19.0 (IBM) software.

Results

Mean IR torque and %IEMG comparisons between Ba-pre and Ba-post measurements for all subjects are shown in Table 1 and Figure 3. In both groups, IR torque were significantly decreased in six positions: at 90° of shoulder abduction ((1)90° ER, (2)60° ER, (3)30° ER, (4)0° ER) and 0° of shoulder abduction ((6)30° ER, (8)30° IR) ($p < 0.05$). There was no change in the outer muscle activation at all positions. In the training group after the ome-month training, mean IR torque comparisons between Af-pre and

Table 1. IR torque comparisons between baseline-pre and post measurements for all subjects.

		Baseline - pre	Baseline - post
90° of shoulder abduction	90° ER	34.7 ± 8.4	31.9 ± 8.2**
	60° ER	39.5 ± 9.4	35.2 ± 8.5**
	30° ER	35.8 ± 8.8	31.9 ± 7.0**
	0° ER	28.4 ± 6.3	26.0 ± 5.7*
	30° IR	20.2 ± 5.0	18.7 ± 4.9
0° of shoulder abduction	30° ER	40.4 ± 8.5	38.0 ± 8.8**
	0° ER	35.7 ± 7.7	34.4 ± 7.3
	30° IR	26.6 ± 5.2	24.1 ± 4.8**

** : p<0.01 vs. Baseline - pre * : p<0.05 vs. Baseline - pre

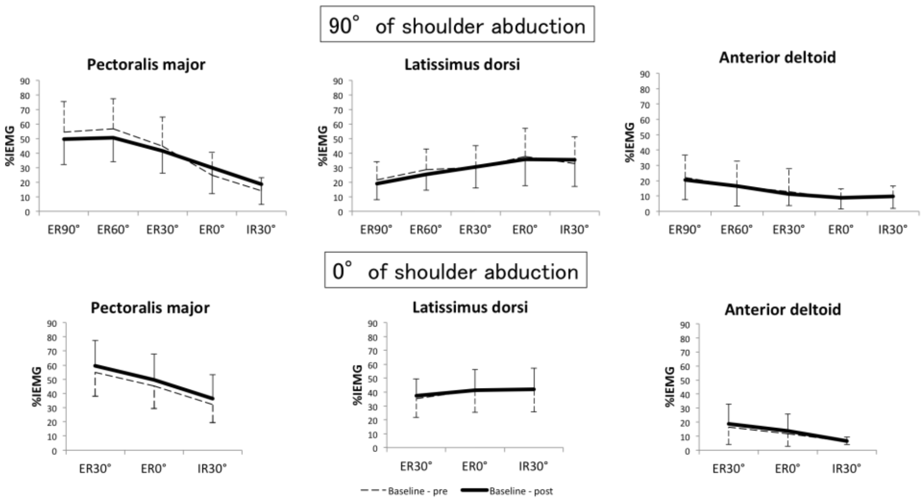

Figure3. EMG activity of each muscle for baseline-pre and post as %IEMG.

Table 2. IR torque comparisons between after 1 month-pre and post measurements in the training group.

		After 1 month - pre	After 1 month - post
90° of shoulder abduction	90° ER	39.5 ± 10.8	35.6 ± 10.8*
	60° ER	42.0 ± 13.4	38.3 ± 14.5**
	30° ER	38.1 ± 11.4	34.8 ± 12.3*
	0° ER	32.4 ± 10.3	28.8 ± 9.2**
	30° IR	25.5 ± 5.5	21.7 ± 6.2**
0° of shoulder abduction	30° ER	43.6 ± 13.4	41.1 ± 14.0**
	0° ER	39.3 ± 12.1	36.4 ± 11.4**
	30° IR	29.7 ± 5.9	25.1 ± 6.1**

** : p<0.01 vs. After 1 month - pre * : p<0.05 vs. After 1 month - pre

Af-post measurements are shown in Table 2. The IR torque of Af-post was significantly decreased at all positions compared with Af-pre. Mean IR torque and %IEMG comparisons

Table 3. IR torque comparisons between baseline-pre and after 1month-pre measurements for both groups.

		Training group (n=13)		Control group (n=13)	
		Baseline - pre	After 1 month - pre	Baseline - pre	After 1 month - pre
90° of shoulder abduction	90° ER	31.3 ± 6.9	39.5 ± 10.8**	38.0 ± 8.7	37.2 ± 7.8
	60° ER	36.9 ± 8.9	42.0 ± 13.4**	42.1 ± 9.6	41.1 ± 7.7
	30° ER	33.6 ± 8.2	38.1 ± 11.4**	38.0 ± 9.1	36.0 ± 8.1
	0° ER	27.0 ± 6.7	32.4 ± 10.3**	29.8 ± 5.8	28.7 ± 5.7
	30° IR	19.2 ± 5.1	25.5 ± 5.5**	21.2 ± 4.9	20.9 ± 5.2
0° of shoulder abduction	30° ER	38.6 ± 8.8	43.6 ± 13.4**	42.1 ± 8.2	41.7 ± 9.4
	0° ER	33.9 ± 6.8	39.2 ± 12.1**	37.4 ± 8.4	37.2 ± 8.5
	30° IR	25.2 ± 5.0	29.7 ± 5.9**	27.9 ± 5.3	28.7 ± 6.3

** : p<0.01 vs. Training group, Baseline - pre

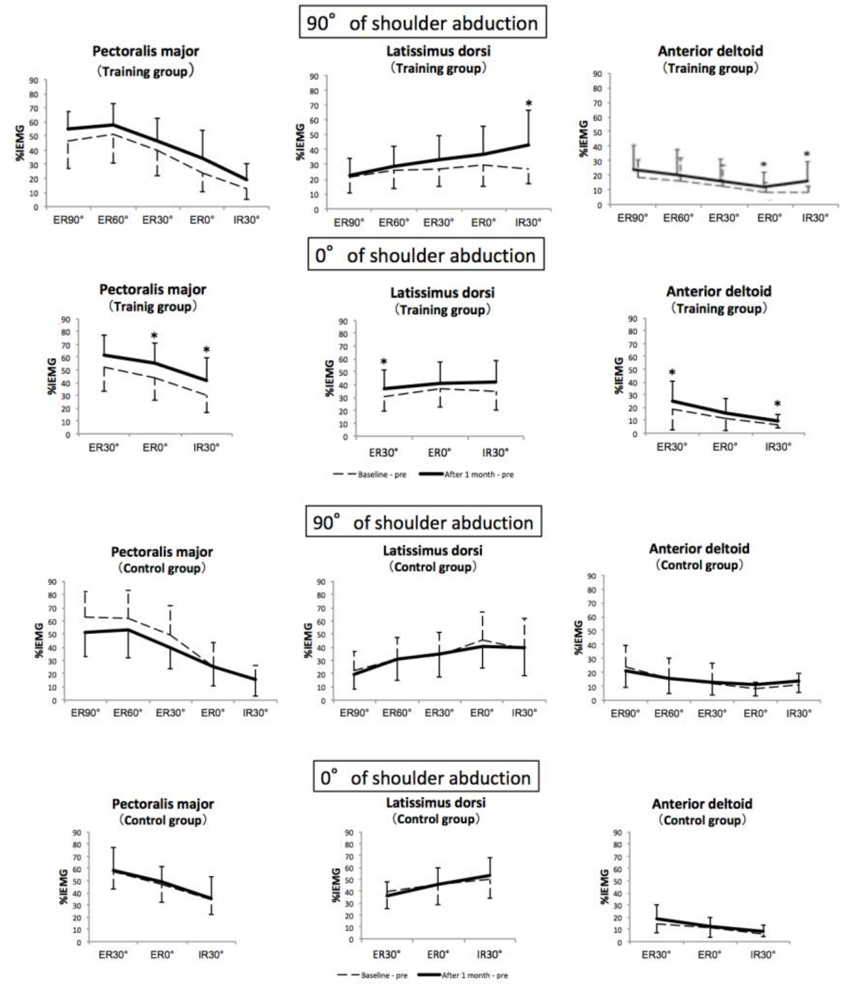

Figure 4. EMG activity of each muscle for baseline-pre and after 1 month-pre as %IEMG.

between Ba-pre and Af-pre measurements for both groups are shown in Table 3 and Figure 4. In the training group, the IR torque of Af-pre was significantly increased at all positions compared with Ba-pre (p<0.01). In the control group, there was no change in Af-pre compared with Ba-pre at all positions.

Analysis

The present results showed that RCM training decreased the IR torque immediately in six positions (Table 1). However, there was no change in outer muscle activation for IR torque (PM, latissimus dorsi, anterior deltoid) at all positions (Figure 3). Because this study used only surface EMG, the inner muscles activation such as subscapularis was not measured. Considering that the outer muscles activation did not change, the inner muscles, including the subscapularis, could be fatigued with RCM training. Therefore, the IR torque might be decreased immediately in six positions. Myers et al. [2] demonstrated by using a combination of surface and fine-wire EMG that resistance tubing exercises exhibited moderate activation (>20% MVC) in each shoulder muscle including RCM. Identically, the RCM training adopted in this study also might be exhibited moderate activation of the shoulder muscles. In the training group after the one-month program, the single RCM training immediately decreased IR torque at all positions (Table 2) . We suggested that even if they perform periodical RCM training, IR torque might be decreased immediately after a single training. The IR torque of the shoulder is significantly correlated with throwing velocity[8] . Hence, the results suggest that these exercises for throwers during their pre-throwing warm-up routine might decrease the throwing velocity in baseball games. In the training group, the isometric IR torque was strengthened by RCM training for 1 month (3 days per week) , regardless of the shoulder joint angle (Table 3) . After RCM training, decrease in the IR torque was caused by fatigue of the inner muscles immediately. However, the periodical RCM training improves the contraction force of the inner muscles (particularly the subscapularis and the infraspinatus), which improves the force couple during IR of the glenohumeral joint. The isometric IR torque might be improved as a result of increased dynamic stability during IR of the shoulder joint while maintaining the humeral head centered in the glenoid fossa. The PM has the largest muscle volume and long muscle fiber length[9] , so it is greatly involved in the exertion of the maximum IR force. However, considering the PM muscle fibers direction, the shear force separating the humeral head from the glenoid fossa increases during IR. Therefore, high-intensity IR training for strengthening the PM could cause instability of the shoulder joint. On the other hand, considering the muscle fibers direction of the subscapularis and infraspinatus, RCM training could increase the compression force of the humeral head to the glenoid fossa during IR. Thus, if you want to strengthen IR torque of the shoulder, not only high-intensity training for the PM but also low-intensity training such as RCM should be selected for the purpose of preventing shoulder joint injuries.

Our study has several limitations. First, study used only surface EMG without intramuscular fine-wire EMG. Therefore, the activities and fatigues of the inner muscle were unknown during and after the RCM training. A second limitation is the subjective loads on the tube during each exercise. It might be beneficial for throwers to change the loads during their pre-throwing routine. Research conducted in the future should focus on comparing the effects of changing the number of sets and exercise intensity or different populations.

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A conservative therapy for reducing meralgia paresthetica :a case study

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Keywords：meralgia paresthetica, entrapment syndrome, clinical reasoning

【Abstract】

I experienced a patient with pain located in his anterolateral aspect of thigh.As a result of physical therapy assessment, it might be caused by entrapment of lateral femoral cutaneous nerve(LFCN). And I thought the entrapment has been occurred by several factors. The main three factors I thought was that hypertonic muscles surrounding right hip joint, lumbar instability syndrome, and his daily habit spending much time in sitting. So, I mainly carried out treatments of L2/3 disc traction and soft tissue mobilization for right psoas major(PA) and tensor fasciae latae(TFL). Then, those treatment was effective immediately. After that, his progress was good, and he left the hospital and was able to reinstated three days later.

【Background】

The LFCN of the thigh is a sensory nerve which travels through the pelvis heading towards the anterior superior iliac spine(ASIS) and exits the lesser pelvis below the inguinal ligament, anterior to the ASIS. It is reported that meralgia paresthetica(MP) is caused by entrapment of LFCN[1)]. MP is frequently caused by the entrapment at the level of the inguinal ligament[1)]. When it comes to treatments for MP, it is suggested that we should carry out conservative therapy such as medication and nerve block initially, then surgery can be selected in case those treatments are not effective. At present, conservative treatments including physical therapy are inadequate for evidence[2)].

The aim of this report is to explain my experience which I treated a patient who had the pain and numbness located in the anterolateral aspects of thigh.

【Case report】

The patient was a 40-year-old male, worked in a city hall. Day of injury, he felt a coxalgia when he got out of car. Then he couldn’t walk around, so he has been transported to emergency, eventually had been hospitalized. He had been diagnosed for the Lumbar disc herniation, with L2/3,4/5 posterior disc protrusion result of the MRI scan. He had past history of high blood pressure, injury of posterior cruciate ligament, a strained back, and chronic low back pain. He was a rugby player in his high school days, and his hobby was working out in training gym.

【Ethical considerations】

Based on the Helsinki Declaration, I had explained the purpose and content of this study to the patient orally, and obtained the agreement for participation of this study.

【Tests and measures】

The patient complained a pain located in the anterolateral aspects(Fig.1) of his thigh (Numerical Rating Scale:NRS=7~8). He had no rest pain, but he couldn't stand up nor walk due to the pain. His progress was well, but the pain was aggravated by supine position, whereas it was eased by supine position with his knee bended. It was positive that right Straight Leg Raising(SLR) test, Femoral Nerve Stretching Test(FNST) and LFCN stretching test. His postural alignment appeared to be the flat back posture but L2-4 were locally extended. The patient demonstrated decreased muscle performance of the iliopsoas(3/4) and quadriceps(4/5). Range Of Motion(ROM)-t: lumbar extension(10°) and right hip extension(0°) were restricted. Accessory movement test:L1,3 were hypomobile, whereas L2,L4-5 were hypermobile. Muscle length tests:right Ober test, Ely test and Thomas test were positive. Palpation: right rectus femoris, TFL, PM, erector lumbar spinae were hypertonic. As Orthopedic tests, Anterior impingement test, Patrick test, and various SI Joint tests were negative.

As a result of MRI, there were L2/3,4/5 posterior disc protrusion, but there was no abnormal findings in hip joint.

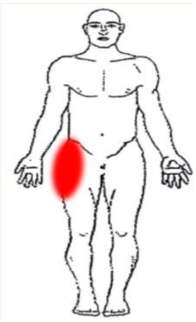

Fig.1:Pain and numbness area

【Clinical impression and intervention】

I thought that he had been suffering from L3 nerve root symptoms caused by neuropathic compression And it is reported that neuropathic pain compressive neuropathy should be treated with the priority than peripheral nerve sensitization[3]. So, I made the trial treatment with the L2/3 disc traction(Fig.2). Furthermore, I suspected it also had the entrapment syndrome of LFCN, because there was a finding LFCN test was positive. I added the treatment for right TFL(Fig.3) and PM(Fig.4).

【Results】

As a result of treatment with the L2/3 disc traction, his pain had decreased(NRS=1~2). Furthermore, additional treatments for right TFL and PM were also effective for his pain so that he had no pain after the treatment.

The patient left the hospital and he was able to be reinstated three days later. He received the outpatient therapy, then we finished the program when he could manage his self-exercises.

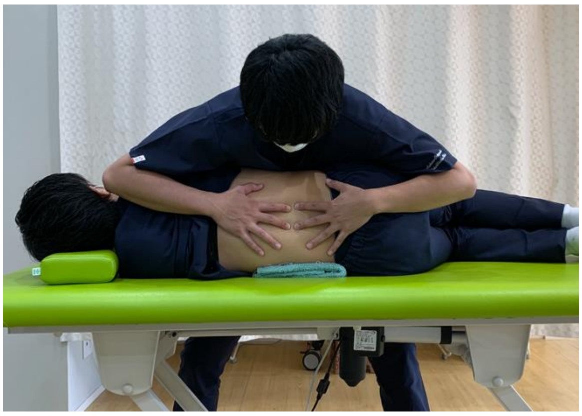

Fig.2:L2/3 disc traction

Fig.3:Deep transverse friction massage for TFL

Table1.History and system review

Date	Program
Day of injury	Onset of the pain
The next day following the onset	Admission
1 week later	First Session of PT
3 days later	Discharge
2 Months later	Completion of the PT

Fig.4-1:Functional massage for PM-Starting Position

Fig.4-2:Functional massage for PM-End Position

【Discussion】

LFCN is a sensory nerve, so I thought that the pain was caused by L3 nerve root. However, it is undeniable he mainly had suffered from MP. The patient had high intensity symptoms and presented high irritability so I couldn't carry out some assessments.

MP is said that it's often found in office worker sitting longtime when working. There are several contributing factors such as his sitting posture in working. Furthermore, it is indicated he has been suffering from lumbar instability syndrome chronically due to past history of a strained back and chronic low back pain.

At present, conservative therapies including physical therapy has little evidence for treatment of MP, but the reason why the patient got well by conservative treatment is possibly the entrapment was acute phase and mild. Kudo has investigated that the positional relation between LFCN and PM. In this study, it is found that 8 cases among 12 cases goes through PM, and they mention the possibility for treatment of MP by improving the dysfunction of PM or lumbopelvic malalignment. Besides, it is reported that

LFCN has different travels and branches[4]. Thus, clinical features and pathophysiology might differ by individual patients.

In this case, he has dysfunction of hip joint flexors surrounding the inguinal ligament, so it might be effective to relieve the entrapment of LFCN by improving the flexibility or sliding of hip joint flexors.

【Conclusion】

There is little evidence about treatment for meralgia paresthetica. However, I experienced a patient with his thigh. As a result of the individualized assessment and treatment based on clinical reasoning, the patient got well and he was able to be reinstated. This case has reconfirmed the importance of proceeding the clinical reasoning not only using the known evidence but also discovering the problems which varies by each individual.

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Relationship between rotational angle of vertebral body on frontal spinal X-ray and Cobb angle

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Key words : scoliosis, rotational angle, Cobb angle

Abstract

We studied the relationship between the Cobb angle and the degree of spinal rotation measured by using a method that we developed, and we established an index of the degree of spinal rotation. The subjects were 39 patients with idiopathic scoliosis (two male, 37 female; age 16.1 ± 2.8 years). The focus of our measurements was the body of the apical vertebra of the vertebral curve. We used a method normally used to measure the ratio between heart and chest dimensions to measure the vertebral body rotation on frontal X-ray images. We determined the relationship between this average value and the average Cobb angle for statistical processing; this was performed in both the supine position and the standing position. No correlation was observed between the degree of vertebral body rotation and the Cobb angle in the supine position. ($r = 0.272$, $P < 0.09$). In the standing position the Cobb angle was 41.6° ± 8.0° and the degree of vertebral body rotation was 19.2% ± 7.2%. The two were significantly positively correlated ($r = 0.43$, $P < 0.01$). In scoliosis, the thorax on the convex side generally projects backward, and the projecting part decreases both lateral curvature and rotation when it touches the X-ray table. We are of the opinion that we failed to find a correlation in the supine position because of this difference in the flexibility of the thorax.

Introduction

Scoliosis was traditionally defined as a disease in which the spine curves laterally, but image analysis today has clarified that it is a three-dimensional rotation deformity. It is caused by various factors, and recent studies indicate that genes have something to do with its occurrence.[1), 2)] The prevalence of scoliosis is 1% to 2%, although this value varies among reports. Idiopathic scoliosis accounts for 80% to 90% of all scolioses. The prevalence of idiopathic scoliosis is high, and it is especially high among adolescent female childrens. The most common form is a convexity of the thoracic vertebrae to the right side. There is always a vertebral rotation accompanied by secondary curvatures.[3] For this reason, primary physical examination requires postural observation and analysis from the feet to the top of the head three dimensionally. In addition, it is common to conduct a forward bending examination in both the standing position and the sitting position, to observe the backward displacement of the ribs caused by the spinal rotation, and to measure the angle of trunk rotation with the help of a scoliometer (Fig. 1).

For definitive diagnosis, we take a full-length X-ray image in the standing position. We can examine lateral curvature and rotation on a frontal X-ray image. In scoliosis curves, the apical vertebra is the point of the curve that projects most laterally. The inclination of the body of the apical vertebra is horizontal, and the rotation is maximal. The inclination of the other vertebral bodies

Figure1. angle of trunk rotation

increases gradually and craniocaudally. The vertebrae making up the sides of the curve are the transitional vertebrae, and the vertebral body that has the largest inclination, and where rotation is minimal, is called the end vertebra. Generally, to determine the degree of scoliosis we measure the degree of scoliosis (Cobb angle). The Cobb angle is the angle made by the superior margin of the upper end vertebra of the curve and the inferior margin of the lower end vertebra.

We tend to focus on the Cobb angle as an indicator of the extent of scoliosis, but the degree of vertebral rotation is also very important. In general, we use the method developed by Nash and Moe,[4] which displays the degree of rotation as the degree of shadowing of left-right asymmetry of the vertebral pedicles on frontal X-rays (Fig. 2). This method, however, does not give detailed information on rotation because it only classifies the results into four stages. The method developed by Perdriolle[5] uses angles to measure rotation, but it cannot be used easily on digital images because we need to place the specialized template directly on to the X-ray image. Therefore, we have developed a method that allows us to figure out the angle of vertebral body easily by comparing

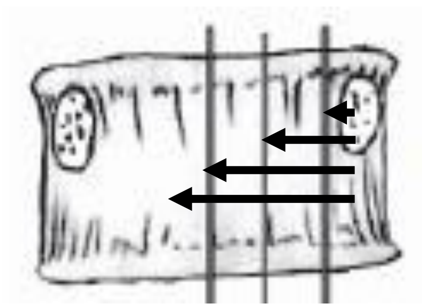

Figure2. degree of vertebral rotation (Nash and Moe)

CT images with an X-ray image of the front of the vertebral body, and we use it in our clinical practice.

The medical effects of exercise therapy for the treatment of idiopathic scoliosis have not been determined.[6] However, we use exercise therapy to improve lateral curvature and rotation of the spine. In clinical practice, we think that the pattern and degree of scoliosis vary with the individual, and no relationship exists between lateral curvature and the degree of rotation. We therefore studied the relationship between Cobb angle and vertebral rotation in both the supine position and the standing position by using the method of measuring rotation that we developed. Our aim was to study the characteristics of changes in alignment of the thoracic vertebrae of patients with idiopathic scoliosis in the frontal and horizontal planes with a view to applying these characteristics to exercise therapy. Here, we report our research results.

Subjects

The subjects were 39 patients with idiopathic scoliosis (two male, 37 female; age 16.1 ± 2.8 years). The apical vertebra in one patient was the fifth thoracic vertebra; in eight it was the sixth thoracic vertebra; in 20 the eighth thoracic vertebra, in nine the ninth thoracic vertebra, and in one the 10th thoracic vertebra. In one of the 39 patients the convexity was to the left, and in the remaining 38 it was to the right. For our research we used X-rays taken as part of the patient workup, and no surgery was performed especially for our research purposes. We made every possible effort to prevent the identification of personal information.

Methods

We used frontal spinal X-ray images taken on the same day to measure Cobb angles and rotation angles, and measured them on a digital screen.

The Cobb angle was measured as follows: We drew a line parallel to the upper border of the highest vertebral body of the thoracic curve and another line parallel to the lower border of the lowest vertebral body of the curve, and we extended these lines to make them intersect. The resulting angle was then measured.

To measure rotation angles we used a method designed originally for measuring cardiothoracic ratio. In the case of a vertebral body that rotated rightward, we divided the distance between the right edge of the vertebral body and the center of the right pedicle of the vertebral arch (a) by the distance between the two edges of the vertebral body (b), and we expressed the value as a percentage (hereafter referred to as the degree of rotation of the vertebral body) (Fig. 3). The same examiner measured

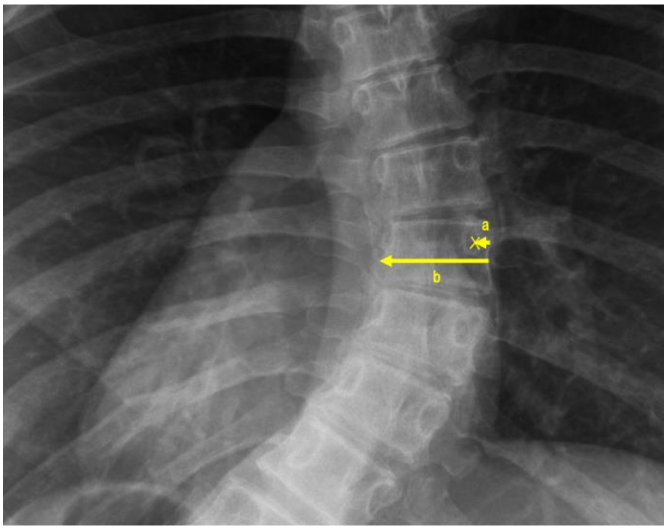

Figure3. degree of rotation of the vertebral body

the Cobb angle and the degree of rotation of the vertebral body three times, and we adopted the averages of the three values. We used SPSS (version 21.0, IBM) and set the significance level at 1%. We used the intraclass correlation coefficient to examine the reliability of the examiners. We used Pearson's coefficient of correlation to figure out the relationships between each Cobb angle and rotation angle of the vertebral body measured in both the supine position and the standing position.

Results

In the supine position, the Cobb angle was 33.3° ± 6.0° and the degree of rotation of the vertebral body was 17.9% ± 6.2%; no correlation was observed ($r = 0.272$, $P < 0.09$) (Fig. 4a). In the standing position, the Cobb angle was 41.6° ± 8.0° and the vertebral rotation was 19.2% ± 7.2%; there was a significant positive correlation between the two ($r = 0.43$, $P < 0.01$) (Fig. 4b).

Discussion

Scoliosis is a generic term for the condition in which the spine bends laterally while rotating for some reason; it is caused not by one disease but by a wide variety of diseases. Scoliosis observed in children is usually classified into three kinds: idiopathic scoliosis, which is frequently found among slender girls, inborn scoliosis caused by abnormal vertebral shape, and syndromic scoliosis caused by various syndromes.7) Scoliotic deformity is classified into functional and structural, each of which has its own treatment. Functional scoliosis arises for some reason and is sometimes temporary. Characteristically, it has neither rotation deformity nor wedge-shaped deformity.1) On the other hand, in the case of structural scoliosis, the deformity can be observed in the connective tissue, cartilage, and bone, and vertebral body rotation and wedge-shaped deformity can be observed. Structural scoliosis is classified into two kinds: One arises for known reasons, and the other for unknown reasons. The latter is called idiopathic scoliosis; that is, idiopathic scoliosis is a disease in which the spine deforms for unknown reasons. In Japan, both orthotic treatment and operative treatment are used effectively, and a wait-

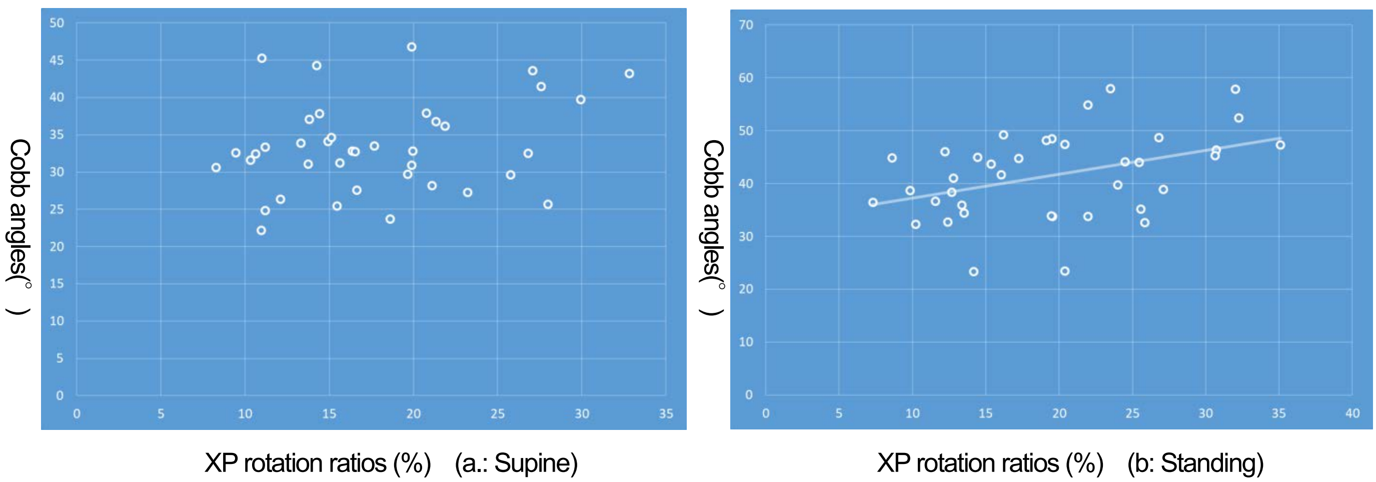

Figure4. Correlation between Cobb angles and XP rotation ratios

and-see approach is taken for mild spinal deformity. The Cobb angle is frequently used to select between orthotic treatment and operative treatment, and the rotation angle is not emphasized.

However, scoliosis is not formed simply by vertebral column flexion but by a coupling motion: Rotation and lateral curvature occur simultaneously. Because scoliosis includes vertebral torsion,9) both rotation and the lateral curvature angle should be examined. In clinical settings, a scoliometer placed on the patient's skin is used to measure the vertebral body rotation angle. This value does not increase with increasing Cobb angle. It is therefore vital to measure both lateral side curvature and the rotation angle to follow up scoliosis patients.

In this research, we did not observe a correlation between lateral curvature and vertebral rotation on frontal X-ray images in the supine position, but we found a positive correlation between the two in the standing position. We have in fact learned that a patient whose scoliosis is serious enough to necessitate surgery has a certain relationship between the Cobb angle and the degree of rotation of the thoracic vertebrae. Tyrakowski at al.10) stated that the Cobb angle as measured on X-rays was positively correlated with the angle of trunk rotation and the rib hump elevation as an indicator of the rotation angle of the spine. This leads us to surmise that a large rotation angle means a large Cobb angle; that is, we surmise that there was no correlation in the supine position because the thoracic vertebrae on the convex side generally project backward in scoliosis, decreasing the rotation when the convexity touches the X-ray table.

No evidence exists regarding the effectiveness of the exercise treatment applied by physical therapists, although the exercise treatments epitomized by the Schroth method and Pilates, which focus on stretching of the trunk, have been practiced lately.7) Because no definitive effect has been established, exercise treatment is rarely practiced for idiopathic scoliosis. However, Karu and others8) recently reported that they decreased the Cobb angle by 2.53・ and the rotation angle by 4.23・ by applying the Schroth method for 6 weeks (three times a week at 1.5 h per treatment). As this case shows, it is important to examine improvements in scoliosis and rotation independently. Idiopathic scoliosis is a spinal deformity caused by a coupling motion in which rotation and lateral curvature arise at the same time, and the deformity grows more complicated with the progress of the disease.

In a greatly curved spine, the spinous processes rotate and deviate to the concave side, whereas the vertebral bodies rotate to the convex side. The results of this study suggest that the greater the Cobb angle in the frontal plane, the greater the rotation angle of the vertebral body. Taking this into consideration, we need to keep monitoring, and applying exercise treatment for, lateral curvature and rotation simultaneously, instead of treating each of these independently.

Conclusion

For comprehensive treatment it is imperative that we understand and treat three-dimensional spinal deformity in idiopathic scoliosis. We devised a method of measuring vertebral body rotation by using plain X-rays as a simplified way of assessing serious scoliosis. In future, we intend to further explore the relationship between Cobb angle and vertebral body rotation angle. We have no conflict of interest to disclose in regard to publication of this paper.

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Cervical Stabilization Exercises improve Postural Balance

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Key Words: cervical deep muscles, stabilization exercises, postural balance function

【Abstract】

Cervical spine is the site where disease occurs frequently because it requires both stability and mobility. In cervical diseases, there is a problem of cervical instability due to dysfunction of cervical muscles. Therefore, we practice Cervical Stabilization Exercises (CSEx) that activate cervical deep muscles in our physical therapy treatment. Cervical deep muscles are believed to not only contribute to neck stability but also play an important role to control posture because they contain muscle spindles of the proprioceptive receptor in high density. We conducted this research with an aim to clarify the effect of CSEx on postural balance. We measured sway of the center of gravity of the body in the standing position and compared measurements before CSEx with those after CSEx. As a result, CSEx is found effective to correct postural balance. This is presumably because the tectonics stability of cervical segment was improved by activated cervical deep muscles and because the postural control mechanism of proprioceptive sensibility was promoted. In this study, CSEx is effective not only to stabilize neck but also to improve postural balance.

【Introduction】

Cervical spine is located at the top of spine. It protects nerve and blood vessels and offers attachment sites for muscles and ligaments, not to mention supporting the heavy head. On top of that, head has organs of such special senses as vision, smell, and hearing, and spine has a big range of motion to secure these functions for the execution of diverse motions[1]. That is, spine is a site required to comply with two incompatible requests of securing head stability and securing its diverse mobility[2]. For this reason, cervical spine is the site where orthopedic diseases occur frequently.

As problems occur frequently in cervical spine, manipulative physical therapy is practiced for the treatment. We, therefore, practice CSEx to improve cervical stability.

CSEx is the exercise based on the concept of Kaltenborn-Evjenth OMT that is a manipulative physical therapy[3]. It is a low load exercise to retrain muscle functions of cervical deep muscles that contributes to the stability of joints. Exercising cervical deep muscles allows them to operate in coordination with surface muscles and improves the stability of the neck. Lately, a group of Australian manipulative physical therapists took initiative in studying the effect of exercising cervical deep muscles and demonstrated that it is effective to improve both muscle function and motor function[4,5].

On the other hand, cervical deep muscles transmit information on sensorimotor control because it contains many spindles that are proprioceptive receptors. Above all, cervical deep muscle has muscle spindle in high density and actually has more muscle spindles than joint[6,7], indicating that cervical deep muscles are rather influential as a sensor to detect length and tension.

As mentioned above, cervical deep muscles are supposed to play an important role in controlling posture because it contains muscle spindle of the proprioceptive receptor besides contributing to the stability of neck. In clinical practice, it has been proved that conducting CSEx to cervical deep muscles alleviates pain and improves motor function. However, the effects of CSEx on postural balance still remain unknown. In this research, we verified the effects of CSEx from the viewpoint of postural balance.

【Methods】

(1) Subjects

Subjects are 14 healthy adults(male, 24.1±4.8 years, 168.6±7.4cm), without orthopedic disease.

(2) Measurement condition (Fig.1)

We asked the subjects to stand on the stabilometer (UM-BAR, UNIMEC, Japan) and measured their sway of the center of gravity of the body before and after CSEx(30 sec, sampling frequently 60 Hz) .

The measurement position was stand on the stabilometer with closed legs with medial edges of both feet. After subjects focused on the marker at the height of subject' s eye, closed eyes and kept their head and neck in the same position during measurement.

(3) Analysis

We analyzed six measurement parameters. They are total locus length (TL), anteroposterior locus length (A-P L), right and left locus length (R-L L), outer peripheral area (OPA), anteroposterior maximum amplitude (A-P Max), and right and left maximum amplitude (R-L Max).

We compared measured values before CSEx and those after CSEx. We used IBM SPSS Statistics ver. 25 (IBM Japan) for statistical analysis (Wilcoxon signed rank test, $p<0.05$).

(4) Method of CSEx (Fig.2)

CSEx is an exercise therapy based on Kaltenborn-Evjenth OMT that is a manipulative physical therapy[3]. It is made up of two

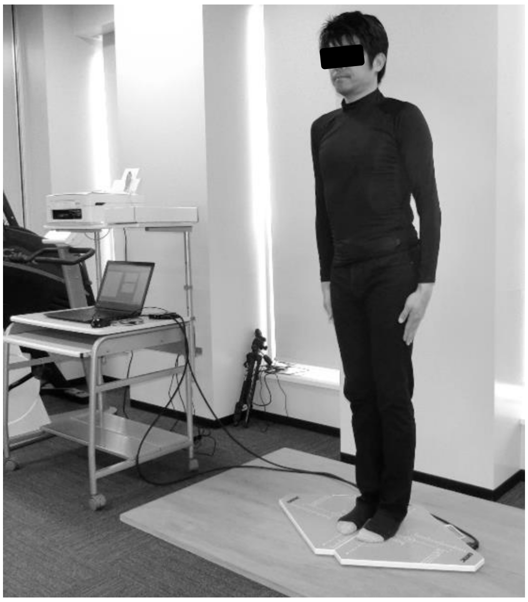

Fig.1: Measurement position

exercises that we developed by adding methods developed by previous studies[8-10]. 1) We asked the subjects to gaze by moving the eyeball upward and downward direction (10 sec. x 10 rep for each direction). 2) We asked them to put the cuff of the sphygmomanometer into the posterior neck in line with the lordosis curve and push the cuff lightly. While they were keeping this position, we asked them to apply resistance to glabella by themselves using their thumbs and do nodding (chin-in) motion with mouth open (10 sec x 5 rep). While subjects were following our instructions, we measured the compression using the cuff of the sphygmomanometer and kept the compression stable while giving them feedback. We increase the compression up to about 4 mmHg and asked them to keep it. During these procedures, we paid attention to control excessive contraction of sternocleidomastoid muscle.

Fig.2: Cervical Stabilization Exercises (CSEx)

(5) Ethical consideration

We conducted this research in conformity with the Ethical Standards of Bukkyo University(Ethical Approval Number: H30-9B).

【Results】

The results are shown in Table 1. As the table shows, we got significantly low values after CSEx in each of total locus length (TL), anteroposterior locus length (A-P L), outer peripheral area (OPA), and anteroposterior maximum amplitude (A-P Max) ($p<0.05$). However, we failed to get significantly low values both in right and left locus length (R-L L) and right and left maximum amplitude (R-L Max), though we got low values in these two items after CSEx.

【Discussion】

We verified the effects on postural balance of CSEx that we practice for patients with cervical spine disease. From the measured results, we observed that CSEx decreased body anteroposterior sway and reduced anteroposterior maximum amplitude (A-P Max) that shows the width of sway. This means that neck motion was stabilized especially in

Table1: Results of measurement parameters

	before CSEx	after CSEx	*p*
Total Locus Length (mm)	784.1 ± 273.6	683.1 ± 132.1	*
Outer Peripheral Area (mm^2)	729.7 ± 536.1	508.3 ± 220.1	*
Anteroposterior Locus Length (mm)	458.5 ± 141.2	393.5 ± 63.5	*
Right and Left Locus Length (mm)	534.6 ± 216.9	471.4 ± 107.7	
Anteroposterior Maximum Amplitude (mm)	31.6 ± 13.8	23.9 ± 4.8	*
Right and Left Maximum Amplitude (mm)	28.9 ± 9.2	25.6 ± 8.0	

*p < 0.05

sagittal plane. Thereby, the outer peripheral area (OPA) that shows the outermost area of gravity sway became narrow. Previous studies clarified that exercising cervical deep muscle is effective to ease the pain of patients with neck pain and improve the motion function[4,5]. Results of this research clarified that exercising cervical deep muscle is also effective to improve postural balance. That is, we can say safely that CSEx is also an exercise to improve postural balance.

The results can be attributed to the fact that cervical deep muscles activated by CSEx improved the tectonics stability at cervical spine and promoted the posture control mechanism by proprioceptive sensitivity of cervical deep muscle.

Muscles especially important as cervical deep muscles are extensor and flexor muscles. The former includes suboccipital muscle group, multifidus muscle, and semispinalis cervicis muscle(Fig.3). The latter includes longus colli muscle, longus capitis muscle, rectus capitis muscle, and rectus capitis lateralis muscle[2,11] (Fig.4). These deep muscles are designed to supply spinal segments with stability[12]. Surface muscles can produce big torque than deep muscle because the former has a bigger lever arm and cross-sectional area than the latter. On the contrary, deep muscles attach to each segment and function only in restricted areas as compared with surface muscles. In addition, they have muscle spindles in high density and a composition that allows muscle fibers to support the motions of spinal segments [7,13].

Longus colli muscle and longus capitis muscle, each of which is the deep muscle located anterior cervical spine, cover cervical spine in the deep layer of front surface and their functions are associated with stabilization of head and neck and with flexion of neck[2]. At the same time, longus colli muscle has an extremely important role to modify cervical lordosis and stabilize cervical spine[14]. Suboccipital muscles, which are neck dorsal deep layer located suboccipitally, is much smaller than large muscle located in the surface layer. While large muscles are anatomical terms of muscles, suboccipital muscle group adjust the motion of head and neck delicately in response to the request of special sense organ[2].

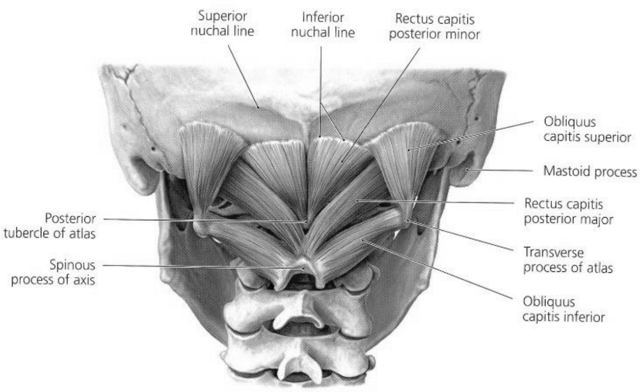

Fig.3: Cervical deep muscles (back)

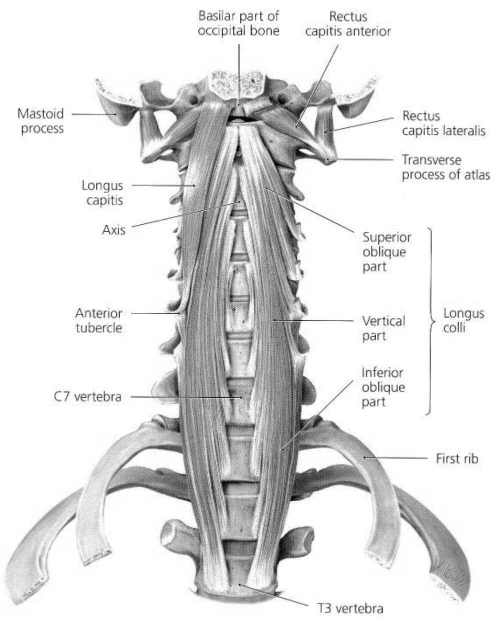

Fig.4: Cervical deep muscles (front)

These cervical deep muscles do not have a moment arm advantageous dynamically because they do not have short muscle length and because they located in a short segment. Consequently, they are not involved much in coarse movements. Instead, muscle spindles of proprioceptive receptor exist in neck muscle at higher density than in other region[6,7] (Table 2). This indicates that cervical deep muscle is rather influential as a sense organ to detect changes of length and tension.

Afferent nerve coming from neck is associated with the central nervous system and involved in the output of appropriate efference[15,16]. In addition, some reports indicate that they are closely associated with the eye.

Judging from the specific morphological and functional characteristics of cervical deep muscle and existence of high density muscle spindle, deep muscles not only simply control the movements of neck and head but also play such important roles as transmitting proprioceptive information, controlling head positon, and collaborative control of eye and head.

It has become clear that the cervical deep muscles play diverse and important roles, and patients with neck pain impair its muscle function greatly, causing instability of retaining head and movement of head[17-22]. Once these muscle functions deteriorate, they cannot recover them naturally easily[23,24]. For this reason, treatment to recover the function is necessary. This is exactly the reason why we practice CSEx.

CSEx is an exercise that focuses on cervical deep muscles. We practiced CSEx in two steps. Firstly, 1) we activated cervical deep muscles by up-and-down eyes movements. The receptor of neck muscle plays an important role especially to control sensory movement[15,16]. Controlling eye movement is included, and this exercise is meaningful to relearning of the collaborative movement between eye and cervical deep muscles. Secondly, 2) we asked to co-contraction of flexor and extensor muscles of cervical deep muscles by nodding motion. In the nodding motion, we asked them to retrain longus colli muscle and longus capitis muscle intentionally. Especially, as longus colli muscle has the function to decrease cervical lordosis, we adjusted the compression force using cuff of the sphygmomanometer put on the back of the head. At the same time, we

Table2: Muscle spindle content and spindle density of human muscles

Muscle	muscle weight (g)	Spindle content	Spindle density (/g)
Obliquus capitis superior	0.19	36	189.5
Obliquus capitis inferior	0.33	88	266.7
Rectus capitis posterior (major, minor)	0.59	58	98.3
Longus colli	3.22	143	44.4
Opponens pollicis	2.5	44	17.6
Latissimus dorsi	246	368	1.5
Trapezius	201	437	2.2

facilitated the contraction of extensor muscle by putting the back of the head lightly, and increased the bearing properties.

Cervical deep muscles we focused on CSEx contributed the stability of neck segments, and muscle spindles of proprioceptive sensibility are contained in high densities. Therefore, CSEx is thought to have retrained cervical deep muscles and realized constructive stability. At the same time, it became possible to maintain the physiological muscle length of the muscle, and functional stability was obtained by the accurate functioning of proprioceptors. It is our opinion that postural control functioned effectives and improved postural balance with the help of these factors.

【Conclusion】

It is clinically accepted that CSEx is effective to alleviate neck pain and improve joint's range of motion. In this research, we verified the effects of CSEx from the viewpoint of postural balance and observed that postural balance improved after CSEx. This is because CSEx trained cervical deep muscles, improved the stability from the viewpoint of tectonics, and facilitated the function of proprioceptive sensitivity of cervical deep muscles. Taking these outcomes into consideration, we can conclude that CSEx is an exercise competent enough to improve postural balance.

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Development of a clinical prediction rule for assessing gait ability following total knee arthroplasty

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Keywords: clinical prediction rule, total knee arthroplasty, gait instability

ABSTRACT

【Introduction】Total knee arthroplasty (TKA) is a common and effective treatment for knee osteoarthritis (KOA), and the number of people undergoing TKA surgery will increase as the population grows older. However, we occasionally encounter patients who cannot walk stably after surgery. If such patients could be identified and sorted in advance, more appropriate and effective physical therapy could be provided. Therefore, the development of a clinical prediction rule (CPR) for gait ability at discharge after TKA surgery is required. The purpose of this study was to develop a CPR to identify patients at high risk of gait instability at discharge using the results of their preoperative assessment. 【Participants and Methods】This retrospective study included 77 patients who underwent primary TKA due to KOA at the Suzuka Kaisei Hospital. Data on patient characteristics (socio-demographic variables, body mass index, etc.) and preoperative physical function were collected. Based on the results of the Timed Up & Go Test on discharge, patients were classified into the “gait stable group” and “gait unstable group.” Differences between the groups were analyzed using the Mann-Whitney U test. Variables with significant differences between the groups were analyzed using receiver operating characteristic curves and Youden’s index to determine cut-off values. A CPR for gait ability was developed from determined cut-off values. 【Results】A CPR with four variables (bilateral knee extension peak torque and bilateral one-leg standing time) was identified. Twenty of the 77 patients were classified into the “gait unstable group.” When the total score for the CPR was 3, the positive likelihood ratio was 14.3 and the positive predictive value was 83.4%. 【Conclusions】The gait ability following TKA on discharge may be predicted from variables collected from the preoperative examination. However, further studies are necessary to validate this CPR.

INTRODUCTION

Knee osteoarthritis (KOA) is one of the most common joint diseases and its incidence to increase with the growing elderly population. An estimated 25.3 million people in Japan are reportedly affected by KOA[1]. Total knee arthroplasty (TKA) is the primary surgical treatment for KOA, with most patients showing improvement in pain and activity limitations. In contrast, approximately 20% of patients undergoing TKA are aware of activity limitations after surgery[2,3]. We occasionally encounter patients whose physical function does not improve and who cannot walk stably after surgery. Previous studies have reported that preoperative physical function is a major predictive factor for postoperative functional recovery[4,5]. However, few studies have examined the preoperative physical function values required to achieve a stable gait after TKA surgery. Thus, it remains a challenge to identify the TKA candidates who will be able to walk stably or will become unstable.

A clinical prediction rule (CPR) consists of combinations of variables obtained from patient-reported outcome measures and clinical examinations. It assists with the subgrouping of patients and supports clinical decision-making of patients by therapists for their treatment[6]. A CPR would greatly enhance the quality of physical therapy provided to patients[7]. Recent overseas studies have reported a few CPRs for TKA[8,9]. However, little has been reported on CPRs that suit the Japanese patient population.

The purpose of this study was to develop a CPR to identify patients at high risk of gait instability on discharge using the results of their preoperative assessment.

PARTICIPANTS AND METHODS

The participants of this study were patients diagnosed with KOA who underwent primary TKA at the Suzuka Kaisei Hospital between April 2010 and March 2019. The inclusion criterion was age ≥ 50 years. The exclusion criteria were history of a prior contralateral TKA, revision knee surgery, complications of severe mental disorders (e.g., depression, schizophrenia, or dementia), and deviation from the clinical pathway owing to postoperative complications (e.g., wound infection, peroneal nerve palsy, deep vein thrombosis). In addition, we excluded patients with missing data from the preoperative assessment. Ultimately, 77 patients meeting these criteria were included in this study.

The present study was approved by the Ethics Committee of the Suzuka Kaisei Hospital (n. 2019-06). Informed consent was obtained in the form of an opt-out on the website.

This study employed a retrospective study design. The survey items were as follows: sex, age, height, weight, and body mass index as patient characteristics; bilateral knee extension/flexion muscle strength, knee pain, bilateral one-leg standing time, and bilateral knee extension/flexion ROM as preoperative physical function; and TUG at discharge. All data were collected from the patients' medical record.

To measure muscle strength, an isokinetic knee muscular function test was performed using the Cybex Humac Norm System (CSMi, Stoughton, MA, USA). The extensor and flexor of both knee joints were evaluated four times each at 60° /sec, and the peak torque/body weight (%) was calculated from the results. The ROM of the knee joint was measured passively using a goniometer according to the methods recommended by the Japanese Orthopaedic Association and the Japanese Association of Rehabilitation Medicine and recorded in increments of 5° . Knee pain was assessed using the visual analogue scale. One-leg standing time is an assessment of static balance. We used digital stopwatches to measure standing time on one leg with eyes open. The maximum value for the measurement was 60 s. The TUG assesses mobility, walking ability, and fall risks of older adults. Patients sitting on the chair were required to stand up, walk 3 m, turn around, walk back to the chair, and sit down. The measurement was performed at a "quick yet safe speed."

A previous study reported that TUG score ≥ 13.5 s is the cut-off point to identify elderly individuals who are at risk of falls in community dwellings[10]. Accordingly, in this study, patients with a TUG score ≥ 13.5 s were classified into the "gait unstable group" and those with a TUG score < 13.5 s were classified into the "gait stable group".

To identify the differences between groups, we performed the Mann-Whitney U test. The relationships between the variables that were found to be significant were analyzed using Spearman's rank correlation coefficient and selected accordingly. The selected variables were receiver operating characteristic (ROC) curves' analysis and cut-off values were determined using Youden's index. A CPR predicting gait ability was generated from the determined cut-off values and for the resulting CPR, sensitivity, specificity, area under the ROC curve (AUC), positive predictive value, negative predictive value, and positive and negative likelihood ratios (LR+, LR-) were calculated. All statistical analyses were performed using SPSS Statistics version 23 (IBM, Chicago, IL, USA). The overall significance of the study was assessed at $p < 0.05$.

Table 1. Demographic data of patients.

Characteristic	All Patients (n=77)
Age (years)	72.7 ± 6.6
Sex	Male 18, Female 59
Height (cm)	152.7 ± 8.3
Weight (kg)	61.0 ± 11.3
BMI (kg/m^2)	26.1 ± 3.8

Means ± SD, BMI: body mass index

RESULTS

Demographic data of the patients are shown in Table 1. Twenty of the 77 patients (26%) belonged to the "gait unstable group" and 57 to the "gait stable group." There were significant differences in six variables (bilateral knee extension %body weight (BW), bilateral knee flexion %BW, and bilateral one-leg standing time) between the two groups (Table 2). Only two variables of knee extension were included, as variables of knee extension and flexion strength were highly correlated (operative side: r=0.809, p<0.01, non-operative side: r=0.791, p<0.01; Fig. 1 and 2). Therefore, a CPR with four variables (bilateral knee extension %BW and bilateral one-leg standing time) was identified. The CPR and cut-off values are shown in Table 3. Furthermore, the ROC curve and AUC of the CPR are shown in Fig. 3. The AUC was 0.841 and showed a high diagnostic performance. The cut-off value for CPR obtained using Youden's index was 3 points. The diagnostic feature of this CPR was that when the total score for the CPR was 3, the positive likelihood ratio was 14.3 and the positive predictive value was 83.4% (Table 4).

Table 2. Comparison of variables between two groups.

	gait stable group		gait unstable group		p value
Preoperative knee pain (VAS)	70.0	(75.0—50.0)	74.0	(84.25—49.25)	0.205
One leg standing time (sec)					
non-operated side	7.6	(12.9—3.5)	2.8	(4.8—1.9)	0.003
operated side	6.0	(12.7—3.0)	2.6	(5.7—1.3)	0.007
Knee extension %BW (Nm/kg)					
non-operated side	80.0	(104.0—60.0)	43.5	(67.5—31.5)	<0.001
operated side	57.0	(69.0—45.0)	39.0	(57.0—25.5)	0.005
Knee flexion %BW (Nm/kg)					
non-operated side	39.0	(51.0—30.0)	19.5	(33.8—5.3)	<0.001
operated side	33.0	(42.0—21.0)	21.0	(28.5—9.0)	0.01
Knee extension ROM (°)					
non-operated side	0	(0—-10)	0	(0—-10)	0.995
operated side	-10	(0—-15)	-15	(-5—-20)	0.081
Knee flexion ROM (°)					
non-operated side	135	(140—127.5)	135	(142.5—120)	0.445
operated side	125	(135-115)	125	(137.5-107.5)	0.546

median (interquartile range)

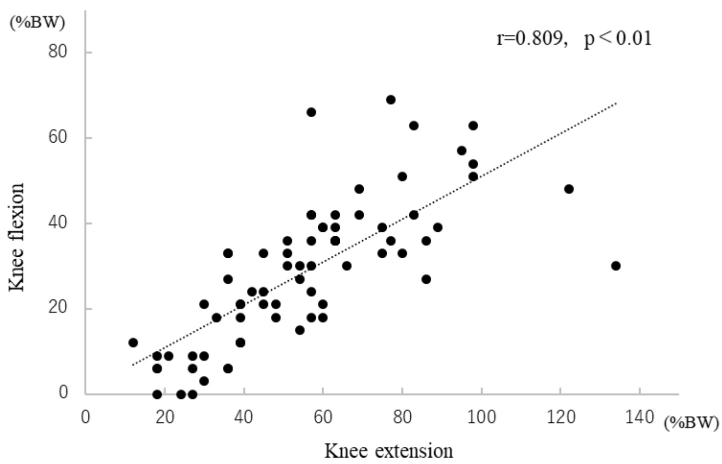

Fig. 1. Correlation between knee extension and flexion muscle strength in operative side.

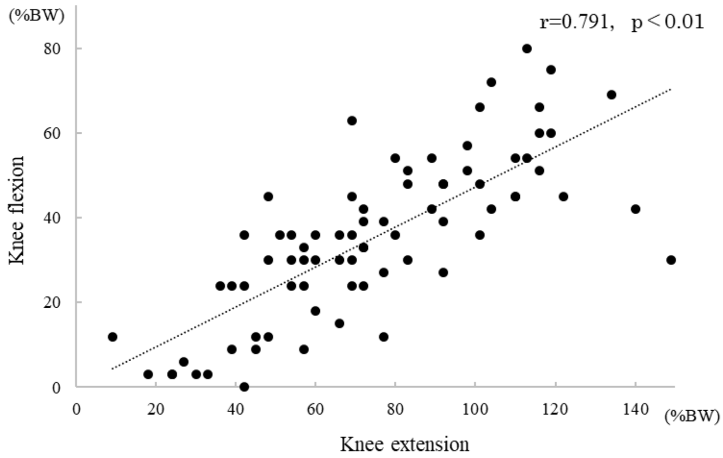

Fig. 2. Correlation between knee extension and flexion muscle strength in non-operative side.

Table 3. The developed CPR and cut-off values.

Item	Cut-off value	
① Knee extension %BW of the operated side (Nm/kg)	1 point : <46.5	0 point : ≥46.5
② Knee extension %BW of the non-operated side (Nm/kg)	1 point : <49.5	0 point : ≥49.5
③ One leg standing time of the operated side (sec)	1 point : <2.26	0 point : ≥2.26
④ One leg standing time of the non-operated side (sec)	1 point : <3.22	0 point : ≥3.22
	total score :	point

Table 4. The diagnostic characteristics of this CPR.

Total score	Sensitivity	Specificity	Positive likelihood ratio (LR+)	Negative likelihood ratio (LR-)	Post-test probability Positive predictive value	Post-test probability Negative predictive value
1	0.9	0.56	2.05	0.18	41.9%	94.1%
2	0.7	0.84	4.43	0.36	60.9%	88.9%
3	0.5	0.97	14.29	0.52	83.4%	84.6%
4	0.3	0.98	16.67	0.71	85.4%	80.0%

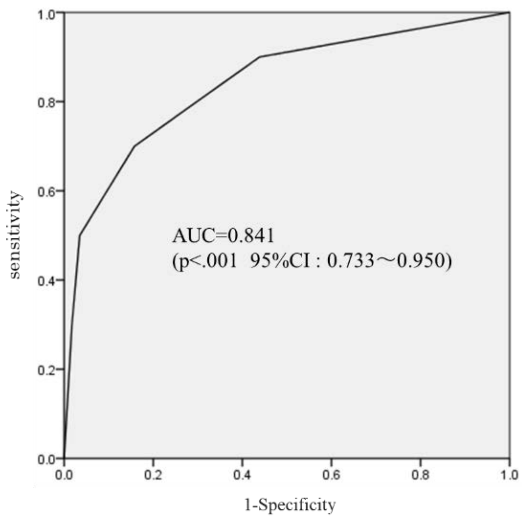

Fig. 3. The ROC curve and AUC of the CPR.
AUC: Area Under Curve, CI: confidence interval.

DISCUSSION

In this study, we collected the results of a preoperative assessment to develop a CPR to identify patients at high risk of gait instability on discharge among those who underwent TKA. The results of the study aided in the development of a CPR consisting of a combination of four items: (1) knee extension %BW of the operated side, (2) knee extension %BW of the non-operated side, (3) one-leg standing time of the operated side, and (4) one-leg standing time of the non-operated side.

The AUC of the CPR in this study was 0.841, which shows a relatively high predictive accuracy[11]. The cut-off calculated from the optimal sensitivity and specificity using Youden' s index was 3 points. At this score, both positive and negative predictive values were > 80%, with an LR+ of 14.3. LR+ is considered a clinically valuable test if it is greater than 10[12]. Even with a total score of 4, the positive and negative predictive values were > 80%, and LR+ was 16.7. LR- shows relatively smaller values for a total score of 3 than for a total score of 4. Therefore, we considered that a total score of 3 points was more useful when judged comprehensively. Thus, this CPR can predict with a certain accuracy that patients will be gait unstable on discharge and may help in clinical decision-making.

We have adopted the TUG score as the outcome of this study. TUG scores increase with age and have been reported to be related to history of falls, frequency of outdoor activity, and habitual exercise[13]. Hence, the TUG has been used in many studies as a measure of functional mobility in the elderly and as an indicator of gait and balance ability. Previous studies have reported that weakening of knee extension strength is associated with difficulty in standing up and a decrease in walking speed[14-16]. As mentioned above, several studies have reported the effect of knee extensor strength, suggesting that this study is similarly highly influenced by knee extensor strength. Regarding the one-leg standing time, Tsuda et al.[17] reported that cut-off values for the one-leg standing time required for independent walking were 3.6 seconds for the right side and 2.9 seconds for the left side. Although the participants were different, it is thought that a one-leg standing time of approximately 2-3 seconds is necessary for a stable gait.

The CPR developed in this study can support the decision-making of therapists as a tool for appropriately planning post-operative physical therapy considering the patient' s condition. A CPR consists of only objective information in the assessment of physical therapy. Objective assessment has the advantage of quantifying results, making it easier to judge and compare the effectiveness of the treatment, and providing patients with feedback.

One limitation of our study is that only patients for whom all preoperative assessments could be performed were included. Patients who could not be examined were excluded; for example, patients who could not sit on the Cybex seat or who refused to be examined because of immense pain. Consequently, the use of this CPR may be limited to patients with high levels of physical function.

Thus, in future, it is necessary to perform preoperative prediction using this CPR in different sample populations, confirm whether these findings are reproducible, and verify the validity of the developed CPR. Furthermore, the clinical and financial impacts of using this CPR should be investigated. In recent years, patient-reported outcome measures have been used more widely to assess post-discharge function and Quality of life as a measure of treatment effectiveness. Hence, future research should focus on these outcome measures.

In conclusion, gait ability following TKA on discharge may be predicted by variables collected from the preoperative examination. This CPR could help manage patients after TKA. However, future studies are necessary to validate this CPR.

Conflict of Interest statement: The authors have no conflicts of interest directly relevant to the content of this article.

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Research on the treatment of ankle instability after inversion sprain

- Comparison between taping and application of ankle brace -

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keyword：inversion sprain, ankle brace, reaction time of peroneal muscle

Abstract:

【Objective】Inversion sprain of ankle is one of the many inquiries caused by sports activities, and it is liable to repeat recurrence.This research aims to compare the effect of taping and applying brace for an increase of inversion sprain of ankle and delay in reaction time of peroneus muscle, both of which are caused by jumping side to side after inversion sprain of ankle.【Method】Subjects were 11 females with a history of inversion sprain (Average age: 15±1.5, Average height: 158.0±2.5 cm, Average weight: 53.0±4.2 kg). We let them do jumping side to side under three conditions of in bare feet, with brace, and with taping.We measured inversion angles of ankle and surface electromyogram of peroneus muscle in quick turn during jumping side to side. The inversion angle is the angle created by lower limb and the vertical axis of heel bone. To measure the reaction time of peroneus muscle, we set the time of standing in quick turn to 100% and normalized the time needed to start the activities of peroneus muscle.We conducted one-way analysis of variance and used Bonferroni method for multiple comparison analysis testing for three conditions of in bare feet, with brace, and with taping. The significance level was set at lower than 5%.【Results】The inversion degrees we got were 12.6±1.8 degrees in bare feet, 5.8±1.5 degrees with brace, and 5.0±1.0 degrees with taping, indicating that degrees with brace and those with taping were significantly lower than those in bare feet. The reaction time of peroneus muscle was 53.1±1.5% in bare feet, 44.4±1.5% with brace, and 44.1±2.2% with taping, indicating that reaction time with brace and that with taping was significantly lower than that in bare feet. We did not observe any significant difference in inversion angle and reaction time of peroneal muscle between with brace and with taping. 【Conclusion】 Both brace and taping decreased the ankle inversion angle, and they consequently shortened the reaction time of peroneal muscle. This research successfully clarified that applying taping and brace is effective to decrease instability to a certain degree for people with established inversion sprain.

【Introduction】

Ankle sprain mostly occurs in sports activities. In particular, the occurrence rate of inversion sprain is as high as 67-85% of all sprains[1]. Moreover, injury of anterior talofibular ligament accounts for 75-73% of inversion sprain and reportedly yields a high frequency of ankle instability[2]. In addition, some reports indicate that more than 80% of people will damage anterior talofibular ligament again once they damaged it in the past[3]. We have so far reported on an increase of ankle inversion angle and a delay in the reaction time of peroneal muscle in sideways juming[4]. In the report that examined the braking force created by brace to improve ankle instability with the help of X-ray photography, we found that brace improved ankle bone inclination more than bare feet without brace did when ankle is inverted forcibly by external force[5]. We clarified that taping improved both inversion angle of ankle and reaction time of peroneal muscle in repetitive sideways jumping[6]. Our past research results clarified that both applying brace and taping are effective to improve ankle instability to a certain degree.

This research is intended to compare applying brace and taping to know how much each of them can improve inversion angle of ankle and reaction time of peroneal muscle.

【Method】

1. Subjects

We studied 11 females who have established inversion sprain (Average age: 15.0±1.5 years old, Average height: 158.0±2.5 cm, Average weight: 53.0±4.2 kg). For ethical considerations, we conducted the research in compliance with the Declaration of Helsinki, and we explained the objective and intent of the research to them in advance and obtained prior consent for participation from them.

2. Method

We let the subjects do repetitive sideways jumping in three conditions: in bare feet, with brace, and with taping. The brace we used was Exaid Ankle 3 made by Sigmax (Fig. 1), and we used three sizes of S, M, and L depending on the foot length of the subjects. We used 50 mm wide stretchy adhesive tape (NITREAT EB-50 tape made by Nitoms, Inc.) and applied two ways of figure 8 ankle taping and heel rock taping (Fig.2) for taping.

The method of doing sideways jumping complied with the Implementation Guidelines of the New Physical Fitness Test[7] by the Ministry of Education, Culture, Sports, Science and Technology. We drew a line and two parallel lines on both sides in the position 100 meters away from the center line (Fig.3). Measurement time was 20 seconds. We asked the 11 subjects orally to land on their feet within the line stuck to the floor after quick turn because we wished them to land on feet at the same place as much as possible. In addition, we instructed them to make the angle of feet as close to 0° as possible and do repetitive sideways jumping at their maximum speed.

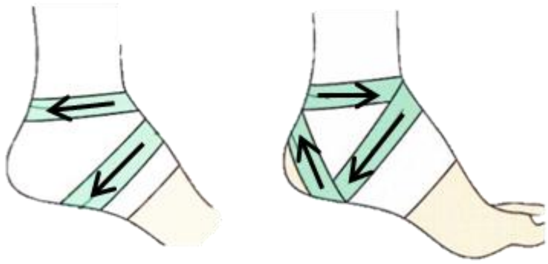
3. Measurement items

We measured two items: ankle inversion angles in quick turn and reaction times of peroneal muscle calculated from waveforms of surface electromyogram.

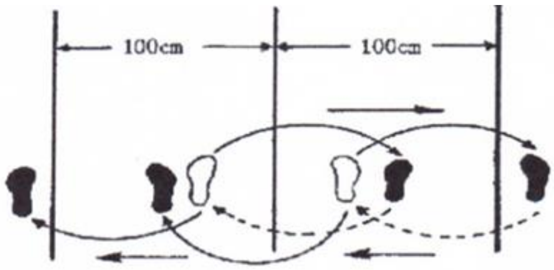
①Measurement of ankle inversion angles

We videotaped movements in quick turn during repetitive sideways jumping from the back with the help of a digital video camera (HDR-HC9 made by Sony Corporation). In compliance with the method developed by James et al[8], we measured the angle made by lower leg and vertical axis of heel bone, and designated inversion angle as positive and extroversion angle as negative. We applied taping on the vertical axis of lower legs and heel bones to measure inversion angles using videos we shot from behind. We used image processing software (Image J) to measure ankle inversion angles (Fig.4).

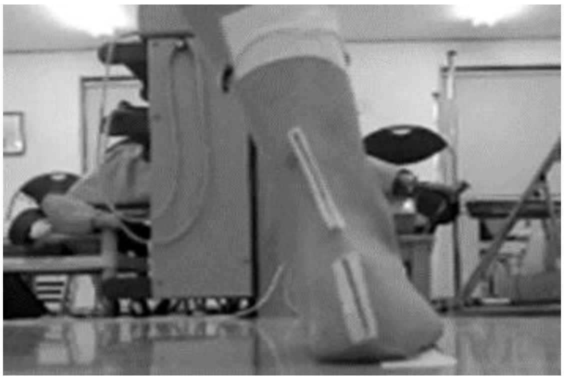
(Fig. 1) Exaid Ankle 3 made by Sigmax



(Fig.2) Taping method
Left : figure 8 taping
right : heel rock taping



(Fig.3) repetitive sideways jumping



(Fig.4) Measurement of ankle inversion angles

② Calculation of the reaction time of peroneal muscle

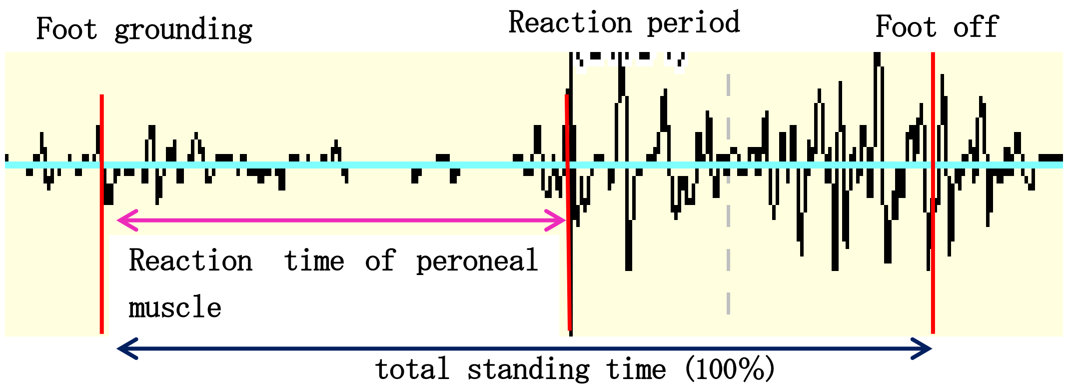
While measuring inversion angles, we simultaneously measured the electromyogram of peroneal muscle in quick turn during repetitive sideways jumping by synchronizing the electromyography (Vital Recorder 2, Version 2.6.1.908 made by Kissei Comtec Co., Ltd.) with the video camera. Following instructions by Aldo[9], we attached electrodes to the position three fingerbreadths away from peroneal muscle at 2 cm intervals. We confirmed the movements from landing to jump-up in quick turn from the video and designated the standing time as total standing time. We figured out the reaction time of peroneal muscle by normalizing the time before start-up of peroneal muscle activity on the condition that total standing time is 100% (Fig.5).

The formula for computation is (Reaction time - landing of sole) / (Jumping from ground - landing of sole) x 100 = Time of peroneal muscle (%).

Furthermore, we used images and values of surface electromyogram whose toe out angles are close to 0° that we picked at random from all results of 20-second long repetitive sideways jumping.

4. Analytical method and statistical treatment

We used IBM SPSS Statistical ver. 25 (released by IBM Japan) for statistical analysis, and conducted one-way analysis of variance for each of in bare feet, with brace, and with taping. We used the Bonferroni method for multiple comparison tests and set the significance level at lower than 5%.



(Fig.5) Calculation of the reaction time of peroneal muscle

(Table.1) Comparison between taping and application of ankle brace

	bare feet	brace	taping
inversion angle (°)	12.6±1.8	5.8±1.5 ＊	5.0±1.0 ＊
reaction time of peroneal muscle (%)	53.1±1.5	44.4±1.5＊	44.1±2.2＊

Numbers are mean and standard deviation

＊P<0.05 Those with a significant difference from bare

【Research results】

The inversion angles were 12.6±1.8° for in bare feet, 5.8±1.5° for with brace, and 5.0±1.0° for with taping. That is, with brace and with taping showed significantly lower values than in bare feet, showing that both with brace and with taping improved the inversion angle significantly.

Reaction times of peroneal muscle were 53.1±1.5% for in bare feet, 44.4±1.5% for with brace, and 44.1±2.2% for with taping. That is, with brace and with taping gave significantly lower values than in bare feet, showing both with brace and with taping improved the delay in reaction time of peroneal muscle significantly. We did not observe any significant difference in inversion angle and reaction time of peroneal muscle between with brace and with taping.

【Discussions】

As we have already stated, we applied brace and taping to females who have established inversion sprain and let them do repetitive sideways jumping. Based on the results, we observed that both inversion angle and reaction time of peroneal muscle decreased significantly after they did sideways jumping and quick turn repetitively. In our past studies, taping decreased ankle inversion angle from 13.1±3.1° to 5.5±1.8° and decreased reaction time of in bare feet from 56.2±8.4% to 47.0±4.6%. These values in our past studies are very close to those we obtained in this research, reconfirming the effect of taping[6]. We also confirmed the effect of applying brace because we observed that with brace realized a significant improvement as compared with in bare feet. We can indicate that taping is as effective as with brace because we did not observe significant differences between them in terms of efficacy.

Ankle instability can be discussed from two aspects of structural instability and functional instability. Structural instability is defined as the state where ankle deviates from the physiological range of joint motion because of damage on joint constituent and ankle instability remains because of increased accessory movements[1]. Inversion sprain of ankle is supposed to leave structural instability caused by relaxation and rupture of ligament because it is associated with a high incidence of ligament damage. Functional instability is defined as the state where ligament damage remains after inversion sprain of ankle regardless of whether or not structural instability exists[1]. Fukubayashi et al.[1] indicate that a proprioceptive organ exists in the lateral ligament of ankle and that proprioceptive sensibility deteriorates because of ligament damage caused by inversion sprain of ankle. Ohnuma et al.[10] indicate that reaction time of peroneal muscle is delayed because of functional deterioration resulting from ligament damage caused by sprain of ankle, arthrochalasis caused by inversion sprain of ankle, and muscular depression of peroneal muscle after inversion sprain of ankle. In general, damage of proprioceptive organ caused by ligament damage is supposed to be the major cause of ankle instability.

In this research, we evaluated structural instability from inversion angle and functional instability from the reaction time of peroneal muscle. The inversion angles of ankle in bare feet that were 12.6±1.8° in our past studies improved significantly to 5.8±1.5° with brace and 5.0±1.0° with taping. We compared 5.3±1.7° [6] that we obtained from inversion angles of healthy people in our past studies with the values we obtained in this research, and found that both with brace and with taping contributed to improving the instability to a certain degree. The reaction times of peroneal muscle improved significantly from 53.1±1.5% in bare feet to 44.4±1.5% with brace and to 44.1±2.2 with taping. These values after improvement decreased at a faster pace than 49.9±5.0%[6] that we obtained from healthy people in our past studies.

Both brace and taping decreased the ankle inversion angle, and they consequently shortened the reaction time of peroneal muscle. This shows that improving structural instability can improve functional instability. That is, functional instability was not affected much by a decrease of afferent information because of damage on mechanoreceptor resulting from sprain. Rather, we suppose that abnormal positional relationship of ankle caused functional instability.

No past studies exist on the existence of damage caused by sprain and amount of its afferent information, and causes of functional instability are still unknown. However, this research indicates that normalizing the position of joints affects functional instability greatly.

This research successfully clarified that applying taping and brace is effective to decrease instability to a certain degree for people with established inversion sprain. The advantage of taping is the ability to adjust fixing strength and way of application in detail. However, it has a disadvantage, too. It is reported that taping decreased the control power by 18-40% in 10 minutes[11]. Therefore, detailed research is necessary on the effect of taping during exercise that lasts longer than 10 minutes. In addition, variation between individuals cannot be avoided because knowledge of kinds of tapes, experience in taping, and application technique of the therapist are critical for taping.

On the other hand, we can point out the advantage of applying brace. Because we use magic tape to adjust brace, it is possible to readjust the brace and increase its control power easily on the spot during long sports activities. On the other hand, applying brace has a disadvantage that adjusting strength of fixing and other factors cannot be done easily because off-the-shelf brace cannot be adjusted to the figure and size of foot of each person easily.

This research indicates that no difference exists between taping and applying brace, though each of them has both advantages and disadvantages. This means that it is advisable to choose easier way of application in consideration of various factors to obtain a desired effect.

【Summary】

・We compared the effectiveness between taping and applying brace for ankle inversion angle and reaction time of peroneal muscle.

・Taping and applying brace significantly improved inversion angle and reaction time of peroneal muscle in quick turn during repetitive sideways jumping.

・It was clarified that applying brace is as effective as taping.

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