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ORIGINAL ARTICLE

Applied Tension and Coping with Blood Donation: A Randomized Trial

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Abstract
Background Despite the ongoing need for blood donation, few people give blood. A common reason is concern about vasovagal symptoms.
Purpose The aim of this study was to evaluate the effectiveness of applied tension in reducing vasovagal symptoms during blood donation and the mechanisms of action.
Method Two hundred eighty-two young adult blood donors were randomly assigned to conditions involving applied tension during the pre-donation wait period, during the blood draw, both, or no applied tension at all.
Results Applied tension was effective in reducing vasovagal symptoms in blood donors, particularly when practiced during the pre-donation wait period ($p<0.001$). People who practiced applied tension during the pre-donation wait period required less treatment for vasovagal reactions than people who did not (8% vs. 16%).
Conclusions The results of this study suggest that the effects of applied tension on vasovagal symptoms are not mediated entirely by exercise-related changes in blood pressure and heart rate. Rather, it may reduce anxiety or physiological consequences of anxiety. Applied tension is a useful treatment which can help people cope during blood donation and other invasive medical interventions.

Keywords Applied tension · Vasovagal syncope · Blood donation · Anxiety

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Introduction

Despite widespread agreement on the medical and social importance of blood donation, only a small proportion of the population, e.g., approximately 3% in the USA [1], gives blood. As pressing as current needs are, this is going to be an even greater problem in the future as the population ages and new uses for blood are developed. At the same time, safety-related concerns have led to increasing rates of blood donor deferrals and exclusions [2]. These considerations underscore the importance of ensuring that people who are healthy enough and willing enough to volunteer to give blood become and remain donors. Unfortunately, there are a number of disincentives to giving blood. Perhaps the most important is the fact that blood donation is not always a pleasant experience. Considerable research indicates that the common experience of unpleasant vasovagal symptoms during blood donation significantly reduces the chance of subsequent donation [3, 4].

Applied tension is a promising behavioral technique that has been shown to reduce the occurrence of vasovagal symptoms in people undergoing a medical intervention [5]. These symptoms range from light headache and dizziness to full-out fainting (vasovagal syncope). Applied tension was originally developed by Öst and Sterner for use with blood, injection, and injury phobics [6]. Compared to the typical fear reaction involving sympathetic activation and an increase in blood pressure, there is often a unique "diphasic" cardiovascular response to feared stimuli in blood, injection, and injury phobics. Initially, the expected increases in heart rate (HR) and blood pressure (BP) are seen, but they are followed swiftly by decreases in HR and BP increasing the risk for vasovagal symptoms due to a decrease in cerebral blood flow [7, 8], though there has been some recent discussion of this model [9]. Öst et al.

found that repeated isometric muscle tension was a successful intervention for the dizziness and fainting that many of his blood phobic patients experienced while practicing exposure therapy [6, 10, 11] as it presumably maintained HR and BP.

While research shows that applied tension can reduce vasovagal symptoms, the mechanisms by which it works are not entirely clear. The exercise-related component of applied tension maintains HR and BP in blood, injection, and injury phobics exposed to relevant stimuli [12] and blood donors while giving blood [13], but it is not clear if this is responsible for symptom reductions. For example, in the context of a laboratory investigation of applied tension, we recently observed significant general increases in HR and BP just before participants watched a video depicting blood draws, but applied tension reduced symptoms only among female participants [14]. Similarly, Ditto and colleagues [5] found that female blood donors who practiced applied tension reported fewer symptoms and required less treatment for vasovagal symptoms as compared to a no-treatment and a placebo group, but males did not experience these benefits. This suggests that other factors besides exercise-related change in HR and BP are responsible for the impact on symptoms, perhaps involving anxiety reduction.

Despite its origin as a treatment for blood, injection, and injury phobia, the possible anxiety-reducing aspects of applied tension have not been emphasized in relation to its effects on blood donation. This is probably due to the fact that blood donors are obviously not blood, injection, and injury phobics. Indeed, as a group, they are likely less fearful of blood, injection, and injury stimuli than the general population. On the other hand, while a voluntary activity, it is well-known that people decide to give blood for a variety of reasons ranging from a general social benevolence, concern about a natural or manmade disaster such as 9/11 [15], a sense of personal debt after a loved one receives a transfusion, or even friendly coercion [16]. As a result, all donors are not necessarily at ease with needles and the donation procedure in general. A number of investigators have noted an increase in anxiety before donation [1, 17], and Meade and colleagues [18] found that fear-related psychological variables were better predictors of vasovagal symptoms in this environment than more commonly used demographic predictors such as age, sex, and previous blood donation experience. This may be related to the fact that donation usually involves a significant wait before giving blood. The typical process involves reading informative material, registration, and a blood and health screen even before waiting for the next available donation chair. While attempts are made to expedite the procedure in order to prevent discouraging donors [19], only so much can be done to reduce the potentially stressful wait. Interestingly, Hanson and France [20] found that extra social support by volunteers during waiting reduced vasovagal symptoms.

In sum, it is possible that psychological aspects of applied tension such as distraction and providing a coping behavior reduce donor anxiety and are responsible for some of the effects on vasovagal symptoms [5, 21]. That is, applied tension may dampen both the first as well as the second stage of the diphasic response. If this is the case, donors might benefit from applied tension during the waiting period as well as during the actual procedure as typically done. In one previous study [5], we administered applied tension during the waiting period but only for a very brief period (approximately 2 min) very late in the wait period. The present study sought to examine the effects of applied tension by looking at its impact on blood donation-related anxiety, physiological activity, and vasovagal symptoms and more thoroughly study the impact of the timing of applied tension on these measures. It was predicted that applied tension would reduce both anxiety and vasovagal symptoms and that practicing applied tension before as well as during blood donation would reduce these measures.

Method

Participants and Experimental Conditions

Participants (maximum age=40 years) were recruited at mobile blood clinics held by the provincial blood collection agency, Héma-Québec between 2008 and 2009. People were recruited and assigned randomly (through a randomly generated number list) to experimental condition upon entry. When approached, participants had previously been screened for basic eligibility to donate blood and but not been through the medical screening interview nor had participated in any other activities. Written informed consent was obtained from all participants. They were assigned to one condition in a 2×2 design, that is, whether or not they would practice applied tension during the pre-donation wait period and whether or not they would practice applied tension while giving blood (Fig. 1). As all participants were donating blood, they were subsequently screened for medical issues and exclusionary criteria for blood donation, ensuring a group of healthy young adults. Consistent with the random assignment of participants to conditions, there were no significant differences in demographic variables (Table 1) though one—age—approached significance, $F(3, 280)=2.52$, $p=0.058$. As a result, age was included as a covariate in all analyses. All participants were English speaking. The study was approved by the relevant ethical human subjects committees of McGill University and Héma-Québec.

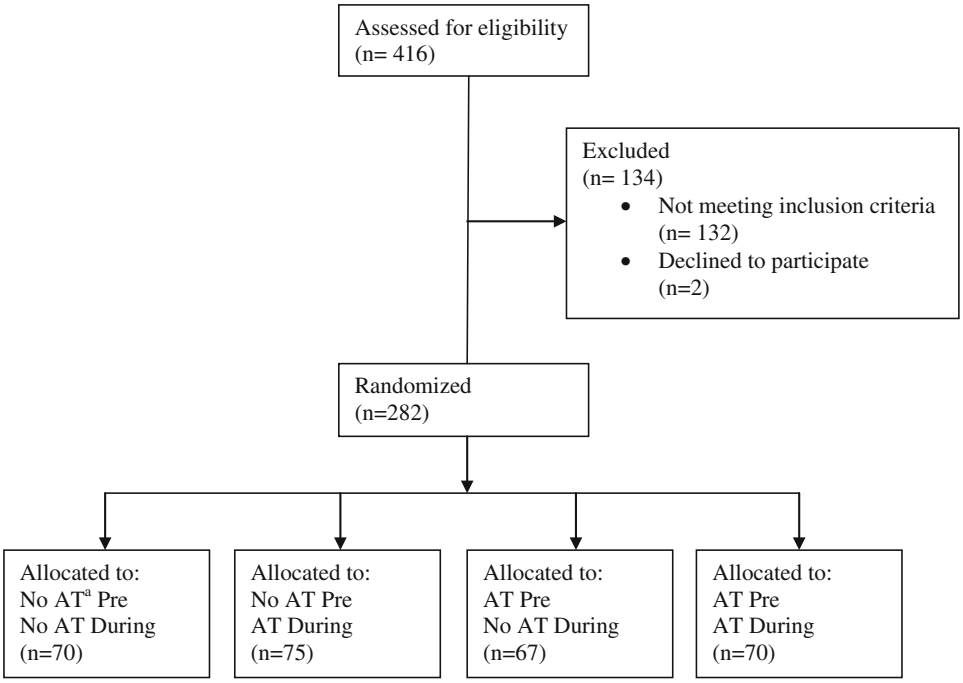


Fig. 1 Participant flow diagram (CONSORT)

a. AT is applied tension

Apparatus

Physiological measurements were obtained at the beginning and end of the blood donation procedure. Systolic (SBP) and diastolic blood pressure (DBP; in millimeters of mercury) and HR (in beats per minute) were obtained using a Datascope Accutorr Plus blood pressure monitor (www.datascope.com). Participants learned applied tension by watching a 2-min instructional video used in previous research [22] on a notebook computer. The video depicts repeated 5-s on, 5-s off cycles of whole body isometric tension while maintaining regular breathing. Participants were asked to tense the muscles of their legs, abdomen, and arms at 5-s intervals at a level comparable to "squeezing a tennis ball." They were also told to breathe normally and not hold their breath while tensing. Inadvertent viewing of the video (by control subjects or non-participants) was not possible.

Questionnaires

Participants completed a number of questionnaires before and after blood donation. Prior to donation, participants completed a short demographic questionnaire and the

Table 1 Demographic characteristics of participants

	No AT pre-donation		AT pre-donation	
	No AT during donation	AT during donation	No AT during donation	AT during donation
N	70	75	67	70
Sex (% female)	43 (61.4%)	40 (53.3%)	32 (47.7%)	36 (51.4%)
Age	20.8 (3.2)	20.7 (3.3)	19.7 (1.8)	21.1 (3.5)
BMI	22.7 (3.2)	22.7 (3.3)	23.6 (4.0)	23.2 (4.1)
Baseline SBP (mmHg)	119.1 (1.6)	118.8 (1.6)	119.8 (1.5)	118.0 (1.5)
Baseline DBP (mmHg)	71.5 (1.1)	71.7 (1.1)	72.5 (1.1)	71.2 (1.1)
Baseline HR (bpm)	79.4 (1.4)	77.7 (1.4)	77.2 (1.4)	76.8 (1.4)
Donation experience (previous donations)	1.8 (2.8)	2.0 (2.6)	1.6 (1.6)	2.0 (2.4)
Needle insertion difficulty (nurse's 1–5 rating)	1.6 (0.9)	1.60 (0.9)	1.5 (0.7)	1.6 (0.9)

AT applied tension

Spielberger State Anxiety Inventory [23]. The Spielberger State Anxiety Inventory is a 20-item self-report scale where various mood statements are rated on a five-point Likert scale ranging from 1 (*not at all*) to 4 (*very much*). After donation, while sitting in the recovery area, participants completed a longer questionnaire including the Spielberger State Anxiety Inventory and the Blood Donation Reactions Inventory [18]. The Blood Donation Reactions Inventory is a well-validated, self-report index of 11 vasovagal symptoms such as dizziness, lightheadedness, and nausea. Items are rated on a six-point Likert scale ranging from 0 (*not at all*) to 5(*to an extreme degree*). They rated the pain of the pre-donation screening fingerprick and donation needle insertion on 165 mm visual analog scales with legends of *no pain* and *extreme pain*. Finally, participants also completed a general measure of medical fears, the Medical Fears Survey [24] (not discussed in the present report), as well as a treatment evaluation questionnaire inquiring about treatment compliance and acceptance.

Procedure and Research Assistant Measures

After recruitment, participants completed the brief (to minimize interference with the blood donation procedure) pre-donation questionnaire and measurements of BP and HR were obtained. Those assigned to an applied tension group were taught the technique via the instructional video. Participants in a pre-donation applied tension group were instructed to begin practicing applied tension from that moment on, until they arrived at the blood donation chair. Those in a during-donation group were instructed to practice applied tension from the moment they got on the donation chair until they were just about to get up. Participants in the combined group were asked to practice throughout the entire process. Research assistants monitored participants in the clinic and reminded them to comply with their applied tension directives. All continued through the standard blood donation procedure.

During blood donation, a research assistant visited each participant at bedside and recorded information such as a rating from the nurse of the difficulty of needle insertion, the participant's compliance with applied tension directives, whether or not the participant fainted, and whether or not treatment was required for a vasovagal reaction. Treatment for a reaction included reclining the donor's chair and occasionally placing a damp cloth on the forehead. After the participant sat on the donation chair but before needle insertion the research assistant also asked them to rate how relaxed they felt on a 0 (not relaxed at all)–100 (fully relaxed) scale. This question was repeated just before the participant was about to get off the donation chair. Donors were not questioned directly about vasovagal symptoms while in the donation chair to minimize interference with the collection process and the possibility of inadvertently increasing the chance of a reaction. However, they completed the Blood Donation Reactions Inventory and other components of the post-donation questionnaire immediately afterward in the post-donation recovery area while consuming a snack. Another set of physiological measures was obtained after the questionnaire was completed.

Data Analyses and Reduction

Mean values of BP and HR were calculated before and after donation. Pre- to post-donation change scores were computed for BP and HR. A recent factor analysis of Blood Donation Reactions Inventory items [25] revealed four items (dizziness, faintness, weakness, and lightheadedness) that reflect the primary vasovagal experience. As a result, ratings of these items were summed and, consistent with previous research, log-transformed to reduce skewness. Similarly, pre- and post-donation Spielberger State Anxiety Inventory scores and the other behavioral measures were log-transformed. Preliminary analyses revealed no significant interactions between the effects of condition and sex, primarily main effects of sex on baseline (pre-donation) values of the physiological measures. As a result, the primary analyses were 2 Applied Tension Pre-donation (yes, no)×2 Applied Tension During Donation (yes, no) analyses of covariance (ANCOVAs) using age as a covariate. The analyses of physiological change scores included the initial baseline values as another covariate. All analyses were conducted on an intent-to-treat basis.

Results

Self-Report Anxiety

Spielberger State Anxiety Inventory scores were analyzed using a 2 Applied Tension Pre-donation×2 Applied Tension Pre-donation×2 Time (pre-donation questionnaire, post-donation questionnaire) ANCOVA. A strong effect of Time was observed, $F(1, 253)=28.38$, $p<0.001$, indicating that participants felt more anxious before than after donation but no other significant effects were observed. However, these observations (just after recruitment and sitting in the post-donation recovery area) may have been too far removed from treatment to reveal an effect. Consistent with this idea, the 2 Applied Tension Pre-donation×2 Applied Tension During Donation×2 Time (just before needle insertion, just before leaving donation chair) ANCOVA of participants ratings of in-chair relaxation produced a significant Applied Tension Pre×Applied Tension During Interaction, $F(1, 275)=3.95$, $p=0.048$. A one-tailed t test was conducted to compare anxiety levels between those

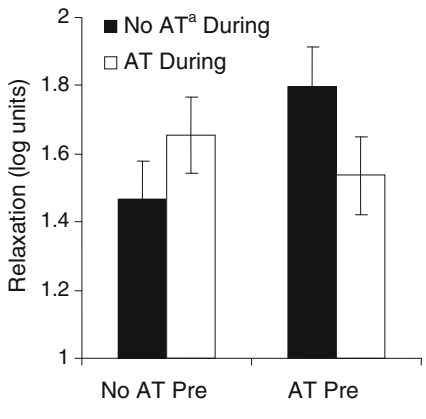
who did and did not practice applied tension as it was predicted that participants in applied tension conditions would experience less anxiety than participants in the no-treatment control condition. As can be seen in Fig. 2, participants asked to practice applied tension pre- but not during donation said they were more relaxed than those who did not practice applied tension, $t(136)=-1.87$, $p=0.032$. Participants in the other applied tension groups reported being somewhat, but not significantly, more relaxed than no-treatment participants.

Treatment Compliance

Since the research assistants only rated compliance while the participant was in the donation chair, which did not include the pre-donation wait period, the main indicator was whether or not the participant said they used the assigned technique. Ninety-four percent of participants said they used their assigned technique on the post-donation questionnaire. There were no differences between groups.

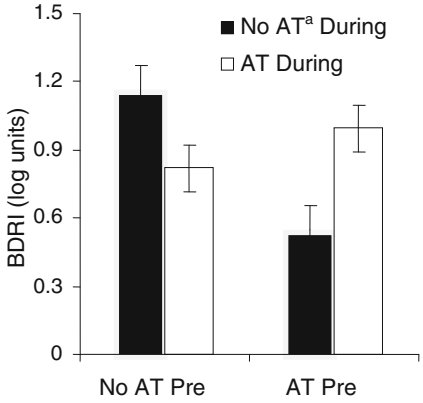
Pain and Vasovagal Symptoms

There were no significant effects of treatment on fainting though consistent with previous research outright faints were rare (only 11 participants fainted). However, the ANCOVA of Blood Donation Reactions Inventory scores revealed a significant main effect of practicing Applied Tension Pre-donation, $F(1, 274)=4.52$, $p=0.034$, as well as a significant Applied Tension Pre × Applied Tension During Interaction, $F(1, 274)=14.01$, $p<0.001$. As can be seen in Fig. 3, participants who practiced applied tension before but not during donation as well as participants who practiced applied tension during but not pre-donation reported significantly fewer vasovagal symptoms than no-treatment participants, $t(134)=4.08$, $p<0.001$ and $t(140)=2.12$, $p=0.018$, respectively. There were no significant effects in the analyses of pain ratings, suggesting relatively specific effects of treatment on vasovagal symptoms. Consistent with this, a logistic regression of nurse-initiated treatment for vasovagal symptoms revealed a significant main effect of practicing applied tension before arriving at the donation chair, odds ratio (OR)=0.46, 95% confidence interval (CI)=0.21–0.97, $p=0.042$. Overall, people who practiced applied tension before they got to the donation chair were less likely to require treatment (chair reclining) compared to those who did not (8% vs. 16%).



a. AT is applied tension

Fig. 2 Effect of practicing Applied Tension Pre- and/or During Donation (Condition) on in-chair ratings of relaxation (log units)



a. AT is applied tension

Fig. 3 Effect of practicing Applied Tension Pre- and/or During Donation on vasovagal symptoms measured by the Blood Donations Reaction Inventory (BDRI log units)

Finally, pairwise comparisons of the participant's rating of how strongly they would recommend muscle tensing to a friend who was going to give blood in the three groups who practiced some form of applied tension (before, during, or both, pairwise comparisons were necessary since people who did not practice applied tension did not rate this variable) revealed that there was no difference between people who practiced applied tension either before or during donation, but people in both of these groups were more enthusiastic about applied tension than participants who were asked to practice applied tension from the very beginning to the very end, $t(133)=1.89$, $p=0.031$ and $t(123)=1.83$, $p=0.035$.

Physiological Data

No significant group differences (or anything approaching significance) were found in any of the baseline physiological measurements (Table 1). There were no significant effects of practicing applied tension, either before or during donation, on change in systolic blood pressure or heart rate. However, the main effect of applied tension during was significant in the ANCOVA of diastolic blood pressure change, $F(1, 265)=4.04$, $p=$

0.045. In general, people who did not practice applied tension while in the donation chair had no change in DBP (X=−0.5±0.7 mmHg) while those who practiced applied tension in the chair had a significant increase in DBP (X=1.6±0.7 mmHg).

Discussion

This study used a modified version of Öst's traditional "clinical version" of applied tension—cycling in 5-s intervals versus 10–20-s intervals of tension [11]. The 5-s cycling better matches the demands placed on blood donors by the phlebotomists when asked to pump their arm muscles in order to speed the blood donation. While the overall rate of fainting (vasovagal syncope) in participants was low, vasovagal symptoms were nevertheless common. Twelve percent of blood donors required some form of treatment during the donation and 71% reported experiencing at least one mild vasovagal symptom during donation such as dizziness and nausea on the Blood Donation Reactions Inventory.

The clearest impact of applied tension was among those who practiced it before arriving at the chair though it is interesting to note that for those who were *not* asked to do applied tension in this early stage of the donation process, participants who practiced applied tension while they were actually in the chair reported fewer symptoms than participants who did not (Fig. 2). In this respect, the results replicate previous findings of the effects of applied tension [5, 26]. However, the clearest benefit, including a reduction in nurse-initiated treatment for vasovagal symptoms, came from practicing applied tension before arriving at the chair. Confidence in this effect is enhanced by the fact that the nurses who conducted the blood draws did not interact with donors until they arrived at the chair and thus were blind to whether or not the participant was using applied tension earlier. This finding supports the belief that while the exercise-related cardiovascular effects of applied tension may play some role in reducing symptoms, they cannot explain the full impact of applied tension.

Although participants may have been anxious before arriving at the chair and needle insertion, blood pressure does not start to drop until the blood draw begins. If the only benefit comes from exercise-related maintenance of heart rate and blood pressure, practicing applied tension before arriving at the chair is much too soon.

Applied tension appears to work at least in part by some kind of stress-buffering mechanism, either reducing anxiety or perhaps the physiological consequences of anxiety. That said, the results may appear inconsistent with a previous study [5] in which we found that a brief pre-donation period of applied tension did *not* reduce symptoms. However, applied tension was administered for a very limited amount of time (2 min) late in the wait period (just before needle insertion). As a result, it was more properly considered a placebo intervention since participants were lead to believe it might be effective but there was insufficient time for it to have a significant psychological or physiological effect. Thus, applied tension does not appear to be simply a placebo, producing its effects by the expectation of positive benefit (the fact that the effects of applied tension do not seem to be limited to novice donors also supports this idea) though the exact stress-buffering effects remain to be determined. These may include distraction, social support, and respiratory control. Distraction has been found to improve coping with invasive medical procedures such as dentistry [27], injections, and chemotherapy [28, 29]. Similarly, in another study of blood donors [21], we found that asking some participants to pay particular attention to the arm that did not have the needle in it while just tensing their arms (presumably to develop a better sense of the amount of muscle tension) decreased symptoms more than no treatment though not as well as full body applied tension.

Social support has also been implicated as an important factor in the blood donation process. In a recent study, Hanson and France [20] found that donors who were accompanied by a research assistant who provided encouragement and engaged in small talk experienced fewer reactions. While participants in the present study who practiced applied tension during the wait period were not accompanied by a research assistant, it is possible that they felt less isolated being part of the "team" that was testing applied tension, especially compared to the no-treatment control participants who underwent the normal blood collection procedure.

Finally, it is also possible that practicing during the stressful wait period had a beneficial effect in terms of maintaining regular breathing. While participants were not asked to breathe in concert with the 5-s cycles of muscle tension, it is likely that many did since it is a comfortable pace and the video encouraged people to breathe regularly, albeit to discourage breath-holding. Ritz et al. [9] recently suggested that emotional fainting is due less to a diphasic cardiovascular response than altered breathing patterns that lead to hypocapnia. The idea that anxiety-driven changes in respiratory activity may be responsible for many vasovagal symptoms is consistent with observations such as the much higher rates of reactions among young and inexperienced donors [30, 31], associations between anxiety and blood donation reactions [32], and, in the present case, the apparent importance of pre-donation intervention. Even though applied tension was not conceived as a means to regularize breathing, it is possible its effects are mediated by effects on respiration as much as cardiovascular activity.

There were several limitations to the research. For example, the study environment did not permit continuous measurement of BP and HR which may have limited the ability to detect intervention-related cardiovascular changes. Similarly, it was not possible to collect electromyographic measures that would have allowed better assessment of compliance with muscle-tensing instructions. Given the coaching involved in learning applied tension, the public nature of blood clinics, and participant self-reports, it seems likely that compliance was reasonable. However, further research is required to determine whether outcome varies with treatment compliance. Analyses were conducted on an intention-to-treat basis which may provide a conservative estimation of the treatment effect due to non-compliance; however, this was deemed the most appropriate approach as it most closely represents the real clinical situation [33]. Finally, another interesting puzzle is why participants who were asked to practice applied tension throughout the pre-donation and donation process did not seem to benefit quite as much (though not significantly less) from applied tension as those in the pre-donation only condition. A speculative explanation, partially supported by ratings of how much they would recommend applied tension to a friend, is that this request was viewed as too demanding, and as a result, these participants practiced applied tension with less enthusiasm. In any case, practicing applied tension while waiting for the procedure to begin seems particularly helpful.

Applied tension is a useful treatment for both phobic and non-phobic individuals undergoing blood donation. The mechanisms of treatment in these two situations may not be identical but seem closer than originally anticipated and do not appear limited to exercise-induced changes in cardiovascular activity. Applied tension is a simple, practical intervention that may help people cope better with a variety of invasive medical procedures.

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Conflict of Interest Statement The authors of this research have no conflicts of interest to disclose.

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