Training on Muscle Palpation Using Artificial Muscle Nodule Models

Kaoru Isogai, Shogo Okamoto, Asuka Noda, Ayumi Matsuzawa and Yoji Yamada

Abstract We developed a palpation simulator for training on muscle palpation techniques for myofascial pain syndrome. This simulator consisted of two layers that resemble the hardness of actual human skin-fat and muscle tissues. Furthermore, a muscle nodule model made of urethane rubber was laid in the simulator. Five participants were trained on the palpation technique for localizing the muscle nodule models, using our simulators. After the training session, they localized the muscle nodule models more definitely than before. The proposed muscle nodule palpation simulator may improve manual palpation techniques used for examining myofascial pain syndrome.

Keywords Palpation · Simulator · Muscle nodule · Myofascial pain syndrome

1 Introduction

Many musculoskeletal pains such as neck or back pains are associated with myofascial pain syndrome, which is caused by myofascial trigger points. Myofascial trigger points are hyperirritable spots located at the muscle nodules along the taut bands in the muscle belly [1]. In a clinical setting, myofascial trigger points are localized by palpation. Therefore, the difference in hardness between a muscle nodule and muscle belly is an important objective for the diagnosis of myofascial pain syndrome. However, it is demanding for clinicians to find the slightly hard spots in the muscles, and previous studies have reported that the localization of trigger points by palpation is not reliable [2, 3]. To solve this issue,

K. Isogai (✉) · A. Noda · A. Matsuzawa
Department of Physical Therapy, Tokoha University, Hamamatsu, Japan
e-mail: kisogai@hm.tokoha-u.ac.jp

K. Isogai · S. Okamoto · Y. Yamada
Department of Mechanical Science & Engineering, Nagoya University, Nagoya, Japan

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we developed an artificial fat and muscle model for training on palpation for myofascial pain syndrome.

Because the muscles are palpated through the skin and fat tissues, the muscle nodule palpation simulator should also consist of subcutaneous and muscular layers. The hardness of the two layers should resemble that of the actual human skin-fat tissue and muscle tissue, respectively. However, the mechanical characteristics of the human subcutaneous and muscle tissues are nonlinear [4, 5], and the solid model, which is made up of a unique material, cannot represent the mechanical characteristics of human body tissues. Fortunately, a layered rubber structure is known to realize the mechanical characteristics similar to those of human tissues [5, 6]. Therefore, we also adjusted the mechanical characteristics of urethane models by adopting a layered structure with fabric sheets between layers. In this study, we demonstrated that our simulator could improve the palpation technique used for localizing the muscle nodules by physical therapy trainees.

2 Muscle Nodule Palpation Simulator

We developed a urethane rubber model of human gluteal tissue basis on the methods of our previous study [5]. As shown in Fig. 1, the model was cylindrical in shape, with the height and diameter being 70 mm and 120 mm, respectively. The upper layer of the model corresponds to the subcutaneous layer, and its thickness was 12 mm. The lower layer of the model corresponds to the muscle layer, and its thickness was 58 mm. The thickness of skin-fat and muscle layers were comparable to the depth of the human gluteal subcutaneous tissues and muscle tissues. A cotton sheet was laid between the two layers of the skin-fat model and between the skin-fat and muscle layers. Furthermore, the top surface was covered by a stretchable knit sheet. These layered structures achieved nonlinear stress-strain characteristics similar to that of human tissues [5].

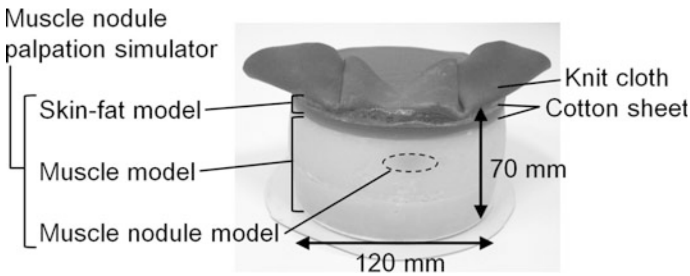

Fig. 1 Urethane—made skin-fat and muscle model for muscle nodule palpation

We embedded a muscle nodule model, which was 31 mm in length, 16 mm in width, and 9 mm in thickness, at 24 mm depth from the surface of the muscle model. The form and burying depth of muscle nodule model were determined based on opinions from clinicians. The nodule model was made of urethane rubber of 405.5 kPa and colored with red ink.

3 Experiment: Training on Muscle Nodule Palpation by Using Artificial Urethane Simulators

Our muscle nodule palpation simulator was intended to aid training on palpation. To confirm the availability, we investigated the effect of the training on localization of the muscle nodule model by using the simulator. This study was conducted with the approval of the internal review board of Tokoha University (Registration no. 2014-015H).

3.1 Stimuli: Artificial Muscle Nodules

As shown in Fig. 2, we developed four types of simulators that differed in terms of the position and direction of muscle nodule models, and one that did not contain a muscle nodule model. Simulator CS contained the muscle nodule model at the position of the circular center. Simulators DRS, DCS, and DSS contained the muscle nodule model at the position 15 mm deviated from the circular center, and the models oriented radial, circumferential, and slant directions, respectively. The participants were blinded to the conditions of the muscle nodule model because all simulators were covered with an opaque knit cloth.

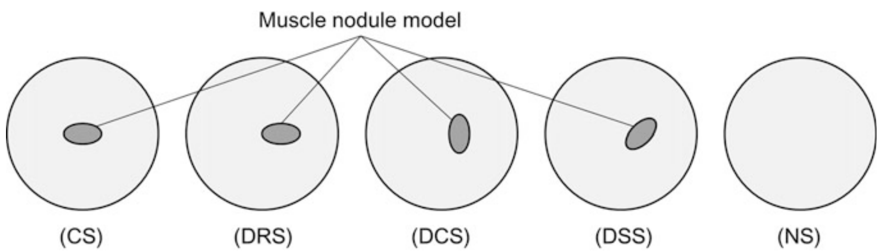

Fig. 2 Positions of muscle nodule models in the urethane models

3.2 Participants

Five physical therapy trainees participated in this experiment. None of them had used the simulators for muscle palpation and they were unaware of the objectives of the present study.

3.3 Procedures

3.3.1 Localization of Nodule Prior to the Training Session

After all the participants were presented a muscle nodule model, they received explanations that some simulators would contain the muscle nodule model within a radius of 30 mm from the circular center at the half depth of the simulator. They were instructed not to lift the simulator and not to peep from the side. Furthermore, they were told not to push the simulator with excessive force, which might cause pain if applied on the actual human body. The participants were allowed to examine each of the four types of simulators—DRS, DCS, DSS, and NS—within 1 min. Simulator CS was not used in the localization task. The simulators were presented in a random order and direction. During each trial, they judged whether the muscle nodule model existed in the simulator. If they judged that the muscle nodule model existed, they placed a paper leaf, which imitated the outer shape of muscle nodule model, on the top surface of the simulator, judging both position and direction. All the participants repeated the procedures mentioned above 20 times, i.e., five repetition for each type of simulator.

3.3.2 Training Session by Using Palpation Simulator

All the participants were trained on palpation using simulator CS to know the sensation experienced by palpating the muscle nodule model for 5 min. They were allowed to lift the simulator and to check the position of the muscle nodule model by looking through the transparent bottom of the simulator. After the training, they were required to freely describe their impressions about the training.

3.3.3 Localization of the Nodule After the Training Session

All participants repeated the same task described in Sect. 3.3.1. Thereafter, they freely described their impressions about the effect of the training session on their judgment.

3.4 Analysis

For the trials in which the simulator was perceived to contain the muscle nodule model, we measured the gaps of distance and rotational angle between the silhouettes of the muscle nodule model that was projected to the top surface of the simulator and the paper leaf placed by each participant. We regarded the participants' answers as correct when the distance and angle gaps were smaller than 16 mm and 30°, respectively. We applied Wilcoxon signed rank test on the correct answer ratios for simulators DRS, DCS, and DSS. Note that we excluded the answer for simulator NS, for which the participants mostly responded correctly, from the analysis because they would increase the apparent correct answer ratios.

3.5 Results

Figure 3 shows the mean correct answer ratios for each session and the results of the statistical analysis. The correct answer ratios for the position significantly improved after training. According to the introspective reports provided by the participants after the training session, they could acquire exploratory motion to sense the muscle nodule model deep in the simulator, and they understood the appropriate strength of pressure required to identify the muscle nodule model. Furthermore, in their introspective reports after the post-training session, the effects of the training session were positively recognized. They reported that they could utilize the experiences acquired through the training session.

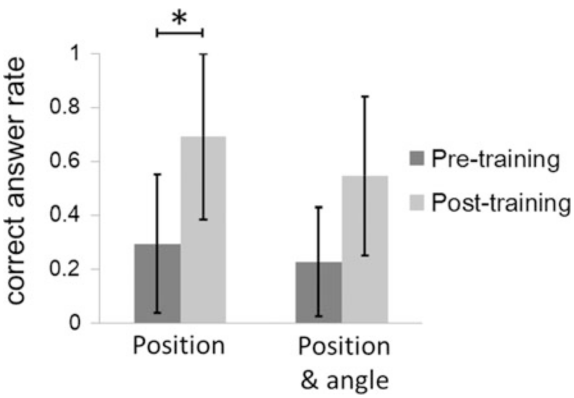

Fig. 3 Correct answer ratios for a localization task before and after the training session

4 Conclusions

In this study, we demonstrated that the localization techniques for the slightly hard spot in the muscle model had improved after a training session using our palpation simulator. The localization experiments and introspective reports from the trainees suggested the beneficial influences of the knowledge of haptic sensations felt because of nodules in the muscle and exploratory hand motions for effective palpation. The models used in the present study exhibited stress-strain characteristics similar to those of the human gluteal tissues. In addition, these models are believed to be similar to actual human tissues [5]. Clinicians' examination ability for the myofascial pain syndrome may improve by a training program using our simulators.

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