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A soft massage tool is advantageous for compressing deep soft tissue with low muscle tension: Therapeutic evidence for self-myofascial release

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ABSTRACT

Objectives: This study aimed to compare the amount of deep tissue pressure and muscle relaxation between a soft inflatable rubber ball (SIRB) and a hard massage ball (HMB).

Design: Crossover experimental design study.

Interventions: Thirty participants with neck pain (age: 65.9 ± 3.4, Neck Disability Index score: 34.0% ± 15.2) pillowed a SIRB or an HMB beneath the suboccipital region in the supine position. For the baseline condition, participants pillowed a foam block without a ball.

Main outcome measures: To quantify the amount of deep-tissue pressure by a ball, compressed soft tissue thickness was measured with lateral cervical radiographs. To assess muscle relaxation, the amount of muscle tension was determined using electromyography of the sternocleidomastoid and upper trapezius muscles. To monitor the cervical lordosis in each condition, the extension angles of the cervical vertebrae were quantified using the relative rotation angles.

Results: The compressed soft tissue thickness in the SIRB condition was significantly lower than that in the HMB condition. The normalised muscle activities exhibited that right sternocleidomastoid muscle activity in the HMB condition was significantly higher than that in the baseline and SIRB conditions. In the SIRB and HMB conditions, Numeric Rating Scale for pain was 0.2 ± 0.5 and 5.2 ± 1.4, respectively.

Conclusions: Our findings demonstrate that a SIRB is more advantageous than an HMB for pressing the soft tissue deeply. This finding would be related to reduced muscle tension and discomfort in the SIRB condition when compared with the HMB condition.

1. Introduction

Massage is one of the earliest and most primitive forms of personal healthcare used for physical and psychological relaxation, and its therapeutic effects are scientifically established.[1,2] The literature on massage has generally focused on the systematic manipulation of deep soft tissues such as the fascia, with an aim of reducing muscle tension by eliminating myofascial trigger points (MTrPs).[3–6] MTrPs are defined as nodules of tenderness within taut bands of skeletal muscle.[7,8] The formation of MTrPs is mainly attributed to injured or overstressed muscle fibres, resulting in increased acetylcholine release, involuntary muscle contraction, and sensitisation of myofascial pain.[8–10] The clinical signs and symptoms of MTrPs are local pain, reduced range of motion with increased sensitivity to stretching, and muscle weakness.[11] To eliminate MTrPs, manual therapy is applied based on MTrP pressure release, and involves deep tissue massage to apply gentle or firm sustained pressure to an MTrP using the fingers, palm, or elbow.[4,5,12–16] Previous studies have shown that this technique is effective for increasing joint range of motion and decreasing muscle tension.[5,12,15]

The practice of self-massage has been gaining importance for improving individual health and well-being, and self-myofascial release is an increasingly common self-massage program used for MTrP pressure release.[6,17–19] To perform self-myofascial release, individuals apply pressure to the deep muscles using their own body mass on round-shaped therapeutic tools. For example, individuals with musculoskeletal pain in previous studies conducted self-myofascial release while lying on a therapeutic ball, wand, or foam roller.[15,17,19–24] These therapeutic tools provide firm or gentle pressure to the muscle belly,[12,15,25] and are available in a variety of densities and textures. However, effects of the mechanical properties of therapeutic tools for self-myofascial release, such as the outcomes of hard tools versus soft tools on deep pressure applied to the soft tissue, or on the amount of

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reduced muscle tension, remains relatively unknown. As MTrP pressure release requires the exertion of pressure to the deep muscle layer while minimising muscle tension[2,17,23,24,26] it is important to identify which type of self-massage tool is most beneficial for pressing the deep muscle while maintaining low muscle tension. From a physics perspective, a hard massage tool would be advantageous for providing pressure to the deep muscles, as the force induced would be more concentrated to the target tissue rather than being dispersed, as occurs with use of a soft massage tool. On the other hand, the firm pressure of a hard massage tool might induce muscle contraction, resulting in both greater soft tissue thickness and higher muscle activity compared to proper gentle pressure. Unpleasant sensory stimulation, such as pain, is known to increase the muscle activity of adjacent muscles.[27,28]

This study aimed to compare the amount of compressed soft tissue thickness and muscle relaxation between a soft inflatable rubber ball (SIRB) and a hard massage ball (HMB). Given that strong mechanical stimulation by firm pressure could induce ischemic muscle contraction[10] we hypothesised that an HMB might increase muscle tension, obstructing pressure propagation into the deeper soft tissue. To identify soft tissue thickness and muscle tension, we used radiograph measures and electromyography (EMG) while participants pillowed SIRB and HMB, respectively. Additionally, to monitor the cervical lordosis in each condition, the extension angles of the cervical vertebrae were quantified.

2. Methods

Participants who met the following criteria were recruited for this study: (1) neck pain or discomfort lasting for more than 30 days during the last year, (2) pain frequency of at least once a week, and (3) pain intensity of at least 2 on a numeric rating scale from 0 to 10. To identify self-perceived neck disability and pain, we used the Neck Disability Index (NDI).[29] MTrPs at the suboccipital muscles were confirmed by a physician on the basis of the essential diagnostic criteria specified in a previous study (palpation of the taut bands on the muscle, the presence of tender spots within the tender nodules, and reproduction of pain by compressing the tender spot).[30] Exclusion criteria were as follows: (1) neck or shoulder surgery within the past year; (2) clinical evidence of radiculopathy or myelopathy; (3) history of disc disease, fracture, or dislocation of the cervical vertebrae; and (4) cognitive deficits. This study was approved by the institutional review board of Cheongju University (1041107-201712-HR-014-01). All participants gave their written informed consent. All methods were performed in accordance with the relevant guidelines and regulations.

2.1. Procedure

This crossover experimental study comprised three conditions: baseline, HMB, and SIRB. In the baseline condition, participants pillowed a foam block under their neck in the supine position without any added intervention. In the SIRB and HMB conditions, the position of participants was the same as the baseline condition, but a ball was placed between the centre of the suboccipital region and a foam block. Fig. 1A illustrates the placement of the ball. The method used is similar to a pressure release technique used for the suboccipital muscles in which a therapist presses upwards on the corresponding muscles using their fingertips, with the patient in the supine position.[31–33] To determine the suboccipital region for placement of the SIRB and HMB, the spinous process of C2 was palpated, and the suboccptal region was defined as 20 mm above C2.[34] A physical therapist determined both the spinous process of C2 and the suboccipital region, and marked both anatomical landmarks with the participant in the supine position. After marking the landmarks, a steel bead 10 mm in diameter was placed on the skin above the middle and anterior of the neck to calibrate distance on radiographs.[35] Then, a ball was placed below the suboccipital region with the midline of the ball aligned with the centre of the foam block, where a 5 mm groove had been hollowed. While the ball was being placed, the experimenter lifted the head of the participant slightly. The participant was asked not to change their position between conditions. The three conditions were conducted in a random order determined using simple randomization (https://www.random.org/integers/). In all conditions, participants were asked to relax their body with slow and deep breathing.

Lateral cervical radiographs were obtained to evaluate the depth to which therapeutic balls compressed the soft tissue at the suboccipital region. During cervical radiographs, the participants were placed at the supine position and their head posture was maintained. In particular, the nose of the participant was directed vertically, so as not to rotate the head. The position of participants was not changed between conditions during radiography. A lateral vertebral scan was centred at the level of the C2 vertebra. The film cartridge was placed to the right side of the participant's head and radiographs were obtained after 10 s of relaxation in each condition. A radiology technician with 25 years of experience obtained the radiographs.

After radiography, EMG was measured to quantify muscle relaxation, following the same procedure and anatomical landmarks as mentioned above. In this study, lower EMG activity was considered to correspond to a more relaxed state. EMG signals were recorded with surface electrodes using a wireless EMG system (FREEEMG, BTS, Quincy, MA, USA). After standard skin preparation, surface electrodes were attached on both sternocleidomastoid (SCM) and upper trapezius (TRA) muscles, oriented parallel to the muscle fibres. Interelectrode distance was approximately 2 cm. The electrodes of the SCM were placed at the distal third on the line from the sternal notch to the inferior point of the mastoid process; those of the TRA were placed at 2 cm lateral from the midpoint on the line from the spinous process of the seventh cervical vertebra (C7) to the acromion.[36] The EMG was amplified 1000 times, filtered (band pass, 5–500 Hz, second order), and collected at 1 kHz. For EMG normalisation, maximal voluntary contraction was performed for 3 s with isometric manual resistance in the supine position. For the sternocleidomastoid muscles, manual resistance was applied to the forehead against neck flexion. For the upper trapezius muscles, manual resistance was applied to both acromion processes against shoulder elevation. In each condition, EMG was measured for 10 s.

2.2. Characteristics of self-myofascial release tools

In the SIRB and HMB conditions, an inflatable ball (GB-5, Goodball Academy Inc, Seoul, South Korea) and a massage ball (Naum Care Corporation, Gyeonggi-do, South Korea), respectively, were used (Fig. 2). The diameter of both balls was 60 mm. The SIRB was made by wrapping 4 mm of rubber with a Shore A hardness of 45. The HMB consisted of hard rubber with a Shore A hardness of 90.

2.3. Outcome measures

To identify the compressed soft tissue thickness, an examiner marked 3 points at the external occipital protuberance of the head and the spinous processes of C1 and C2 (Fig. 1B). We defined the compressed soft tissue thickness as the shortest distance between each point and the surface of the ball, namely the head, C1, and C2 depths. The compressed soft tissue thickness values were calibrated based on the diameter of the steel bead presented in each radiograph. This examination was based on the method of assessing muscle thickness on radiographs.[37–39]

All EMG data were calculated as root mean square values at 100-millisecond intervals. For the maximal EMG value, we calculated the peak EMG root mean square value from a maximal voluntary contraction trial. For each condition, we trimmed the EMG data by eliminating the data at the beginning and end of 1 s. Then, the EMG data were normalised as a percentage of the maximal EMG value. Finally, the

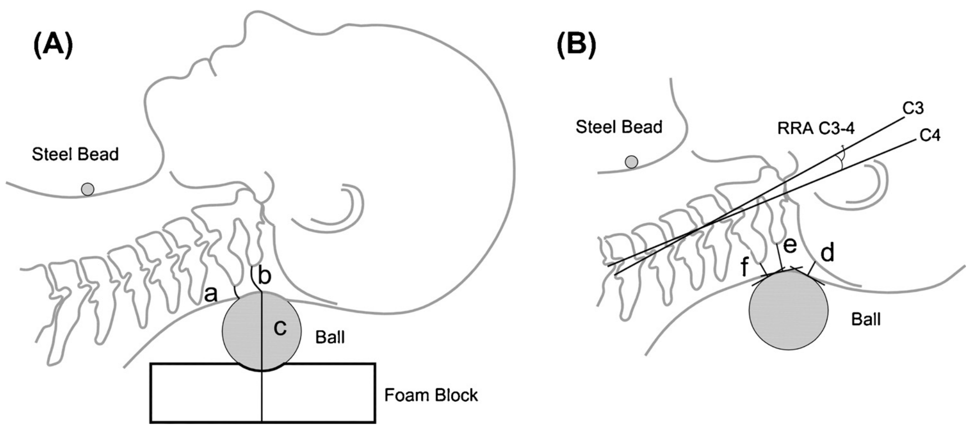

Fig. 1. (A) Placement of the ball. The spinous process of C2 (a) was palpated and 20 mm above C2 (b) was defined as the suboccipital region. The ball was placed beneath the suboccipital region with the midline of the ball aligned to the centre of the foam block, where a 5 mm groove had been hollowed. (B) Measurement of the soft tissue thickness compressed by the ball and the relative rotation angle (RRA) on radiographs. The compressed soft tissue thickness was defined as the shortest distance from the external occipital protuberance of the head (d) and the spinous processes of C1 (e) and C2 (f), respectively, to the surface of the ball. The RRA was the angle between lines that linked the posterosuperior to posteroinferior corners of individual cervical vertebrae. For instance, the RRA of C3-4 was the angle between lines extending the posterior vertebral body margins of C3 and C4.

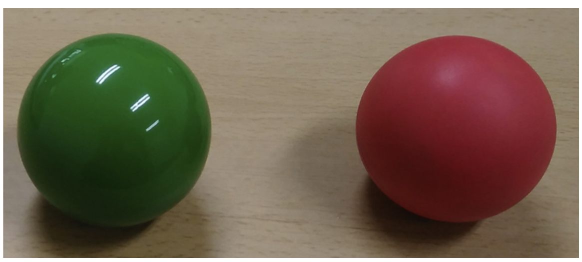

Fig. 2. Self-myofascial release tools (left: a soft inflatable rubber ball, right: a hard massage ball).

normalised EMG data for each muscle were averaged.

As a secondary outcome, the extension angles of the cervical vertebrae were quantified using the relative rotation angles (RRAs) to monitor the cervical lordosis in each condition. To identify the RRAs between the vertebrae (Fig. 1B), the following lines were marked: (1) a perpendicular line from a line between the midanterior and posterior tubercles of C1; and (2) a line between the posterosuperior and posteroinferior body corners of C2 through C6. The RRA of C1-2 was measured as the intersection between the C2 posterior bodyline and a line perpendicular to the line through the midanterior and posterior tubercles of C1. The RRAs of C2 through C6 (C2-3, C3-4, C4-5, and C5-6) were calculated as the intersection between adjacent pairs of lines. We also calculated the total angle, C1-6, as the sum of all the RRAs. The brightness of the radiographs was adjusted to emphasise the cervical vertebrae or soft tissue layers near the ball (Fig. 3).

The intrarater reliability for the compressed soft tissue thickness and RRA values was evaluated. To identify the intrarater reliability, we selected 20 radiographs. The measurement was performed twice by the same physician with a 1-week interval following the same procedure as described above.

In the SIRB and HMB conditions, we measured Numeric Rating Scale (NRS) for pain (0, no pain; 10, worst possible pain)[40] while participants pillowed SIRB and HMB.

2.4. Statistical analysis

To compare the compressed soft tissue thickness at the head, C1, and C2 points between the balls, 2-way repeated measures analysis of variance (RMANOVA) was conducted (HMB vs SIRB conditions × measurement points). Five intersegmental angles ($C_{1\text{-}2}$, $C_{2\text{-}3}$, $C_{3\text{-}4}$, $C_{4\text{-}5}$, and $C_{5\text{-}6}$) measured by the RRAs were compared among the 3 conditions (baseline, HMB, and SIRB) using 2-way RMANOVA (RRAs of the cervical vertebrae × experimental conditions). Two-way RMANOVA was also used to compare the normalised muscle activities between the 3 conditions (muscles × experimental conditions). The total angle, $C_{1\text{-}6}$, between the 3 conditions was compared using 1-way RMANOVA. A post hoc analysis was performed using the Sidak test. Effect sizes (ES) for each comparison also reported using partial eta squared. To identify the intrarater reliability of the radiographic measurements, we used intraclass correlation coefficients (ICCs) comprising 2-way mixed effects, absolute agreement, and a single rater/measurement model ($ICC_{3,1}$). All data were presented as mean ± SD and analysed using SPSS version 19.0 (IBM Corporation, Armonk, NY, USA). Significance was accepted at $P < 0.05$.

3. Results

Thirty participants (17 women, 13 men; age: 65.9 ± 3.4) were enrolled in this study. The total NDI score of all participants was 34.0% ± 15.2. Individual participant NDI scores are presented in Table 1.

Using 2-way RMANOVA, we found that the compressed soft tissue thickness in the SIRB condition was significantly lower than that in the HMB condition (ES = 0.314; $F_{1, 29} = 13.253$, $P = 0.001$). The compressed soft tissue thickness was also significantly different between the measurement points (head, C1, and C2; 2-way RMANOVA; ES = 0.928; $F_{2, 28} = 180.1484$, $P < 0.001$). There was no significant interaction between the ball conditions and measurement points (2-way RMANOVA; ES = 0.105; $F_{2, 28} = 1.639$, $P = 0.212$). Fig. 4 shows the compressed soft tissue thickness values between the HMB and SIRB conditions.

The normalised muscle activities were significantly different between the 3 conditions (2-way RMANOVA; baseline, HMB, and SIRB; ES = 0.435; $F_{2, 28} = 10.791$, $P < 0.001$) and between the muscles (left SCM, right SCM, left TRA, and right TRA; 2-way RMANOVA; ES = 0.291; $F_{3, 27} = 3.701$, $P = 0.024$). Because an interaction effect was also identified (2-way RMANOVA; ES = 0.440; $F_{6, 24} = 3.144$, $P = 0.020$), we performed a post hoc analysis. As a result, right SCM muscle activity in the HMB condition was significantly higher than that in the baseline (Sidak test; $P < 0.001$) and SIRB (Sidak test; $P = 0.029$) conditions. Fig. 5 shows the normalised muscle activities in each condition.

The RRAs of C1 through C6 were significantly different between the experimental conditions (baseline, HMB, and SIRB; 2-way RMANOVA; ES = 0.590; $F_{2, 28} = 20.107$, $P < 0.001$). The five intersegmental angles (RRAs) were also significantly different between the cervical levels ($C_{1\text{-}2}$, $C_{2\text{-}3}$, $C_{3\text{-}4}$, $C_{4\text{-}5}$, and $C_{5\text{-}6}$; 2-way RMANOVA; ES = 0.947; $F_{4, 26} = 116.189$, $P < 0.001$). There was a significant interaction between the ball conditions and the RRAs of C1 through C6 (2-way RMANOVA;

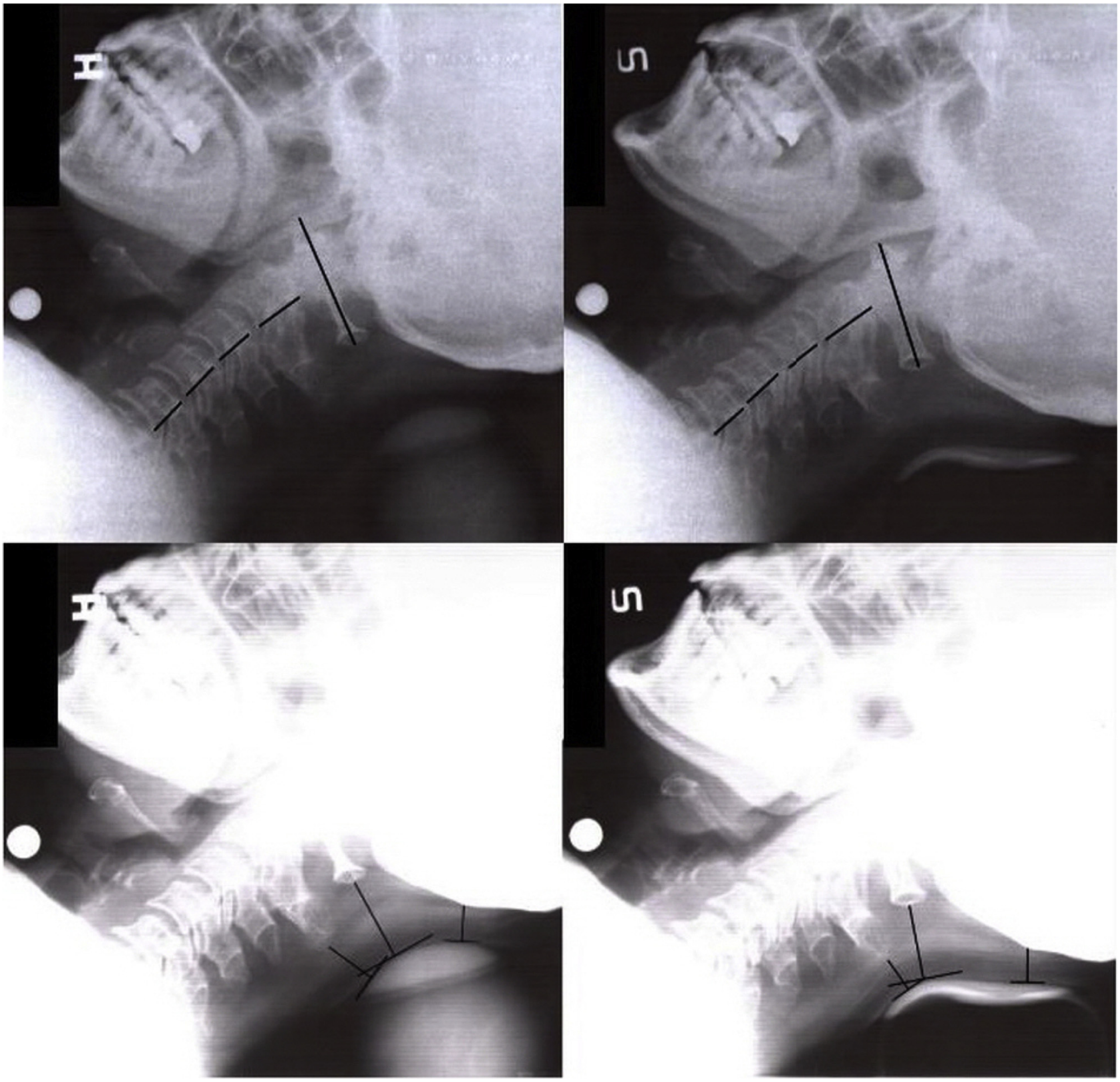

Fig. 3. Sample radiographs of a participant pillowing the hard massage ball (left column) or soft inflatable rubber ball (right column). The brightness of the radiographs was either decreased (upper row), to emphasize the cervical vertebrae in order to examine the relative rotation angles between the vertebrae, or increased (lower row), to highlight the soft tissue layers in order to measure the compressed soft tissue thickness.

Table 1
Individual participants' neck disability index scores.

Index	Mean	Standard deviation
Pain intensity	1.8	0.9
Personal care	1.1	1.0
Lifting	2.1	1.3
Reading	2.2	1.2
Headaches	1.3	0.8
Concentration	2.0	0.9
Work	2.0	1.0
Sleeping	1.6	1.4
Recreation	1.2	0.8

ES = 0.602; $F_{8,\ 22} = 4.165$, P = 0.004). A post hoc analysis (Sidak test) showed no significant differences in the intersegmental angles between the experimental conditions ($P > 0.05$) when the RRAs were compared at the same intersegmental level. When the total angle ($C_{1\text{-}6}$) was compared using 1-way RMANOVA, the values were significantly different between the conditions (ES = 0.590; $F_{2,\ 28} = 20.107$, $P < 0.001$). A post hoc analysis (Sidak test) exhibited that the total angle in the SIRB condition was the greatest in comparison with that of the baseline ($P < 0.001$) and HMB ($P < 0.001$) conditions. No significant difference was identified between the baseline and HMB conditions (Sidak test; P = 0495). Overall results for each RRA value are given in Fig. 6.

$ICC_{3,\ 1}$ analysis showed that the intrarater reliability of the compressed soft tissue thickness and RRA values was excellent. For both the first and second radiographic measurements, the ICC of the compressed soft tissue thickness at the head, C1, and C2 points was 0.907, 0.903, and 0.946, respectively. Mean ± SD for the ICC of the RRAs of C1 through C6 was 0.981 ± 0.009 (range, 0.967-0.990).

In the SIRB and HMB conditions, NRS for pain was 0.2 ± 0.5 and 5.2 ± 1.4, respectively.

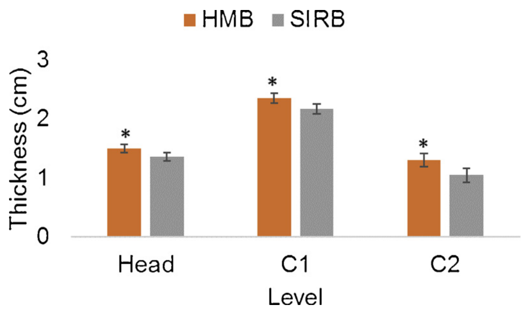

Fig. 4. Comparison of the compressed soft tissue thickness between the hard massage ball (HMB) and soft inflatable rubber ball (SIRB) conditions. The compressed soft tissue thickness is the shortest distance between three anatomical landmarks (head, C1, and C2) and the surface of the ball during pillowing of each ball. The asterisk indicates that the compressed soft tissue thickness values in the HMB condition were significantly greater than those in the SIRB condition ($P < 0.05$).

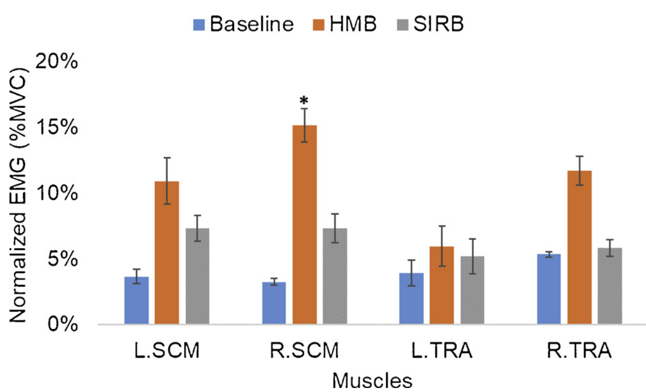

Fig. 5. Comparison of the normalized muscle activities among the baseline, hard massage ball (HMB), and soft inflatable rubber ball (SIRB) conditions. The asterisk indicates that the normalized muscle activities in the HMB condition were significantly greater than those in the baseline and SIRB conditions ($P < 0.05$). L, left; R, right; SCM, sternocleidomastoid; TRA, upper trapezius.

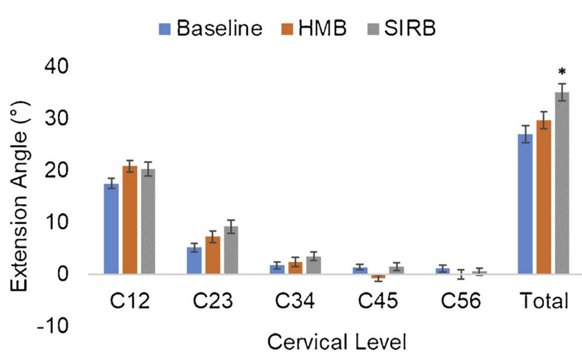

Fig. 6. Comparison of the relative rotation angles of C1 through C6 among the baseline, hard massage ball (HMB), and soft inflatable rubber ball (SIRB) conditions. The asterisk indicates that the total angle (C1-6) in the SIRB condition was significantly greater than that in the baseline and HMB conditions ($P < 0.05$).

4. Discussion

The purpose of this study was to investigate whether the hardness of a therapeutic ball affected the compressed soft tissue thickness and muscle tension. According to our results, the lower total angle ($C_{1\text{-}6}$) and greater muscle activities in the HMB condition support our hypothesis that the firm pressure by the HMB increases muscle tension. Furthermore, the compressed soft tissue thickness values show that the SIRB is comparatively more advantageous in propagating pressure into deeper soft tissue.

This study demonstrates that a SIRB provides lower compressed soft tissue thickness compared with an HMB. The compressed soft tissue thickness was defined as the shortest distance between the bony landmarks and the surface of the ball. A lower compressed soft tissue thickness corresponds to the ball more closely approaching the bone, indicating more effective deep tissue pressure. Our results showed that the thickness of the suboccipital muscles in the SIRB condition was thinner than that in the HMB condition. Considering that applying pressure in a deeper direction helps to lengthen the muscle fascia[10] a SIRB would be superior to an HMB for providing therapeutic effects similar to a pressure release technique. Hence, our findings support the assertion that soft and gentle pressure is recommended for reduce muscle tension and releasing the deep muscle fascia.

Generally, an HMB can create greater pressure than a SIRB when the same force is applied, presumably corresponding to better release. However, our results contradict this presumption, as compressed soft tissue thickness was closely associated with the amount of muscle tension. Our findings suggest that firm pressure by an HMB increases muscle tension, which resists pressure propagation into the deep muscles; therefore, the soft tissue thickness between the bone and the surface of the ball was increased on radiographs.

The greater muscle activities in the HMB condition indicate that muscle tension, especially in the neck flexors, is rarely relaxed when the participant uses an HMB for pressure release of the suboccipital muscles. In this study, we measured EMG for SCM and TRA muscles; however, as a ball was pressed into the suboccipital region during the experiments, and it was therefore not possible to place EMG electrodes on this region, we did not measure EMG for suboccipital muscles. Nevertheless, we presume that the painful sensation elicited by the firm pressure of the HMB obstructs muscle relaxation and increases overall neck muscle tension. This presumption is supported by a previous study that demonstrated a pain-induced increase of neck flexor-extensor muscle co-activation.[28] This co-activation may be a protective response against pain.[41] Furthermore, another study demonstrated that a more rigid foam roller exerted greater contact pressure over a smaller area on the thigh muscles.[19] Given our findings, these results may be explained by muscle co-contraction following an unpleasant or painful perception in a rigid roller condition.

We also found increases in the total angle of neck extension during the SIRB condition. Because the height of the HMB is greater than that of the SIRB when pillowed by a participant, there is room for more neck flexion in the HMB condition. Although there were no significant differences in the RRAs between the segments, the averages in C4-5 and C5-6 showed negative values, indicating flexion of corresponding intervertebral bodies. Given that a straight neck can cause neck pain or disorder[42] a decreased extension angle in the HMB condition indicates that self-myofascial release using an HMB in the suboccipital region is not encouraged for maintaining cervical lordosis. In contrast, a SIRB would be more recommended as a therapeutic tool for self-myofascial release, as the averages of the cervical extension angles were increased or maintained in the SIRB condition compared with those in the baseline condition.

In this study, compressed soft tissue thickness changed by ball compression was examined using lateral cervical radiographic measurements. In the literature, ultrasound has been frequently used to confirm a soft tissue thickness. However, the disadvantage of this method of observing the state of soft tissue pressed by a ball is that the soft tissue is also pressed by an ultrasound probe during examination. Additionally, it is very hard to control the location and angle of the probe between conditions. Thus, we performed lateral cervical radiographic measurements to directly observe the state that the ball is compressing soft tissue. Lateral cervical radiographic measurements have been used frequently to evaluate body alignment in the sagittal plane.[43–46]

The results of this study indicate that therapeutic tools providing gentle pressure are superior to those providing firm pressure. For the practice of self-massage, therapeutic tools have provided firm or gentle pressure to the muscles[12,15,25] but the effect of the mechanical properties of the therapeutic tools has not been considered. Since the transmission of compression force to the deep muscle layer with low muscle tension is emphasized in MTrP pressure release[2,17,23,24,26] we believe that self-massage tools that provide gentle pressure are favourable to the practice of self-massage.

This study has several limitations. First, radiography and EMG were not examined at the same time because EMG electrodes interfere with radiographic images. Therefore, the EMG activities are directly related to the cervical morphology confirmed by radiography. To overcome this disadvantage, we maintained the landmarks, such as the lines for C2 and the suboccipital region, and the measurement was repeated in the same position. Secondly, our study did not determine the optimal hardness of a ball for performing self-myofascial release. We found that a SIRB provided more deep pressure on the muscles than did an HMB; however, pressure that is too gentle may not provide sufficient pressure to the soft tissue. Hence, further study is required to determine the optimal amount of pressure when using a SIRB. Thirdly, this study was designed as a crossover experimental study, not as a randomized controlled trial. If the study design involved comparison of two groups of different participants, the weight of the head and neck should be considered in the measurement of the compressed soft tissue thickness to account for the effect of differences in body weight on soft tissue thickness and measurement error. If the participants' head weights are different, the pressure on the ball will also change. To minimize this issue, we designed a crossover experimental study that repeatedly measures the same participant under different conditions conducted in a random order. In future studies, randomized clinical trials are required to demonstrate the effect of an SIRB on pain and physical function in patients with myofascial pain syndrome. If our experiment was performed in a randomized controlled trial, it would be necessary to measure the weight of the head and neck and to include the calibration process of the data. Moreover, differences in physical characteristics between participants, such as different tensions of the cervical ligament by a difference in cervical lordosis, can affect soft tissue. Hence, control variables for baseline conditions should be considered in between-group comparison studies. Also, when interpreting results of the compressed soft tissue thickness, it is necessary to focus on a difference in the thickness between experimental conditions within a participant. Interpretation of the absolute thickness value is limited as the compressed soft tissue thickness is influenced by different physical characteristics between participants. Lastly, because the measurement is a one-dimensional projection. It may be affected by vertebral rotation. In order to control vertebral rotation, we kept the participant's nose perpendicular to the table during radiographic measurement. However, in order to more precisely control the participant's head rotation, it would be better to use an inclinometer to observe head angle changes. Although head rotation was identified by visual inspection of the experimenter in this study, in future studies, accurate angle measurement of the participant's head rotation should be considered.

5. Conclusions

Our findings demonstrated that a SIRB was superior to an HMB for applying deeper targeted pressure to suboccipital muscles. This finding may be closely related to the low amount of neck muscle tension in the SIRB condition. Because deeper muscle pressure is favourable for releasing the muscle fascia, a SIRB should be recommended as a therapeutic tool for self-myofascial release. Our results indicate that soft massage tools may be more helpful for MTrP pressure release. Based on our findings, further clinical studies are needed to demonstrate the effect of the mechanical properties of therapeutic tools on pain and physical function in patients with myofascial pain syndrome. Given that self-myofascial release with a SIRB does not require assistance of health professionals or visits to clinics, it could be a cost-effective rehabilitation tool for myofascial release.

Conflict of interest

The authors declare no conflict of interest.

Trial registration

This study was registered with the Clinical Research Information Service (registration number: KCT0002731; date of registration: 13/03/2018).

Role of the funding source

The funding sources have not been involved in study design, data collection, analysis, interpretation of data, writing of the manuscript, and submission processes

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