Applied Tension and Blood Donation Symptoms: The Importance of Anxiety Reduction

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Objective: Despite being a voluntary activity, many blood donors experience anxiety, and fainting (syncope) is not unusual. The muscle-tensing technique *applied tension* (AT) has been found to be effective in reducing vasovagal symptoms and syncope. A series of studies was developed to investigate the role of AT on anxiety and fainting. *Methods:* The mechanisms of AT were examined in the laboratory and the blood donor clinic. In Study 1, 70 participants were assigned randomly to either a control group or an experimental group who learned AT before watching a video depicting blood draws. In Study 2, 667 volunteer blood donors completed similar questionnaires. *Results:* In Study 1, a significant Condition \times Sex \times Needle Fear interaction, F(1, 59) = 4.97, p = .03, indicated that AT reduced vasovagal symptoms in higher-fear women. Study 2 also found a significant Condition \times Sex \times Needle Fear effect on vasovagal symptoms, F(2, 653) = 3.95, p = .02, indicating that AT reduced symptoms but primarily among women with more pronounced fear of needles. *Conclusions:* Analysis of the physiological data and self-reported anxiety supports the conclusion that the reduction in vasovagal symptoms was due more to decreased anxiety rather than exercise-related cardiovascular change. These results suggest that AT may provide a useful means of coping with invasive medical procedures in part by reducing anxiety.

Keywords: applied tension, syncope, fainting, anxiety, blood donation

In many respects, the medical system hinges on volunteer blood donations. According to the American Red Cross, every 2 s someone is in need of blood. For many emergency and nonemergency medical procedures, blood is a crucial resource. Unfortunately, less than 40% of the population is eligible to donate blood, and only about 5% of these individuals volunteer each year (Gillespie & Hillyer, 2002). Furthermore, many do not return to give blood another time. It has been estimated that up to half of all first-time donors do not give blood again (Ownby, Kong, Watanabe, Tu, & Nass, 1999). Health psychology has the potential to improve the blood supply by studying factors associated with the recruitment and retention of donors. For example, research shows that the occurrence of even mild symptoms such as dizziness and weakness during blood donation decreases donor return (France, France, Roussos, & Ditto, 2004).

Applied tension (AT) is a behavioral technique that has been found to reduce dizziness and fainting in some contexts. It was developed by L. G. Öst in the 1980s as an aid to behavioral exposure therapy for blood and injury phobias because so many people became dizzy or fainted during exposure, interrupting or terminating treatment (Hellstrm, Fellenius, & Öst, 1996; Öst, Fellenius, & Sterner, 1991; Öst & Sterner, 1987). The primary component is repeated isometric muscle tension, particularly in the arms and legs, which presumably maintains blood pressure in the face of vasovagal activity that would otherwise lead to decreases in blood pressure and cerebral perfusion. The intervention has proven to be effective in reducing vasovagal symptoms in both blood and injury phobics and nonphobic people undergoing medical procedures such as blood donation (Ditto, Byrne, & Holly, 2009; Ditto & France, 2006; Ditto, Wilkins, France, Lavoie, & Adler, 2003).

Although the muscle tension/exercise component of AT clearly increases blood pressure and the delivery of oxygen to the brain (Foulds, Wiedmann, Patterson, & Brooks, 1990; France, France, & Patterson, 2006) and AT has been found to stabilize cardiovascular activity in blood donors (Ditto et al., 2009) and laboratory volunteers watching a video of cardiac surgery (Vgele, Coles, Wardle, & Steptoe, 2003), growing evidence suggests that its effects on vasovagal symptoms may be due more to anxiety reduction than exercise-related cardiovascular activity. For example, AT appears to benefit female donors more than male donors, who generally report less anxiety (Ditto, France, Lavoie, Roussos, & Adler, 2003). We also recently found that a "placebo" version of AT significantly reduced symptoms (Ditto, France, Albert, & Byrne, 2007). In general, donors who tensed just their arms but not their legs did not have reduced symptoms. However, donors who were also asked, somewhat misleadingly, to focus more on the arm that did not have the needle in it in order to "develop a better sense of the amount of tension required" had fewer vasovagal symptoms and lower anxiety scores than did the no-treatment control group. Whether this condition is better viewed a distraction than placebo condition is difficult to say because, more broadly, it is difficult to study issues such as the relative importance of cardiovascular

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change versus anxiety reduction in clinical studies of AT. As a result, one goal of the present research was to develop a laboratory analogue of the blood donation procedure. Another was to examine more closely the relative roles of exercise-related cardiovascular activity versus anxiety reduction in the effects of AT on vasovagal symptoms.

Following in the tradition of laboratory studies that used movies depicting surgery with blood and injury patients (Sarlo, Buodo, Munafo, Stegagno, & Palomba, 2008; Vgele et al., 2003), a less intense video displaying various blood-draw procedures was shown to young adults who might be prospective blood donors. It was hypothesized that AT would reduce vasovagal symptoms primarily by reducing anxiety. As a result, the main beneficiaries were expected to be people with higher preexperiment scores on a questionnaire reflecting anxiety about needles. The laboratory environment also allowed collection of physiological measures such as blood pressure, heart rate, and heart rate variability to clarify the mechanisms of AT.

Study 1

Method

Participants. Seventy healthy young adults were recruited via campus advertisements. To eliminate people with extensive blood donation experience, we screened potential participants for prior blood donation and excluded them if they had given blood more than five times in their lives. Additional exclusion criteria included medical illness (i.e., asthma, cardiovascular issues, and vision or hearing problems), psychological disturbances (i.e., depression, anxiety), and use of medications that might influence cardiovascular activity.

Three of the 70 participants experienced vasovagal symptoms that were severe enough to interfere with data collection (though no clear faints occurred). As a result, analyses were conducted on data obtained from 67 individuals (35 women, 32 men) ages 18 to 30 years (M = 22.8, SD = 3.29). Seventeen men and 17 women were assigned randomly to the treatment (applied tension) group, the others to a no-treatment control group. Participants were re-imbursed \$20 CAD for their time. The research was approved by the McGill University Institutional Research Board.

Apparatus. A Biopac MP35 System was used to obtain continuous measures of interbeat interval (IBI; heart rate) and skin conductance (SC). The electrocardiograph (ECG) electrodes were placed bilaterally on the lower ribcage and on the ankle. Electrodes were placed on the nondominant index and middle fingertips to measure SC. Measurements of systolic and diastolic blood pressure (SBP and DBP) were obtained periodically using a Datascope Accutorr Plus automatic monitor.

BSL Pro 3.7.3 software was used to collect the Biopac data. Heart rate variability was assessed using HRV Analysis Software (Biomedical Signal Analysis Group, Department of Applied Physics, University of Kuopio, Kuopio, Finland). Once abnormal heartbeats and artifacts were removed, a frequency domain analysis was conducted on the data. Analysis of the heart rate variability spectrum reveals a high-frequency (HF; 0.15–0.40 Hz) component, a low-frequency (LF; 0.04–0.15 Hz) component, and very-lowfrequency component. The high-frequency peak is a reliable indicator of parasympathetic (vagal) activity. The autonomic origins of low-frequency HRV are more ambiguous, including both sympathetic and parasympathetic activity. However, the ratio of low- to high-frequency HRV is often used as an index of cardiac sympathetic activity (Task Force of the European Society of Cardiology the North American Society of Pacing Electrophysiology, 1996).

Participants learned AT by watching a 2-min instructional video used in previous research (Ditto et al., 2009). The blood donation stimulus was a 28-min medical instruction video titled *Basic Venipuncture* created by the Center for Phlebotomy Education. A number of venipunctures are displayed along with discussion of proper techniques and problems that can occur during the procedure.

Ouestionnaires. Participants completed a number of questionnaires both before and after viewing the film. Prior to the film, the participants completed a demographic questionnaire and the Medical Fears Survey (Kleinknecht, Thorndike, & Walls, 1996). Fear of a number of medical procedures was rated on a 5-point Likert scale ranging from 0 (no fear at all) to 4 (terror). A needle fear score was computed by summing 10 items related to fear of needles. Participants also completed the Spielberger State-Trait Anxiety Inventory (STAI) (Spielberger, Gorsuch, & Edward, 1970) at the beginning and end of the study. The STAI is a 20-item self-report scale in which various mood statements are rated on a 5-point Likert scale ranging from 1 (not at all) to 4 (very much). Finally, the Blood Donation Reaction Inventory (BDRI; Meade, France, & Peterson, 1996) was completed after viewing the film. The BDRI assesses severity of 11 common vasovagal symptoms on a 6-point Likert scale ranging from 0 (not at all) to 5 (to an extreme degree). We used the recently recommended factor analysis-based scoring scheme focusing on four key items (dizziness, faintness, weakness, and lightheadedness; France, Ditto, France, & Himawan, 2008).

Procedure. After obtaining informed consent, participants were given the first set of questionnaires to complete. Subsequently, the physiological recording apparatus was attached. The body of the study consisted of ten 5-min intervals during which participants were asked to perform certain tasks. In Section 1 (segments 1-3), all participants began by resting for 5 min to allow baseline physiological data to be collected. Afterward, those assigned to the AT group learned and practiced applied tension for 10 min while the others continued to sit quietly. AT involves gentle repeated whole-body isometric tension in 5-s on, 5-s off cycles while maintaining steady breathing. Section 2 began with another 5-min rest period (segment 4) followed by watching the video, Basic Venipuncture (segments 5-10). Participants who had learned AT were asked to practice it while watching the movie. Following the video, all participants completed the BDRI and the STAI. Anyone reporting or displaying signs of a vasovagal reaction was asked to remain in the laboratory until symptoms passed. ECG and SC measurements were obtained continuously during the protocol. Two measurements of blood pressure were obtained during the initial baseline period (segment 1), while participants were practicing AT or resting (segment 3), the prevideo rest period (segment 4), and during the most dramatic part of the video (segment 9).

Data reduction and analysis. Mean values of IBI and SC were calculated for each 5-min block as well as estimates of HF HRV and the LF/HF ratio. Mean values of SBP and DBP were calculated for the initial baseline, AT, prevideo rest, and video

periods. The primary analyses were general linear models (GLM) because they can accommodate both categorical and continuous independent variables. In most analyses, sex and condition (AT or no AT) were included as independent variables along with needle-fear score as a continuous variable. To assess the effects of AT on most of the (non-blood pressure) physiological measures before the venipuncture video, a repeated measure of time with three levels was added to the GLM (segments 1–3). To assess the effects of AT on response to the video, a repeated measure of time with seven levels (prevideo rest + video periods) was added. The Greenhouse–Geisser correction was used in tests of repeated measures involving more than two levels.

Results

Effects of AT on vasovagal symptoms/manipulation check. Although the BDRI is a well-validated measure of vasovagal symptoms, several preliminary analyses were conducted to examine its physiological correlates. Most notably, a 2 (Time: before/ during video) × BDRI (considered as a continuous variable) GLM of systolic blood pressure levels revealed a Time × BDRI interaction, F(1, 63) = 7.52, p = .008, indicating a significant decrease in SBP during the video among those who reported vasovagal symptoms.

The Condition × Sex × Needle Fear GLM of the BDRI scores also supported the validity of scores in that a strong main effect of needle fear score, F(1, 59) = 14.56, p < .001, was observed. That is, people who indicated being more fearful of needles before the experiment reported significantly more dizziness, and so forth, following the video depicting a number of blood draws. More important to the purpose of the experiment, the Condition × Sex × Needle Fear interaction was significant, F(1, 59) = 4.97, p = .03. As can be seen in Figure 1 (which for purposes of illustration divides participants on the median of needle fear), this interaction was due to trends within women. Separate Condition × Needle Fear GLMs for men and women revealed only a main effect of needle fear in males, F(1, 28) = 8.33, p = .007. In contrast, the Condition × Needle Fear interaction was significant in women,

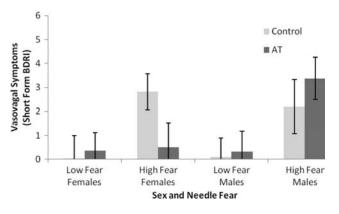


Figure 1. Vasovagal symptom scores (+standard error) in relation to condition, sex, and needle fear. For illustrative purposes, needle fear is displayed as a median split (low/high fear). Higher-fear individuals reported significantly more vasovagal symptoms than did those with low fear, and this was reduced in women using applied tension (AT). BDRI = Blood Donation Reaction Inventory.

F(1, 31) = 5.96, p = .021. AT reduced vasovagal symptoms in woment but only among those with higher needle fear. This suggests that anxiety reduction may have been involved, although on the other hand, women with lower needle fear had few symptoms to begin with. Was the change in vasovagal symptoms associated with exercise-related cardiovascular activity?

Physiological measures.

Effects of AT on physiological activity before the venipuncture The GLM of interbeat intervals in segments 1-3 produced video. a main effect of sex, due to generally smaller interbeat intervals (higher heart rate) among women, F(1, 57) = 6.19, p = .016, but more important a significant Condition \times Time interaction, F(2,(114) = 9.93, p = .001 (see Figure 2). That is, AT produced the expected increase in heart rate. There were no significant effects in the analyses of prevideo SBP, DBP, or HF HRV. However, similar to IBI, the Condition \times Time interaction was significant in the analysis of the low-frequency/high-frequency ratio, F(2, 104) =3.52, p = .035. The ratio increased among those who practiced AT, suggesting that their increase in heart rate was partially sympathetically mediated. Similarly, the GLM of skin conductance produced an interesting Time \times Needle Fear \times Condition interaction, F(2, 114) = 3.89, p = .036. In general, skin conductance increased as people practiced AT, providing further evidence that their increase in heart rate was at least partially sympathetically mediated. However, the increase in SC was particularly marked among participants with higher needle fear, suggesting stressful anticipation of the upcoming venipuncture video.

Effects of the venipuncture video and AT. Similar to the GLM of IBI values when people were learning and practicing AT, the analysis of values just before and during the video (segments 4–10) produced a main effect of sex, F(1, 53) = 4.90, p = .031,as well as a significant Condition \times Time interaction, F(6, 318) =3.83, p = .006. Heart rate went up when people started to do AT. Importantly, sex did not interact with condition, and men and women who practiced AT experienced similar increases in heart rate. Thus, muscle tensing-induced heart rate acceleration per se cannot explain fewer symptoms in female participants. Once again, the Condition \times Time interaction was significant in the GLM of skin conductance, F(6, 318) = 2.90, p = .028, because of a greater increase in people who practiced AT. LF/HF ratios were similar, producing a main effect of condition, F(1, 52) = 4.16, p =.047. There was no difference between participants who practiced and did not practice AT in the 5-min rest period before the video $(M \pm SE = 2.3 \pm 0.7 \text{ vs. } 1.7 \pm 0.7)$, but this changed in the first 5 min of the video as soon they began to do AT ($M \pm SE = 3.8 \pm$ 0.7 vs. 1.6 \pm 0.8). There were no significant effects in the analyses of HF HRV, SBP, or DBP.

Effects of AT on reported anxiety. The GLM of pre- and postexperiment state anxiety scores produced a four-way Condition × Sex × Needle Fear × Time interaction, F(1, 59) = 7.22, p = .009. To clarify this, we conducted separate Condition × Needle Fear analyses of pre and post change in anxiety for men and women. Consistent with previous results, there were no significant effects among men but a significant Condition × Needle Fear interaction in women, F(1, 30) = 6.43, p = .017. As can be seen in Figure 3, women with more needle fear who were assigned to the control group reported increased anxiety after viewing the video, whereas higher-fear women who practiced AT did not.

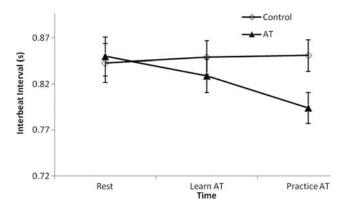


Figure 2. Interbeat interval values before the venipuncture video during Section 1 intervals by condition. Interbeat interval remained stable in the control condition and decreased (heart rate increased) in applied tension (AT) group.

Analyses of covariance. To examine whether the effect of applied tension on vasovagal symptoms was more strongly related to changes in self-reported anxiety or heart rate change, the original GLM of BDRI scores was recalculated using pre and post anxiety change as a covariate. The previous three-way interaction among condition, sex, and needle fear was no longer significant (p = 0.15). On the other hand, the interaction remained significant, F(1, 57) = 4.81, p = .032, when mean heart rate change during the video from the prevideo rest period was substituted for anxiety change as a covariate. In other words, controlling for the impact of AT on anxiety eliminated its effect on vasovagal symptoms. Controlling for the impact of condition on heart rate did not.

Discussion and Introduction to Study 2

In one respect, the results of Study 1 are not surprising. That is, the fact that AT benefited primarily people who rated themselves as more fearful of needles is not surprising because few symptoms would be expected among those who say they are comfortable with needles. On the other hand, the results may provide important

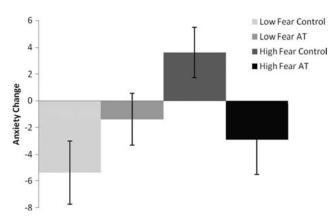


Figure 3. Pre- and postexperiment anxiety change in women (by condition and needle fear). This figure indicates an increase in anxiety over the course of the experiment in higher-fear women who did not practice applied tension (AT). This increase was eliminated with the practice of AT.

directions for future research. First, it was possible to elicit feelings of dizziness and faintness in a laboratory context despite the use of a fairly mild stimulus, at least in comparison to previous studies that used videos of open heart surgery (e.g., Steptoe & Wardle, 1988; Vgele et al., 2003). In fact, 3 participants were sufficiently distressed to the point that it was not possible to obtain physiological recordings. Second, even among the remaining participants who displayed less intense symptoms, an effect of AT was observed in women who are more fearful of needles. Finally, the results point to the potential importance of anxiety reduction by AT as a mechanism for its effects on vasovagal symptoms. On the other hand, although the pattern of results in Study 1 is encouraging, one possible limitation concerns the laboratory nature of the investigation. Even though participants were not selected for the presence of needle fears and were probably fairly representative of college students in that regard, it is possible that the results may not be reflective of young adult blood donors who seem even more removed from the idea of blood and injury phobia.

As a result, a preliminary evaluation of this idea was conducted using archival data from a previous clinical trial of AT (Ditto & France, 2006; Ditto, France, et al., 2003). The Medical Fears Survey was included in the donor information questionnaire packet but has not been analyzed until now. The purpose of this analysis was to see whether the previously observed impact of AT on BDRI scores in women (Ditto, France, et al., 2003) was moderated by needle fear score.

Method

Participants. We tested 1254 volunteer donors at mobile Héma Quebec blood donation clinics held in Montreal-area colleges and universities. We tested 601 men and 653 women, ranging in age from 18 to 40 years (M = 21.9, SD = 21.9). Participants were prescreened for blood donor eligibility (see Figure 4). Further exclusion criteria included more than five previous blood donations. Participation was voluntary, and no payment was provided. The research was approved by the McGill and Héma-Québec IRBs.

Procedure. After recruitment, participants were assigned randomly, in blocks of 10, to (a) a group that learned AT using the

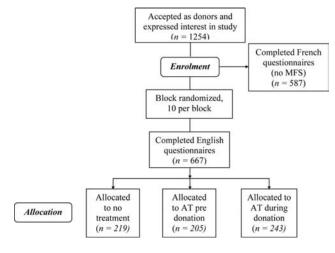


Figure 4. Participant flow in Study 2.

previously described instructional video and was asked to practice it for the entire time they were on the donation chair, (b) a group that learned AT but was asked to practice it only before the needle was inserted, or (c) a group that did not learn AT and underwent the typical blood donation procedure. Although a number of additional dependent measures were assessed, such as whether or not treatment was required to treat a vasovagal reaction, this analysis will focus on BDRI administered while the donor rested afterward in the refreshment area. For present purposes, the BDRI was rescored using the current "short" scoring system as in Study 1 (France et al., 2008). On the other hand, the Medical Fear Survey was administered to only approximately one half (680) of participants because of the lack of a validated French version (see Figure 4). Further information about the sample and procedures can be found in the work of Ditto, France et al. (2003) and Ditto and France (2006).

Results

The primary analysis was a 3 (Condition: no applied tension/ applied tension before needle/applied tension during donation) \times 2 (Sex: male/female) \times Needle Fear Score GLM. Similar to the laboratory study, despite the use of volunteer blood donors who would not be expected to include people who are especially afraid of needles, a strong main effect of needle fear was observed, F(1,(653) = 32.46, p < .001. People who were more afraid of needles reported significantly more symptoms of dizziness, and so forth. However, there was also a significant Sex \times Condition \times Needle Fear interaction, F(2, 653) = 3.95, p = .020. As can be seen in Figure 5, the pattern of means was similar to that of the laboratory results. Women with higher needle fear who practiced AT-in this case, during an actual blood donation-reported significantly fewer symptoms of dizziness, and so forth, in comparison with similar women who did not practice AT. The benefit of AT was limited mostly to people who reported higher levels of needle fear.

Discussion

The version of AT used to date in blood clinics involving repeated 5-s cycles of isometric muscle tension is somewhat less intense than is the classic clinical version used with blood phobics involving longer 10- to 20-s periods of tension (Ost et al., 1991). The briefer

cycle is used to better match a procedure often used by phlebotomists, that is, having the donor "pump" the muscles in the arm with the donation needle to speed blood flow and reduce donation time. Regardless, though the idea of longer cycles is worth further examination, the exercise involved in AT was sufficient to raise heart rate. AT involves repeatedly tensing all of the major muscle groups in the body, and the 5-s cycle has been found to increase heart rate and blood pressure in people who are not exposed to blood and injury stimuli (France et al., 2006). In principle, it might have been expected that the increase in heart rate would have been associated with a decrease in parasympathetic vagal activity and, as a result, high-frequency heart rate variability (Task Force of the European Society of Cardiology the North American Society of Pacing Electrophysiology, 1996), but this was not the case. If anything, the present results suggest that the increase in heart rate was the result of cardiac sympathetic activity. Further research is required to clarify the physiological effects of AT and how they interact with the vasovagal process. At the same time, it seems as though the effects of AT on vasovagal symptoms cannot be attributed entirely to exercise-related cardiovascular activity.

Consistent through the results is the idea that individuals with more medical fears experienced more stress and vasovagal symptoms. This was reflected in both self-report (vasovagal symptoms, anxiety) and physiological measures. For example, people with more medical fears displayed increasing skin conductance before the venipuncture video. In general, this applied to both men and women and is not surprising because individuals who are bloodand injury-phobic experience higher levels of anxiety and stress when exposed to blood donation–related cues (Page, 1994), though both the intensity of fear and the Study 1 stimulus were less strong than in previous research.

Despite this, applied tension was useful in reducing selfreported vasovagal symptoms such as dizziness, lightheadedness, and weakness, though in this case the findings are limited to women who are more fearful about needles. The fact that AT reduced symptoms in women more than in men despite equal changes in exercise-related heart rate—as well as the fact that AT reduced anxiety in women but not in men—supports the idea that AT's effects on vasovagal symptoms are at least partially mediated by anxiety reduction. They are also consistent with suggestions that AT works better in reducing clinical blood donation–related

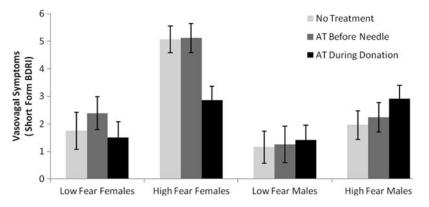


Figure 5. Vasovagal symptom scores in relation to condition and sex. Women with higher needle fear who practiced applied tension (AT) during blood donation experienced fewer vasovagal symptoms than did similar women who did not practice AT. BDRI = Blood Donation Reaction Inventory.

symptoms in women (Ditto, France, et al., 2003). But why do women experience more anxiety reduction with AT than do men? It is possible that women have higher beliefs that this technique will be effective. We have previously found that women were more likely than men to say that they would recommend muscle tensing to a friend who was going to give blood (Ditto, France, et al., 2003). Alternatively, the sex difference may spring from greater skepticism among men or a tendency to attribute positive blood donation experience to one's own intrinsic resilience rather than to a technique.

As was noted above, applied tension was originally developed as an adjunct to exposure therapy for blood and injury phobias. However, it soon became apparent that the tension component may, in and of itself, be useful not just to reduce fear-related fainting but to reduce fear. For example, Ost and colleagues (1991) had three groups of blood and injury phobics who either (a) learned how to practice repeated muscle tension and were exposed to blood and injury stimuli, (b) were repeatedly exposed to blood and injury stimuli, or (c) learned the muscle-tensing technique but were given explicit "antiexposure" instructions during treatment, that is, that they should not expose themselves to blood and injury stimuli. Regardless of whether it was combined with exposure or not, people who learned muscle tension displayed similar general and specific improvements, for example, ability to watch a video depicting surgery. The authors suggested that learning the coping technique may reduce anxiety about the possibility of encountering such stimuli. A subsequent study by this group (Hellstrm et al., 1996) found that one session of tension training could produce positive effects for phobics, consistent with the present application in blood donors.

Medical care often involves stressful and invasive procedures that elicit anxiety and, at times, fainting. Although this typically involves needles (Ditto & Holly, 2009), sharp objects are not always involved. For example, vasovagal reactions occur occasionally during colonosopy (Neri et al., 2007), and even purely noninvasive scans can elicit considerable anxiety and worry about fainting (Thorpe, Salkovskis, & Dittner, 2008). Complications can range from outright faints to premature termination of the procedure to avoidance of the procedure altogether. Applied tension may be useful in a number of health-related contexts.

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