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Original article

Standardized simulated palpation training – Development of a Palpation Trainer and assessment of palpatory skills in experienced and inexperienced clinicians

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ABSTRACT

Specific palpation skills are required to identify and treat myofascial pain. The aim of this study was to develop a device that reflects absolute pressure values during simulated palpation, and to test the hypothesis that training through standardized manual palpation results in improved skills for experienced and inexperienced examiners. Experienced ($n = 30$) and inexperienced ($n = 30$) examiners were randomly divided into either training or control. A device (Palpation Trainer) was constructed to measure pressure intensity (P_{peak}) and rate of pressure development (RPD). Training consisted of 8–10 min standardized simulated palpation, during which examiners followed a standardized pressure–time curve (visualized in real-time on a pc-monitor). Controls received no training. Tests were performed at baseline, immediately post training and again after 48 h and analyzed for P_{peak} and RPD. After simulated palpation training, experienced examiners improved palpatory skills related to P_{peak} and RPD (i.e. performed closer to predetermined guidelines and with reduced inter-examiner variation), while inexperienced examiners only improved RPD ($p < 0.05$). Thus, standardized training resulted in acute and temporary (48 h) changes in selected analysis variables during simulated palpation in experienced and to some extent also in inexperienced clinicians. Whether this can be transferred to clinical *in vivo* setting requires further study.

1. Introduction

Despite radical technological advances in diagnostic instrumentation, physical examination skills remain a core competency for health care professionals. For manual health care practitioners, in particular, often involved in the management of musculoskeletal disorders, a significant proportion of diagnosis and treatment still relies on manual palpation ability. Thus, the rapid acquisition and development of competencies in this regard are essential for obtaining desired outcomes, both during the diagnostic and intervention stages of patient management. Health care educators commit significant resources in developing novel practitioner psychomotor skills relevant to their area of practice (Junger et al., 2005). Where possible, these are often trained through simulation strategies, in order to eliminate health risks and offer the possibility of simultaneous training and assessment (Langrana et al., 1994, 1997; Junger et al., 2005; Manning et al., 2006). In myofascial pain syndromes, the clinician is similarly required to integrate specific knowledge and skills to inform clinical judgment regarding the diagnostic relevance of trigger point(s) (TP) (Gerwin et al., 1997; Simons, 2004; Wheeler, 2004; Treaster et al., 2006). Consequently, training of clinical competencies likely includes developing an appreciation of appropriate pressure parameters required during the physical assessment of skeletal muscle (or other soft tissue structures). In particular, simulated training to enhance the sensitivity regarding the mode and intensity of the digital pressure applied seems to be a sensible strategy. Instrumented simulated palpation training allows to provide on-line feedback of basic biomechanical palpation parameters such as peak digital pressure (P_{Peak}) and rate of pressure development (RPD), thereby offering a consistent frame of learning to the practitioner. Nevertheless, instrumented simulation training has not been widely used in clinical or research settings, probably in

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consequence of the technical difficulties in constructing such devices. To our best knowledge no simulation device is currently in use with the explicit function of training palpatory perception of skeletal muscle. However, it has previously been shown from pressure algometry studies that both the rate and magnitude of manual pressure applied to a subject are key determinants in the subject's subjective scoring of soft tissue tenderness, and that these perceived scorings vary between symptomatic and asymptomatic subjects (Fischer, 1987; Jensen et al., 1993; Fernandez-De-Las-Penas et al., 2006; Tough et al., 2007; Kinser et al., 2009). Furthermore, from developments in finger dolorimetry and pressure algometry, it appears possible to detect relative difference in tissue sensitivity (Bendtsen et al., 1995; Chesterton et al., 2007). Nevertheless, it appears that with respect to TP palpation, practitioners are, for the most part, left to develop their palpation competence individually through years of exposure to patients Myburgh et al., 2008 in lack of any objective guidelines.

The aim of this study was to develop, construct and test a device (incl. analysis software), which can be used to standardize pressure parameters applied during manual palpation of the upper Trapezius muscle. The specific study objectives were to 1) construct a device that reflects absolute pressure values during simulated palpation (peak pressure (P_{peak}) and rate of pressure development (RPD)), 2) observe whether learning effects are evoked during the time course of palpation task training, and 3) observe whether potential learning effects are influenced by clinical experience.

We hypothesized that an *in vitro* objective standardized method for evaluating and training manual palpation would result in improved skills (i.e. closer to predetermined guidelines and reduced inter-examiner variation) and that potential improvements would be dependent of the years of clinical experience of the examiner.

2. Methods

Ethical clearance was granted through the local ethics committee (Region of Southern Denmark).

2.1. Apparatus development

An instrumented device was developed as part of an inter-examiner reliability study of TP examination in the neck/shoulder region. The "Palpation Trainer" (Fig. 1) was constructed to measure pressure intensity and the temporal RPD during *in vitro* palpation. The Palpation Trainer consists of a water-filled palpation cylinder (DripLok wash bottle 500 mL Ethanol, Van Loenen Instruments, Zandam, Netherlands) covered with latex and connected to a pressure sensor (SenSym Sensor Technics, 19C K/L series, Puchheim, Germany) (Fig. 1A). The pressure sensor is connected to a combined Wheatstone bridge (Fig. 1B), through which the intra-chamber pressure is converted to an electric signal (mV) and subsequently digitally sampled (National Instruments, NI 9237, Austin, TX, USA) at a sampling frequency of 1612.9 Hz. The voltage signal is converted to absolute pressure units by means of a calibration procedure (described in detail below). On-line visual feedback of the pressure is provided to the subject on a computer monitor with an update frequency of 32 Hz.

We sought to provide a clinically realistic biofeedback experience, with respect to pressure parameters. Consequently, we created a pressure curve based on available pressure algometry literature. With respect to RPD, evidence suggests that applying pressure too rapidly during an algometer evaluation is likely to induce tenderness in patients prematurely. We therefore followed the suggested appropriate maximum level guidelines of RPD (1 kg/cm^2/s) and P_{peak} (3 kg/cm^2) for eliciting tenderness in symptomatic subjects (Jensen et al., 1993; Chesterton et al., 2007; Kinser et al., 2009).

2.2. Calibration procedure

On each test-day a standardized calibration procedure was performed with known pressures between 0 kPa and 294.2 kPa (3 kg/cm^2) using a digital algometer (Algometer Type II, Somedic Production AB, Hörby, Sweden) (Fig. 1C). To standardize the calibration procedure and to approximate a three-point pincer palpation technique a sliding calibration appendage was developed and fitted to the algometer (Fig. 1D). Thus, it was possible to apply known pressures to the Palpation Trainer for calibration purposes. Linear regression analysis was used to describe the relationship between the pressure (kPa) applied to the Palpation Trainer by the algometer and the electrical output signal recorded from the Palpation (Fig. 2).

2.3. Participants and randomization

Sixty volunteers, 30 experienced clinicians (11.7 ± 6.9 years of experience as chiropractors) and 30 chiropractic students from the University of Southern Denmark volunteered to participate in the study. All students had been attending soft tissue palpation classes

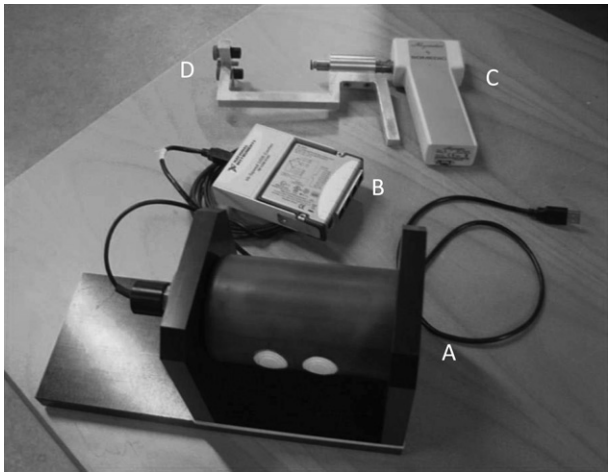

Fig. 1. Illustration of the different compartments of the Palpation Trainer equipment. A) Water-filled palpation cylinder covered with latex. B) Wheatstone bridge, through which the intra-chamber pressure is converted to an electric signal (mV). C) Digital algometer for calibration. D) Sliding calibration appendage to approximate a three-point pincer palpation during calibration.

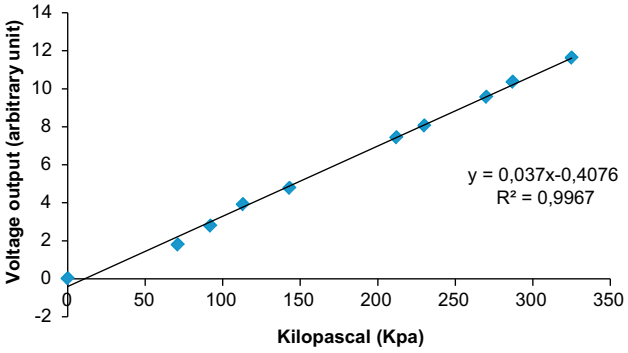

Fig. 2. Linear regression between pressure output (kPa) from the algometer (*x*-axis) and voltage output (arbitrary unit) from the costume developed Palpation Trainer software. Linear regression was performed to yield absolute pressure units (kPa) during simulated palpation.

for at least one year. The objectives of these classes are to train students to identify anatomical structures and abnormalities, including the localizing of TPs in the area of the upper Trapezius musculature. Using a closed envelope method, volunteers were randomly assigned into either training or control. Consequently, four groups were defined that consisted of an experienced training group, an experienced control group, an inexperienced training group, and an inexperienced control group.

2.4. Test protocol

2.4.1. Pre-test familiarization

Prior to all testing and training activities, each subject received a standardized briefing on the purpose of the study (Fig. 3). It was emphasized that the palpation performed on the instrument should mimic the individual's technique used in clinical settings or the procedure taught during their education. Subjects also had the opportunity to palpate the upper Trapezius muscle of the Principal Author as a means of orientation. Furthermore, in order to facilitate data capture and analysis, subjects were instructed in how to develop a 'muscle palpation' pressure curve over a period of 6 s. In this maximum pressure is reached after approximately 3 s, and is then held steady for a further 3 s. Verbal cues were provided to start and stop palpation.

2.4.2. Baseline test

Three blinded trials, separated by approximately 1 min of rest, were recorded in which P_{peak} and RPD were disclosed from the testants (Fig. 4).

2.4.3. Task repetition training

The training group then performed fifteen trials (two per minute) using on-line visual feedback on a pc screen that displayed a standardized pressure–time trajectory that the testants were instructed to follow as closely as possible by manipulating the pressure level feedback through the Palpation Trainer. The standardized pressure–time curve path had a peak pressure of 294.2 kPa (equivalent to 3 kg/cm^2) with an ascending slope (RPD) of 98.1 kPa/s (equivalent to 1 kg/cm^2/s) (Fig. 4). The specific characteristics of the pressure–time curve were based on pre-established clinically relevant norm values for rate of pressure and peak pressure values (Hsieh et al., 2000; Tastekin et al., 2007).

The control group received no visual feedback training and refrained from any activity for a period of time equivalent to the training time in the other group.

2.4.4. Post-training test

To determine whether an immediate training effect could be observed, three blinded trials were performed by all participants following the training trials (same test procedure as in *Baseline test*).

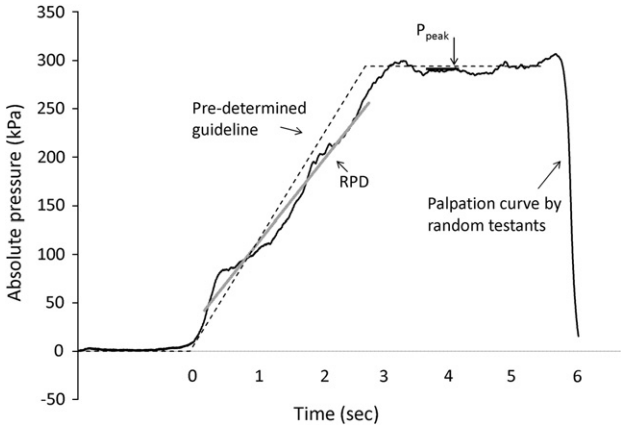

Fig. 4. Absolute pressure values during simulated palpation (peak pressure (P_{peak}) and rate of pressure development (RPD)) performed by a random testants. P_{peak} is calculated during the plateau phase of the pressure-time curve (1-s average). RPD is calculated by means of linear regression. The time points selected for the linear regression analysis are defined as 10% of P_{peak} (start of interval) and 90% of P_{peak} (end).

2.4.5. Retention test

To determine whether a short-term retention effect could be observed, three blinded trials were additionally performed by all participants 48 h after baseline testing (same test procedure as in *Baseline test* and *Post-training test*).

2.5. Statistical analysis

During the process of retrospective analysis all trials were examined for peak pressure (P_{peak}) and the rate at which the pressure was developed (RPD). The outcome variables (P_{peak}, RPD) were averaged over the three trials performed at each of the observation points. In each separate trial P_{peak} was calculated during the plateau phase of the pressure–time curve (1-s average). RPD was calculated by means of linear regression. The time points selected for the linear regression analysis were defined as 10% of P_{peak} (start of interval) and 90% of P_{peak} (end). Trials that had no plateau were excluded.

For the purpose of calibration, a linear correlation analysis of the pressure applied by the algometer and the pressure measured by the Palpation Trainer was performed using the Pearson product–moment method. Statistical comparisons between training groups and control groups were analyzed using a two way ANOVA with the three time points as within-subject factor and group allocation as between-subject factor. To specify potential differences Bonferroni/Dunn post hoc tests subsequently were performed in case statistical significance was reached. To evaluate immediate/acute training effect, the baseline and post-test data

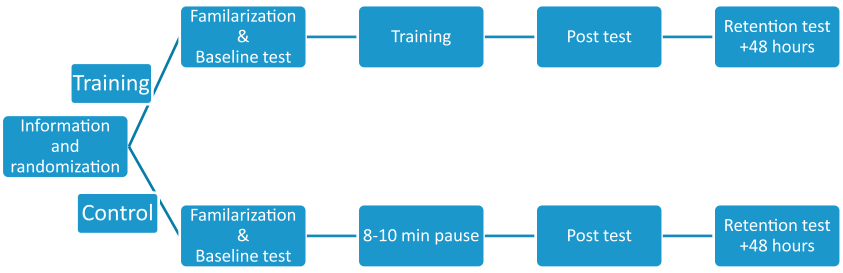

Fig. 3. Flowchart of methodology.

were compared. A more prolonged training effect (48 h) was observed through a comparison of baseline and retention tests. Values were presented as means along with 95% confidence interval. Significance was tested at $p \leq 0.05$ and to avoid mass significance the Bonferroni corrected Dunn post hoc tests were considered acceptable with a value of $p \leq 0.0033$ (due to 15 statistical comparisons ($0.05/15 = 0.0033$)).

Traditionally, inter-examiner variation can be defined as the standard deviation divided by the mean value ((SD/Xmean) × 100). Thus, this parameter is influenced by changes in both the standard deviation and the mean value. However, in this study we expected to find a decrease in both the group mean value (performing palpatory variables closer to predetermined guidelines) and the magnitude of inter-examiner variation (decreased variation). Thus, a simplified method for approximation of the inter-examiner variation, that is independent of changes in group mean value, was introduced. The simplified inter-examiner variation was defined as the distance from each single value to the group mean value and was calculated for P_{peak} and RPD at all separate time points of testing.

3. Results

3.1. Calibration and detection of variables

During the procedure of calibration a linear and highly consistent (between-days) relationship was established between the pressures applied by the algometer and the absolute pressure values recorded by the Palpation Trainer device (Fig. 2). The mean of all r^2-values (obtained on each test-day) derived by the linear regression analysis was 0.981 ± 0.007 (±SD). In those trials where a clear plateau could be defined the two variables defined for the present project were automatically detected by the custom made software. In total 15 trials out 540 trials (<3%) were excluded for not fulfilling the criterion of a plateau phase. As a consequence one inexperienced subject was excluded from the statistical analysis.

3.2. Training effect

Group mean observations for inexperienced and experienced examiners for the three tests (Baseline test, Post-test, and Retention test) are shown in Fig. 5. Values are depicted as numeric delta-values, calculated as the numeric distance from the experimental data points to the guideline value.

3.2.1. Experienced testants

For P_{peak} there was a significant difference between the three time points (Baseline, Post, and Retention) ($F(2, 56) = 5.21$, $p = 0.0084$, $\eta^2 = 0.37$) as well as a significant interaction between the control/training status and the three time points ($F(2, 56) = 8.63$, $p = 0.0005$, $\eta^2 = 0.62$) (Fig. 5A). Finally, Bonferroni corrected tests revealed differences for the training group between Baseline test vs. Post-test ($p < 0.0033$) and between Baseline test vs. Retention ($p < 0.0033$) test (Fig. 5A). For RPD, no significant difference was observed between the different test time points, however a significant interaction for control/training status and the three time points was observed ($F(2, 56) = 4.38$, $p = 0.017$, $\eta^2 = 0.34$) (Fig. 5B). A significant difference for control/training status and the three time points was observed for the simplified

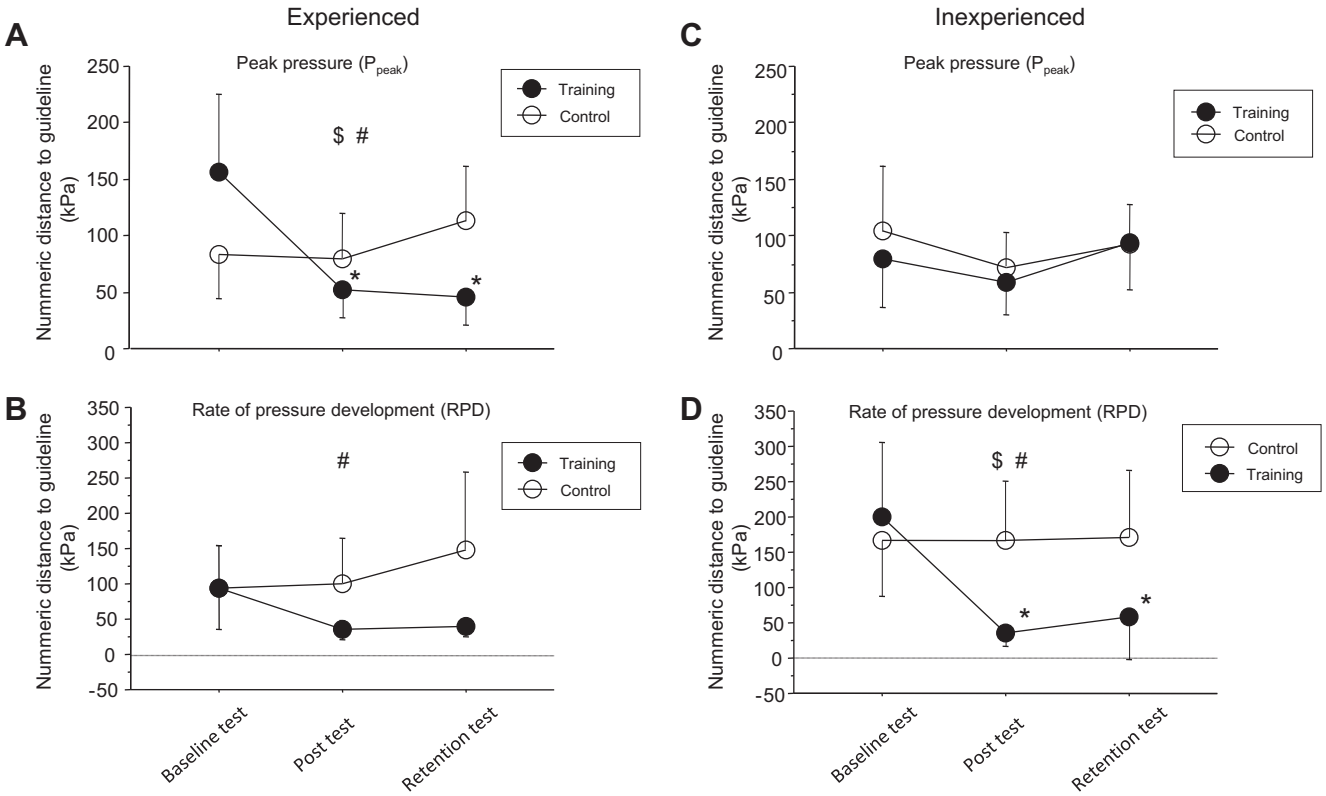

Fig. 5. Group mean values (calculated as distance from pre-defined guideline) at Baseline test, Post-test, and Retention test for P_{peak}-experienced examiners (A), RPD-experienced examiners (B), P_{peak}-inexperienced examiners (C), RPD-inexperienced examiners (D). $Repeated measure, ANOVA, significant interaction for the different tests (Baseline test, Post-test, and Retention test). #Repeated measure, ANOVA, significant interaction for control vs. training. *Bonferroni corrected post hoc test, significant different from baseline value ($p < 0.0033$).

inter-examiner variation for both variables ($F(2, 56) = 4.77$, $p = 0.0122$, $\eta^2 = 0.57$ and $F(2, 56) = 3.71$, $p = 0.031$, $\eta^2 = 0.24$ for P_{peak} and RPD, respectively). Furthermore, the post hoc test revealed that inter-examiner variation for P_{peak} decreased in Post-tests relative to Baseline test ($p < 0.0033$) and in Retention test relative to Baseline test ($p < 0.0033$), respectively (Table 1).

3.2.2. Inexperienced testants

For P_{peak} no significant difference/interaction was demonstrated across the different time points and training status (Fig. 5C). For RPD a significant difference between the three time points ($F(2, 54) = 5.40$, $p = 0.0073$, $\eta^2 = 0.34$) as well as a significant interaction between the control/training status and the three time points ($F(2, 54) = 5.57$, $p = 0.0063$, $\eta^2 = 0.35$) was observed. Furthermore, the Bonferroni corrected tests revealed differences for the training group between Baseline test vs. Post-test ($p < 0.0033$) and between Baseline test vs. Retention test ($p < 0.0033$) (Fig. 5D). For the simplified inter-examiner variation a significant difference for the different time points ($F(2, 54) = 4.40$, $p = 0.017$, $\eta^2 = 0.34$) and a significant interaction between the control/training status and the three time points ($F(2, 54) = 4.3$, $p = 0.018$, $\eta^2 = 0.33$) was observed only for RPD. Furthermore, the post hoc test revealed differences between Post-test vs. Baseline test ($p < 0.0033$), but not when Retention test was compared to Baseline test (Table 1).

3.2.3. Experienced vs. inexperienced testants

A significant interaction for the different time points was observed for P_{peak} when experienced trained subjects were compared to inexperienced trained subjects ($F(2, 56) = 5.2$, $p = 0.0085$, $\eta^2 = 0.48$) (not illustrated). However, no difference was observed for RPD. Furthermore, no difference was observed for P_{peak} or RPD when comparing experienced and inexperienced control groups (not illustrated).

4. Discussion

4.1. Key findings

A new instrument (Palpation Trainer) was developed capable of identifying pressure intensity (P_{peak}) and temporal RPD during *in vitro* palpation (simulated palpation). Our results indicated that an 8–10 min standardized training protocol can induce changes in digital palpation pressure pattern. Specifically, simulated standardized palpation training appears to be effective in producing an acute and short-term training effect in key palpation-related variables (P_{peak} and RPD). These observations were noted in the experienced and to some extent also in the inexperienced cohort of clinicians.

Table 1
Simplified inter-examiner variation (average distance to group mean value).

	Baseline test	Post-test	Retention test
Experienced			
Peak pressure			
Training	85.3 ± 89.1	34.3 ± 27.4[c]	33.2 ± 27.6[b,c]
Control	57.0 ± 37.2	58.7 ± 39.6	68.1 ± 45.1
Rate of pressure development			
Training	76.2 ± 71.7	19.2 ± 14.5	24.5 ± 14.3[b]
Control	82.7 ± 70.5	77.4 ± 81.4	105.2 ± 164.4
Inexperienced			
Peak pressure			
Training	53.3 ± 55.3	38.6 ± 31.1	52.4 ± 30.5
Control	74.2 ± 62.1	46.4 ± 32.8	52.1 ± 47.0
Rate of pressure development			
Training	141.3 ± 120.8	21.0 ± 25.1[c]	62.5 ± 89.9[a,b]
Control	120.5 ± 47.3	115.5 ± 74.3	140.4 ± 75.9

[a] Repeated measure, ANOVA, significant interaction for the different tests (Baseline test, Post-test, and Retention test).
[b] Repeated measure, ANOVA, significant interaction for control vs. training.
[c] Bonferroni corrected post hoc test, significant different from baseline value ($p < 0.0033$).

4.2. The apparatus

The Palpation Trainer was developed as part of an inter-examiner reliability study of TP examination in the neck/shoulder region. Initially, we set out to develop a device that could be used to simulate 3-finger pincer palpation of the upper Trapezius muscle, so that absolute pressure values could be measured in the process. To function as a training tool as well, the device was constructed to provide real-time visual user feedback with respect to graphical display of the applied pressure curve superimposed onto selected target templates (P_{peak} and RPD).

It is important to distinguish between external pressure sensors and the present training apparatus. External pressure sensors detect the individual mechanical pain threshold while using the apparatus, whereas the intention of the present training protocol was to achieve more consistent (less variable) pressure patterns during a simulated standardized palpation procedure. Thus, the present methodology enables examiners to train the application of palpation pressure (rate of pressure rise, plateau pressure phase) in a standardized way, thereby improving their palpation skills in relation to pain thresholds. Concurrently, the Palpation Training device allows examiners to retain full tactile sense in their fingers whilst palpating, since no external instrumentation is fixed to the skin or the fingers. We consider this conservation of tactile sensory function as essential in all types of palpation skill training. Particularly, in the case of myofascial pain syndrome (MPS), both accurate and sensitive palpation techniques are required to locate and distinguish TP.

External pressure sensors have previously been used to examine complex sensorimotor programming of hand and fingers movements in pianists (Parlitz et al., 1998) and health care professions (Langrana et al., 1994; Langrana et al., 1997). Langrana et al. (1994) used a force feedback system based on a virtual model of a knee and later on a liver (Langrana et al., 1997). In terms of MPS external pressure sensors have been used to investigated the reliability with which tenderness could be evaluated by use of manual palpation and Dolorimeter, respectively, in patients with fibromyalgia and matched controls (Tunks et al., 1995). Both dolorimetry and palpation were sufficiently reliable to discriminate control patients from patients with myofascial pain and fibromyalgia, but could not discriminate patients with myofascial pain from those with fibromyalgia (Tunks et al., 1995). Also, neither methods appeared to correlate well with the specific location of pain. The present simulated palpation training allows the examiner to improve accuracy, consistency, stability and reproducibility, which in turn could translate into an improved reliability (Hobart et al., 1996).

4.3. Training effects

The data of the present study support the view that using an objective method for training and standardizing manual palpation can lead to increased inter-examiner reliability and closer to predetermined palpation guidelines. However, whether these, *in vitro* improved skills can be applied to the *in vivo* physical examination of specific skeletal muscles remains unclear. The strongest evidence for a systematic learning effect was observed for peak pressure application (P_{peak}) in the experienced examiners (Fig. 5A) and for the rate of pressure application (RPD) in the inexperienced examiners (Fig. 5D). In these two cases the repeated measure ANOVA and

the Bonferroni corrected tests, both demonstrated a learning effect. RPD for the experienced examiners demonstrated a differential development in trained vs. control subjects, which suggests the presence of a learning effect (Fig. 5B). Furthermore, P_{peak} for the inexperienced examiners varied between different time points, albeit no difference was observed between the mean values of the two subject groups (training vs. controls) (Fig. 5C). Nevertheless, the experienced examiners showed improved inter-examiner variation post training both for P_{peak} and RPD, in support of the initial study hypothesis.

Levoska et al. (1993) investigated the inter- and intra-variation of manual palpation and repeatability of dolorimeter measurements. The authors concluded that the variations were acceptable using standardized dolorimetry, but poor using only manual palpation (Levoska et al., 1993). A modified analysis of inter-examiner variation was employed in the present study since changes in both variation and group mean value were hypothesized. Thus, under the present circumstances a traditional inter-examiner variation would not reveal the hypothesized improvements following short-term training. Inter-examiner variation defined as the average distance from the individual data values to the group mean value demonstrated improved variation both for P_{peak} and RPD in the experienced examiners after short-term training. Notably, the inexperienced examiners only showed improved inter-examiner variation for RPD following 8–10 min of training. However, based on these data it cannot be concluded that experience *per se* causes improved learning abilities regarding diagnostic skills.

The cerebellum is involved in the learning and retention of motor skills (Park et al., 2009). Experience-dependent changes in the brain depend not only on the stage of learning, but also on whether subjects are required to learn a new sequence of movements (motor sequence learning) or learn to adapt to environmental perturbations (motor adaptation) (Doyon et al., 2003). It has been proposed that the cortico-stratial and cortico-cerebellar systems contribute differentially to motor sequence learning and motor adaptation, respectively (Doyon et al., 2003). Manning et al. (2006) observed different eye-tracking parameters and different effect of training in experienced radiographers and undergraduate radiography students when identifying significant pulmonary nodules in postero-anterior views of the chest (Manning et al., 2006). Consequently, the level of clinical experience is likely to have an impact on the motor learning ability when exposed to standardized palpation feedback system including the Palpation Trainer presently used. In humans, improvement occurs within and between training sessions reflecting fast and slow components of motor learning (Karni et al., 1998). Consequently, successful motor skill learning requires sequences of repetitive training interrupted by rest periods (Buitrago et al., 2004). The present study only consisted of a single training session. Accordingly, it is possible that even larger improvement in objectively measured palpation skills could have been achieved by performing multiple training sessions.

The present study essentially investigated the ability to learn to produce a predetermined standardized palpation pressure pattern during an *in vitro* simulated palpation manoeuvre and did as such not investigate the mechanism(s) involved with improvement in palpation competences. Thus, the present device can be used to train the ability to perform and reproduce a standardized pressure pattern in terms of peak pressure and rate of pressure application development without considering the diagnostic relevance of the skill.

4.4. Clinical perspective

Standardized clinical evaluation of skeletal muscle to determine the presence of diagnostically relevant manifestations such as TPs, appears to be more complicated than previously anticipated (Tough et al., 2007). With respect to TP criteria, it is becoming increasingly apparent that the process consists of at least 3 separate diagnostic sub-procedures that are integrated by the clinician (Myburgh et al., 2008). Specifically, palpation, patient feedback and observation of relevant clinical signs are likely to act together, influencing the cognitive process of judging diagnostic relevance.

The present study focused on one of these factors namely the application of pressure parameters during simulated palpation. It was observed that short-duration palpation training had a measureable influence on the palpation skills (consistency) both in experienced and inexperienced examiners in an *in vitro* context. The enhanced skills may then be transferred to the clinical *in vivo* setting. Thus, the use of instrumented pressure palpation devices both in the clinical and study setting should be investigated in future studies.

4.5. Limitations

The custom-built palpation device was designed to investigate simulated palpation and to inspect a potential training effect pre and post simulated palpation training. Whether the observed training effect is clinical relevant was not investigated in the present study. Furthermore, manual palpation requires competencies that include skills and knowledge. The present study alone investigated the manual skills of developing digital pressure according to predetermined guideline, and was not intended to examine the aspect of how to cognitively and professionally interpret the information received during the task. Finally, the available evidence for the predetermined target values for the palpation variables (P_{peak} and RPD) is limited. Consequently, the selected palpation variables examined in the present study, as well as the chosen target values, might not fully reflect the best clinical practice.

5. Conclusions

Pressure intensity (P_{peak}) and the temporal RPD during *in vitro* palpation were successfully measured by a costume made instrumented device (Palpation Trainer). Simulated standardized palpation training appears to be effective in producing an acute and temporary (48 h) training effect in key variables of the palpation (P_{peak} and RPD) in experienced and to some extent also in inexperienced clinicians. However, it cannot be concluded that experience *per se* causes improved learning abilities. Whether the enhanced skills achieved by the present simulated palpation training can be transferred to the clinical *in vivo* setting remains uninvestigated.

Acknowledgments

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