Can teaching ergonomics to ultrasound practitioners reduce white knuckles and transducer grip force?

Abstract:

Ergonomic training is necessary to help to reduce work related upper limb disorders (WRULDs) in ultrasound practitioners. This study provided an ergonomic training session for ultrasound practitioners to determine whether a teaching intervention changed the grip force used to hold a transducer. Thirteen practitioners participated and were placed into two groups (intervention group n=7). Participants were asked to scan the same simulated transabdominal early pregnancy case. An ergometer was used, which enabled all participants to hear the effect of holding the transducer tightly. Their matched grip force was measured before and after the intervention using a dynamometer. The intervention group reviewed videos and photographs taken during the scan to see if this affected the matched grip force further. Study findings showed that the short ergonomic training session with the use of an ergometer significantly reduced the matched grip force applied to a transducer ($p<0.05$) for all participants. The video/photo review did not result in any further significant changes.

Keywords: Work Related Upper Limb Disorder (WRULD); Work Related Musculoskeletal Disorder (WRMSD); ergonomic training; ultrasound; transducer grip; ergometer.

Introduction:

Work related musculoskeletal disorders (WRMSD) have been reported in ultrasound practitioners, with figures of up to 90.5% quoted for ultrasound practitioners scanning in pain[1]. Transducer grip and grip pressure/force have been reported as contributory factors in the development of WRMSD[2]. Baker and Coffin[3] identified poor posture as an additional factor impacting on the increased incidence of WRMSD, along with other factors such as the workforce age, increased patient throughput and increased reporting due to improved awareness of WRMSD. Using a pinch grip to hold the transducer increases the strain on muscles, when compared with a power grip, with a pinch grip involving five times the applied force of a power grip[4]. Some ultrasound practitioners working in specialized areas of practice, such as vascular or cardiac, are more likely to have wrist pain[5, 6] which has been contributed to using a high grip force. Although not found to be causal [6] smaller transducers are used in both vascular and cardiac scanning; which may prevent the sonographer using a power grip to hold the probe; this was supported by one participant's statement, in the research by Evans et al [5].

There has been an increase in both the demand for ultrasound scans and the number of obese patients[7, 8] which can have an impact on grip pressure and potentially WRMSD[2, 3]. This was reflected in the work by Monnington et al,[9] who reported that ultrasound practitioners use increased transducer force when scanning obese patients. Gemark Simonsen and Gard[10], reported that cardiac ultrasound practitioners' extended examination times and increased transducer pressure when scanning obese patients contributing to increased transducer grip force. The authors of the study[10] found that inexperienced ultrasound practitioners who take longer to scan, also suffer due to increased force applied to the transducer. This was supported by Evans et al[5] who concurrently reported that pushing, when scanning, can lead to increased transducer grip and associated injury.

Ergonomic training has been recommended, to improve awareness of ways to reduce the risk of injury amongst ultrasound practitioners[9, 11, 12]. Hoe et al's[13] systematic review suggested no difference in outcome pre- and post- training for computer workers, although they did find self-reported compliance to be increased after training to use ergonomic equipment in one study. However, their review was challenged by the quality and variance between studies and outcome measures[13]. Fisher[14] used video presentations to determine the effect of training on the working practices of ultrasound practitioners. In their small study of 16 participants, they found that 62% self-reported to have changed their working practice after reviewing the video. Martimo et al[15] found a significant difference in self-reported productivity loss in a group of workers who had received conventional health care compared to those who had additional occupational physiotherapy support, but no difference in pain scores. The improved productivity was thought to be due to the changes implemented following advice from the therapist. Despite the limited evidence to support training, the National Institute for Occupational Safety and Health[16] recommend regular training, to include optimization of posture and use of supportive equipment.

Grip strength has been associated with muscle mass and function, with reduced grip strength affecting injury risk and disability[17]. When assessing the hold of an object, to overcome confounding factors such as age and height, matched grip force can be used[18, 19]. This involves participants holding an object, in this case a transducer, then matching the grip by holding a dynamometer (a device for measuring grip force), with the same force as they held the transducer.

In 2006, Murphey and Milowski[20], used an ergometer to highlight the reduction in muscle tension when optimizing the scanning position. An ergometer which emits a sound when muscles are stimulated, increasing in intensity when muscles are under strain, was used in this study to assist in the training, to help improve the ultrasound practitioners' awareness of grip force and to reduce their transducer grip[9]. This current study builds on previous work[21, 22] which evaluated ergonomic training of student ultrasound practitioners in an attempt to reduce transducer grip force. The aim was to ascertain if a short intervention training session using an ergometer could reduce the transducer matched grip force in ultrasound practitioners. This current study also evaluated whether reviewing videos and photos of the hand/wrist, taken whilst scanning, had an impact on transducer matched grip force. It was hypothesized that a short teaching session might reduce the matched grip force applied to an ultrasound transducer. Additionally utilizing visual feedback in the form of videos or images of the participant scanning could lead to further reductions in matched grip force.

Method:

The study was conducted in the ultrasound skills suite at City, University of London, following ethics approval from the School of Health Sciences research ethics committee (ref. Staff/13-14/04). The number of ultrasound practitioners working in the UK (United Kingdom) is unknown, so a sample size calculation was not completed. Convenience sampling was used for the study. Volunteers were recruited from ultrasound clinical supervisors' training days at City, University of London in 2013 and 2014, from participants of a study looking at factors affecting grip strength at the British Medical Ultrasound Society (BMUS) conference in Gateshead[22] and advertisements in Ultrapost, the BMUS on-line newsletter. Inclusion criteria was open to participants having any level of ultrasound scanning experience. Despite the research being well advertised, the uptake was low; low numbers of volunteers for experimental studies have been found to be common [14, 20, 23].

The technique used was adapted from a study looking at matched grip force in ultrasound students[21]. Participants were randomized into two groups; a control and intervention group, using a simple randomization method using cards with C or I on them, to provide a similar number of participants in each group. Participants in both groups had their maximum grip strength measured initially using a Jamar® dynamometer (figure 1a), with the highest of three measurements recorded for their scanning arm using the same standardized technique as Roberts et al[17] and Wood et al[22]. Participants were then invited to scan a case on the UltraSim® ultrasound simulator, during which time photos and/or videos were taken of their hand, wrist and arm, with no intervention from the researcher. Immediately following the scan participants were then asked to grip the dynamometer with the same amount of grip force as they used during the scan, this matched grip force was recorded, following the procedure used by Bao and Silverstein[18] and Bastian et al[19]. Scans were performed using the UltraSim® to try to ensure consistency of the scanning environment. The same transabdominal early pregnancy case was used for each participant. The room was equipped with a Bambach® saddle chair and a moveable ultrasound couch.

Participants then had the ergometer attached to their forearm, using the same technique as Harris[21], (Figure 1b), to assist in the short teaching session. This allowed participants to hear when the muscles were under strain due to their scanning technique, posture and grip force, whilst experienced facilitators worked with the ultrasound practitioner to improve the ergonomics during the scan. At the end of the short teaching session, participant's matched grip force was again measured and recorded. The intervention group were shown videos and / or photographs of their hand and wrist taken during the scan, to look for "white knuckles" (a sign of a tight grip) and hand/wrist positions, whilst holding the transducer, then asked to scan again before measuring the matched grip force for a third time. The control group were simply asked to scan again and the matched grip force measured and recorded (Figure 2).

Measurements of maximum grip strength were used with the matched grip force to calculate the percentage of maximum grip force used, to eliminate variables such as height, age and gender, as used by Roberts et al[17]. Data was stored on an excel spreadsheet, then quantitative analysis was undertaken using SPSS version 22. Parametric and non-parametric tests were used to assess whether the matched grip force changed with ergonomic training and again at final testing, irrespective of participant groups (intervention or control). A value of $p \leq 0.05$ was used to indicate significance in all tests.

Results

Thirteen participants took part in the study, 7 (54%) of which were included within the video/image review intervention group. The subjects demonstrated a higher baseline grip strength for the right hand, mean = 34.33kg, compared with the left hand, mean = 31.16kg. No statistical difference existed in baseline grip strength between the two groups, right hand difference 0.057kg, t=-0.012, p=0.991, left hand difference 0.0238kg, t=-0.0693, p=0.946.

All participants scanned with the right hand. Predominant handedness was not assessed in this study. The control group had a slightly higher matched control grip pre training 2.63 compared with 2.34 in the study group although this difference was not significant, t=-0.303, p=0.767 (Figure 3). The post training grip strength scores did show a greater difference between the two groups, 0.657 than the pre test scores, however the difference between the two groups was still not significant, t=-1.117, p=0.2877. The average reduction in matched grip strength post training was 1.531 with both groups showing a significant reduction (t=4.066, p = 0.039) of their grip strength after training (1.7 for the intervention group and 1.333 for the control group). All subjects except one (90.9%), who was in the intervention group, showed a reduction in matched grip strength after training.

The final stage of the study, to investigate the effect of showing one group videos/photos of their training, demonstrated that showing the photo or video had more effect than doing nothing. The results showed that in the control group there was a slight increase in average matched grip strength, 0.25, p=0.8438, whereas there was a further small reduction, 0.328, p=0.250 in matched grip strength for the intervention group.

Discussion

Previous literature suggests that transducer grip can impact ultrasound practitioners, leading to pain and injury[2, 3, 5, 12]. Measurements of transducer grip force using recommended methods[18, 19] to determine matched grip force, to simulate transducer grip force pre- and post-ergonomic training, were taken. Matched grip force, as a percentage of maximum grip force was used in this study, to compensate for external factors, such as age, previous injury and sex, which can all affect the results of maximum grip force. Further demographic data was not collected in this part of the study, as data for maximum grip strength was collected as part of a wider study[22], which limited the ability to compare data with previous work. The results of this study demonstrated that ergonomic intervention had a significant impact on participants' matched grip force when holding the transducer after training. The hypothesis that review of video / photographs of poor practice in addition to the normal teaching demonstrated might further reduce grip force was demonstrated in the study, with a small reduction in the grip force. Monnington et al[9] had suggested that reviewing videos and photographs may be useful in the teaching of ergonomics, however the results in this study showed that although a slight further reduction was demonstrated in the intervention group, it was not significant.

The findings of a study of information technology (IT) workers[24] demonstrated that direct intervention was more successful in changing habits than photographs without any human intervention. These findings suggest that someone providing advice and support during the training might have a more profound impact on behavior. Similarly, other studies have demonstrated that ergonomic training with a facilitator, in other nonhealthcare settings can reduce the prevalence of WRMDS and strain[25, 26]. Hoe et al's[13] systematic review revealed limited compliance following training in ergonomics, although they found many of the studies to be of poor quality. Younger participants (<40 years) had a higher compliance rate than those over 40. The current study was not able to assess this, as demographic data was not collected and numbers in the study were small.

The matched grip strength was calculated for each participant, with the mean percentage being 8%. Two respondents had a matched grip strength which was >17% of the maximum (one was 20%, the other 23%), suggesting that their transducer grip was much higher than many of the other participants. Bao and Silverstein[18] suggested that a matched grip strength over 17% of the maximum grip strength can lead to carpal tunnel syndrome. This information could be useful when teaching ultrasound practitioners the risks of gripping the transducer too tightly.

It has been suggested that equipment developments may be able to reduce the need for ultrasound practitioners to assert pressure on the transducer[10, 27], such as robotic echocardiography examinations[28]. Until such equipment developments are common place, it is still essential to ensure that ultrasound practitioners are aware of the risks and ways to minimize these, including the need to reduce the transducer grip force. The use of one-to-one training for ergonomics is time consuming, as even in this short intervention study, the trainer needs to be available for at least 30 minutes. This study only reviewed one case of a transabdominal early pregnancy examination. If a range of examinations such as gynecology, obstetrics, abdominal, transvaginal, vascular and superficial structures were to be assessed this could potential take one day per participant. However, the cost implications of the intervention should be compared to the individual and the employer should the ultrasound practitioner sustain a WRMSD.

Ergonomic training has been highlighted as an effective way to reduce the risk of WRMSDs [9, 11, 29, 30]. There are limited studies into how best to train ultrasound practitioners in ergonomics, particularly with reference to transducer grip force. In the Health and Safety Executive (HSE) report[9] it was suggested that local practical training should be incorporated into the practice, but financial support would need to be available to allow this to occur.

Limitations and further studies.

As this study had a small sample size and a narrow focus, wider generalizations cannot be made. To try and reduce bias, this study used a standardized patient, by using the UltraSim, which has limitations when compared to scanning in the clinical situation. The simulator is less pliable than a patient's abdomen, the situation and controls are less familiar than the practitioners' clinical department and equipment. In using the skills suite there are no time pressures, unlike the clinical situations many ultrasound practitioners work in and the study only assessed one transabdominal case. The results can only be used as an indication that additional large-scale studies, relating to ergonomic training may be of value, in assessing ways to reduce the risk of WRMSD amongst ultrasound practitioners. Further studies of this nature, covering a range of different examination types within the participants' own clinical setting would add to this work. Due to the nature of the study at the University, only one intervention was performed, further studies should consider having a larger sample size, so that generalizations can be made and longitudinal follow-up, to ascertain the long-term effects of the training intervention. If this study was carried out in a clinical department, it could also assess the affect on the matched grip force when scanning obese patients, which has been shown to impact on transducer grip force[10, 31].

The dynamometer provides a consistent method of measuring grip pressure, although bias could be introduced, as participants were aware that the researchers wanted to determine whether there was any effect from the training. There are also inherent challenges of using matched grip force, as found in the study by Boa et al[32].

Many other factors influence a workers' chance of developing a WRMSD[1, 2, 9, 33], so further studies would benefit from addressing wider issues, in addition to ergonomics and transducer grip.

Conclusion:

This study has demonstrated that a short ergonomic teaching session, using an ergometer to highlight when muscles are under strain during an ultrasound examination, can reduce transducer grip force. Relaxing transducer grip could help to reduce the chance of developing WRMSD amongst ultrasound practitioners. The use of videos and photographs to demonstrate poor posture and positioning further reduced the matched grip force, but not significantly, in this small cohort. The study only used a very short intervention without longitudinal follow-up and, as suggested by the literature, WRMSDs are multifactorial, suggesting that more extensive intervention should be considered. Until new equipment developments are introduced to reduce the need for ultrasound practitioners to use their own force to manipulate the transducer, particularly with the increasing obesity issues in society, ultrasound practitioners would benefit from some form of education to help them reduce their risk of injury. It appears, from this small study and other previous research; that immediate instructor feedback and guidance, might assist in this process of education.

Disclosure statement

The authors declare to have no conflict of interest.

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Figures

Figure 1a. The dynamometer used to measure maximum grip strength and matched grip force

Figure 1b. The ergometer attached to the scanning arm to measure muscle activity.

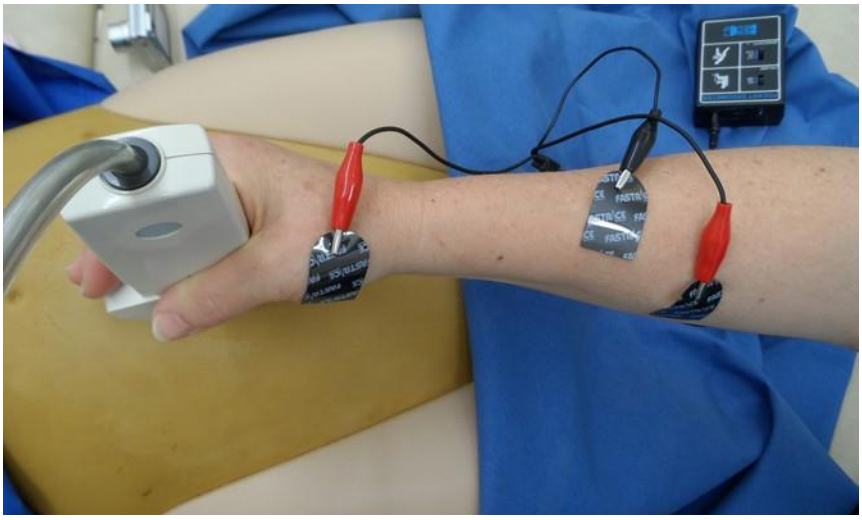

Figure 2. Flow diagram of the study method

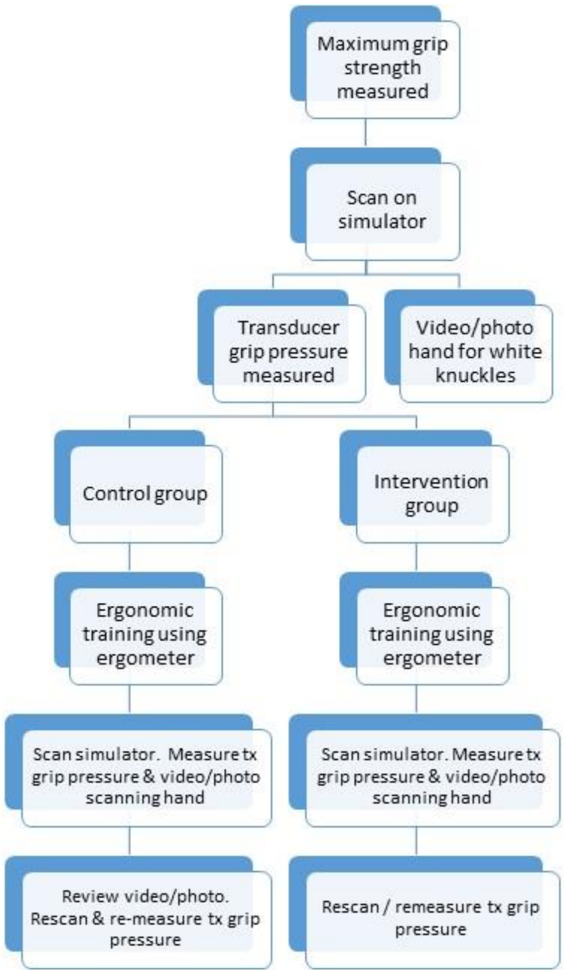

Figure 3: Effect of intervention on matched grip strength scores.

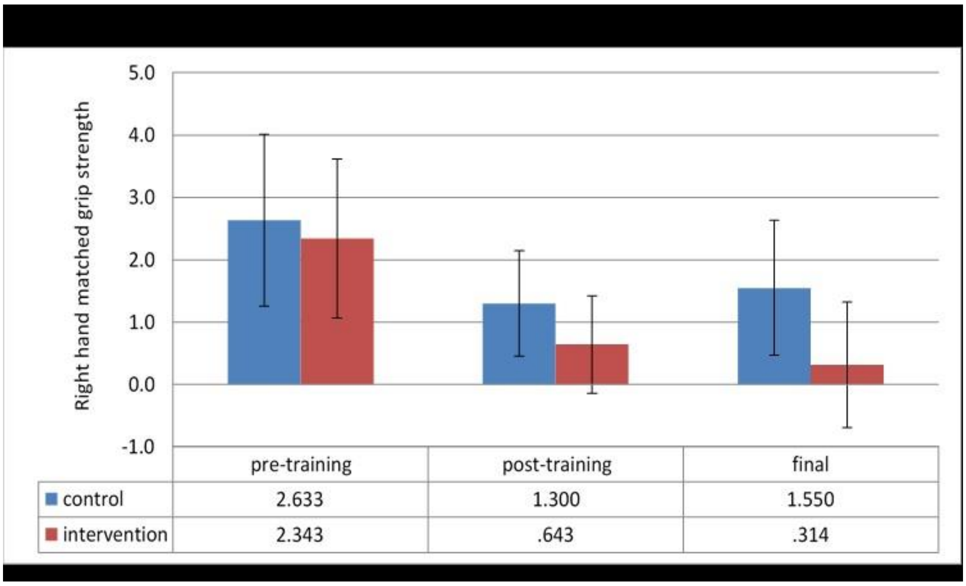

Figure 4: Photograph used to demonstrate poor transducer grip to a participant in the intervention group