Auricular Transcutaneous Electrical Nerve Stimulation (TENS) Reduces Phantom Limb Pain

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Abstract

The present paper evaluates the efficacy of low frequency, high intensity auricular transcutaneous electrical nerve stimulation (TENS) for the relief of phantom limb pain. Auricular TENS was compared with a no-stimulation placebo condition using a controlled crossover design in a group of amputees with (1) phantom limb pain (Group PLP), (2) nonpainful phantom limb sensations (Group PLS), and (3) no phantom limb at all (Group No PL). Small, but significant, reductions in the intensity of nonpainful phantom limb sensations were found for Group PLS during the TENS but not the placebo condition. In addition, 10 min after receiving auricular TENS, Group PLP demonstrated a modest, yet statistically significant decrease in pain as measured by the McGill Pain Questionnaire. Ratings of mood, sleepiness, and anxiety remained virtually unchanged across test occasions and sessions, indicating that the decrease in pain was not mediated by emotional factors. Further placebo-controlled trials of auricular TENS in patients with phantom limb pain are recommended in order to evaluate the importance of electrical stimulation parameters such as pulse width and rate, and to establish the duration of pain relief. J Pain Symptom Manage *1991;6:73–83.*

Key Words

Phantom limb pain, referred sensations, transcutaneous electrical nerve stimulation

Introduction

The application of transcutaneous electrical nerve stimulation (TENS) at specific points on the outer ear has been recommended as an effective therapeutic procedure for the relief of pain.[1] Nogier[1] proposed that (1) the body surface and internal organs are represented at the auricle in a somatotopic organization that resembles an inverted fetus, (2) disease and pain at any body structure is reflected by increased tenderness and skin conductance at a corresponding point at the ear, and (3) electrical stimulation or acupuncture of the appropriate point leads to a decrease in pain in the corresponding part of the body.

There is a growing body of evidence derived from controlled studies which supports these remarkable claims. Oleson and colleagues[2] found

a concordance of 75% between the site of musculoskeletal pain established by medical diagnosis and points of increased tenderness and elevated skin conductance on the outer ear designated by Nogier.[1] In addition, recent controlled studies using healthy volunteers as subjects have found elevated pain thresholds after auricular TENS.[3–6] For example, pain thresholds in response to a high intensity electrical stimulus delivered to the wrist were significantly higher after TENS was administered at points on the ear corresponding to the wrist. In contrast, pain thresholds did not change when TENS was applied at auricular control points unrelated to the site of experimentally-induced pain, or if TENS was not applied at all.[3,4] Other studies have reported increased pain thresholds following unilateral or bilateral auricular TENS,[5] or auricular, somatic, or both auricular and somatic TENS,[6] but pain thresholds remained constant among untreated control subjects.[6] Finally, auricular TENS was significantly more effective than a placebo condition in reducing chronic pain of the distal upper or lower extremity.[7]

The only study which has failed to support the claim that auricular TENS is effective for the relief of pain was a placebo-controlled trial carried out by the present authors on patients suffering chronic pain of diverse etiology.[8] Subsequent work[9] suggested that auricular TENS may be more effective for particular chronic pain syndromes than for chronic pain in general. For example, patients with phantom limb pain reported considerable relief of their pain during and after auricular TENS.[9] Relief of phantom limb pain has also been reported from acupuncture[10] and electro-acupuncture[11] applied at auricular sites, but a placebo-control condition was not included.

The present study was designed to examine the efficacy of auricular TENS for the relief of phantom limb pain using a placebo-controlled crossover design in which subjects received auricular TENS on one session and placebo "stimulation" on the other. On the basis of the favorable results obtained from the amputees reported by Katz and Melzack[9] we predicted that post-stimulation ratings of phantom limb intensity would be significantly lower than pre-stimulation ratings following the administration of auricular TENS but not the placebo-control.

Method

Sample

The subjects were 28 amputees (18 males and 10 females) who had undergone amputation of the upper extremity (above-elbow in 2; below in 1) or lower extremity (above-knee in 16; below in 9). The reason for amputation was peripheral vascular disease (including diabetes mellitus) in 12 subjects, accident in 9, arterial thrombosis in 3, tumor in 2, and one each for radiation damage and polio.The mean age and time since amputation was 52.8 yr (range: 23 to 73 yr) and 5 yr (range: 36 days to 46 yr), respectively.

The subjects were assigned to one of three groups on the initial session based on the presence or absence of painful or nonpainful phantom limb sensations at the time of testing. Group PLS consisted of 9 amputees who reported feeling only nonpainful phantom limb sensations, Group PLP consisted of 11 subjects who reported phantom limb pain, and Group No-PL consisted of 8 amputees who reported that they did not feel the presence of a phantom limb at all. Subjects were recruited by advertisements placed in local newspapers and newsletters, postings at orthopedic appliance shops, and from several hospitals in the Montreal area. The study was approved by research and ethics committees at McGill University and at the individual hospitals where the project was carried out. Informed consent was obtained from all subjects prior to participation.

Pain Assessment and Psychological Measures

Subjects completed a battery of questionnaires and personality inventories which included the McGill Comprehensive Pain Assessment Schedule (MCPAS[12]), McGill Pain Questionnaire (MPQ[13]), Eysenck Personality Inventory (EPI[14]), Beck Depression Inventory (BDI[15]), Spielberger State-Trait Anxiety Inventory (STAI-S and STAI-T[16]), Wesley Rigidity Questionnaire (WRQ[17]), Mood Rating Scale (MRS[18]), and the Sleepiness Rating Scale (SRS[19]).

Experimental Apparatus and Stimulation Parameters

Transcutaneous electrical nerve stimulation (TENS) was delivered to the outer ears using an

Agar Electronics Neurogar III stimulator connected to two silver earrings which gently clasped the subject's earlobes. Stimulation intensity ranged from 10 to 30 volts across a fixed resistance of 2000 ohms. Pulse rate and width were 4 Hz and 100 μ sec respectively.

The subjects rated changes in perceived phantom limb intensity (PLI) by turning a dial which allowed 180 degrees of rotation. The 90 degree setting was labelled "USUAL," 0 degrees, "LESS," and 180 degrees, "MORE." The dial was connected to a 1.35 volt mercury battery via a 10,000 ohm potentiometer and the output fed into a digital voltmeter which registered 0 through 0.675 to 1.35 volts corresponding to the 0, 90, and 180 degree settings, respectively. Measurements were displayed on a continuous basis and were videotaped for later scoring.

Design

The subjects received TENS on the first session and placebo "stimulation" on the second, or the reverse order. The procedure (see below) on both sessions was identical except that on the placebo session, nonconducting leads connected the electrical stimulator and ear electrodes so that the subject received no current. Each session was divided into three consecutive 10 min periods, including an initial resting baseline (B1), bilateral ear stimulation (BES), and a final resting baseline (B2). Throughout the 30 min session the subject monitored changes in (painful and/or nonpainful) phantom limb intensity by turning the dial.

Procedure

The subjects were scheduled for two sessions on consecutive days or with as few days intervening between sessions as could be arranged. They were asked to refrain from smoking and drinking coffee or alcohol on scheduled days. Those with phantom limb pain were asked not to take any pain medication so that an accurate medication-free description of the pain could be obtained.

When the subjects arrived for the first session, they were interviewed using the MCPAS as a structured interview guide and given an envelope containing the EPI, BDI, STAI-T, and WRQ which they completed at home and returned on the second session. The procedure for the remainder of the first session and for the second session was the same. The subjects completed the MRS, SRS, STAI-S, and MPQ, and familiarized themselves with the use of the dial and its range before the start of Period B1.

At the beginning of the bilateral ear stimulation period (BES) on both sessions, the experimenter turned on the TENS unit which was within view of the subjects. They were told that depending on certain stimulation parameters they might or might not feel its effects. Stimulation intensity was increased until they reported a strong but tolerable sensation on their ears (TENS session) or until the experimenter announced that they were receiving the appropriate amount of current (placebo session). Subjects were instructed that if adjustments to the intensity of the ear stimulation were required, they were to inform the experimenter who would increase or decrease it accordingly. At the end of BES the experimenter turned off the stimulator and told subjects that they were no longer receiving current. They were informed that the 10 min final resting baseline period (B2) had begun and were reminded to continue to monitor their phantom limb. Poststimulation measures of the MRS, SRS, STAI-S, and MPQ were obtained after the final resting baseline period. Throughout both 30 min sessions the experimenter monitored the digital displays from behind an opaque curtain.

Results

Group Comparability Check

Univariate one-way ANOVAs comparing the three groups on demographic and clinical variables obtained from the McGill Comprehensive Pain Assessment Schedule (MCPAS) revealed no significant between-group differences (all $p > .05$). Thus, the three groups were comparable in mean age, education level, time since the amputation, number of surgical operations, and current medical problems. In addition, chi-square tests of independence for two-way tables indicated that the three groups did not differ significantly in the number of English- and French-speaking subjects, marital status, living arrangements, cause or level of amputation, use of prosthesis, or site of testing (all $p > .05$). Finally, one-way univariate ANOVAs indicated that at the time of testing the three groups were

comparable in terms of their scores on the EPI, BDI, STAI-T, and WRS (all $p > .05$).

Ratings of Phantom Limb Intensity

The videotape for each subject was reviewed and one value of phantom limb intensity (PLI) was obtained every 10 sec for both 30 min sessions. Values of PLI were transformed by subtracting a constant of 0.675 from each. This served to relocate PLI scores so that the 90 degree setting labelled "USUAL" took on a value of 0.0, and deviations from it, in the clockwise and counter-clockwise directions (corresponding to increases and decreases in PLI), had maximum values of ±0.675, respectively. Raw values of PLI were then submitted to a nonlinear smoothing procedure[20] which uses running medians to calculate the smoothed values, computes and smooths the residuals, and then adds the two smoothed series. Figure 1 shows plots of the raw and smoothed values of PLI for both groups during the TENS and placebo sessions. It can be seen that for Group PLS phantom limb intensity decreased progressively after receiving several minutes of auricular TENS and remained relatively low until BES offset. This pattern was not evident on the placebo session or for Group PLP.

In order to assess the statistical significance of the mean changes from period to period, smoothed values of phantom limb intensity (PLI) were averaged across each of the three 10-min periods and planned comparisons were carried out evaluating the mean difference in PLI from B1 to BES and BES to B2 for each group on both sessions. Significant differences were found only for Group PLS on the TENS session. As displayed in Figure 2, the intensity of nonpainful phantom limb sensations was reduced significantly during BES when compared to the initial and final resting baseline levels [$F(1,69) = 4.26$, $p < .05$ and $F(1,69) = 7.91$, $p < .01$, respectively]. Despite the statistical significance of the TENS-induced reduction in PLI, its clinical significance appears to be quite modest. Figure 2 shows that the mean decrease in PLI from Period B1 to Period BES for Group

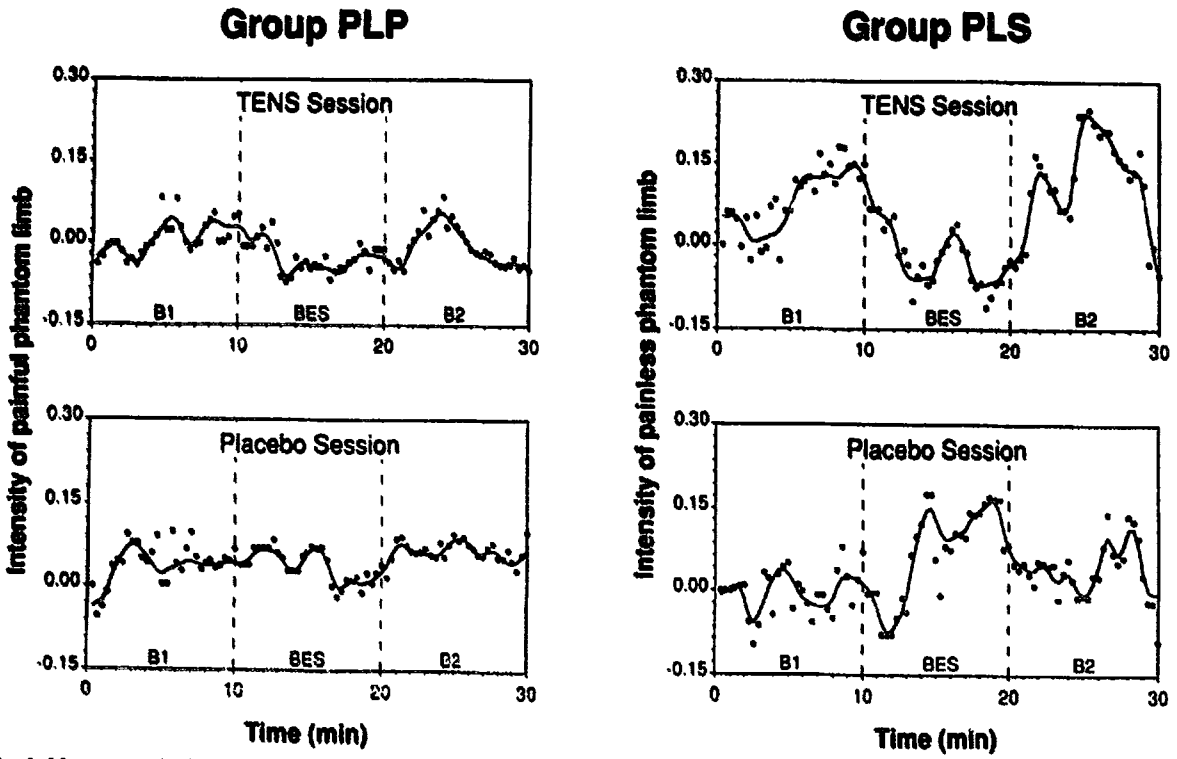

Fig. 1. Mean smoothed and unsmoothed raw data values of phantom limb intensity (PLI) for Groups PLP and PLS during Periods B1 (initial resting baseline), BES (bilateral ear stimulation), and B2 (final resting baseline) on the TENS and placebo sessions. Original unsmoothed values are represented by points (.); smoothed values are joined by a solid line (see text for details of smoothing function). PLI was sampled every 10 sec from a continuous record of the 30-min sessions in which the subject monitored changes in PLI by turning a dial. Each data value represents a group mean at a particular point in time. Intensity ratings have been transformed so that a value of 0.0 represents the subject's level of phantom limb intensity at the start of the session and deviations from it correspond to increases and decreases in PLI.

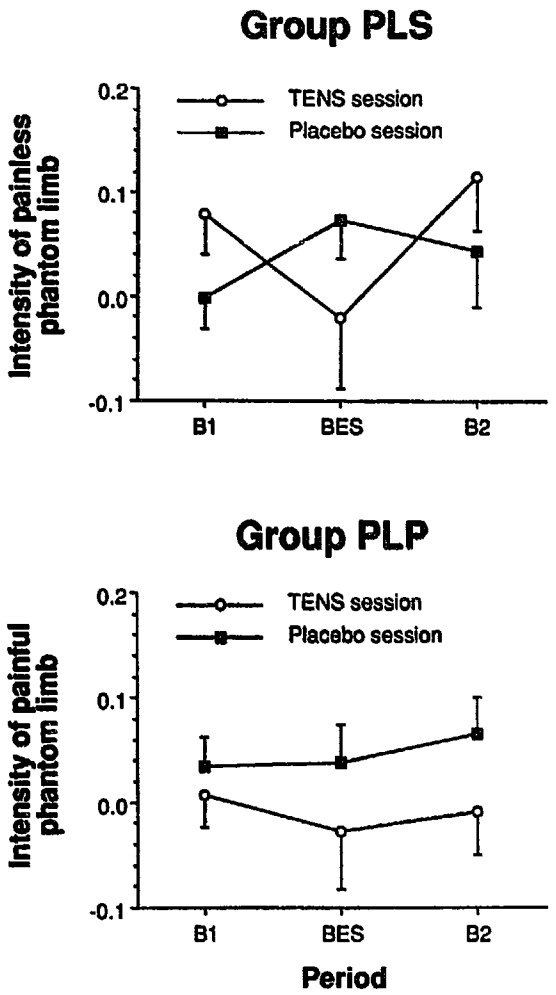

Fig. 2. Mean intensity level of painless (Group PLS) and painful (Group PLP) phantom limb sensations for Periods B1, BES, and B2 on the TENS and placebo sessions. Group PLS demonstrated a significant reduction ($p < .01$) in phantom limb intensity during Period BES and a significant increase ($p < .01$) during Period B2 which followed.

PLS is approximately 0.1, which amounts to only 7% of the total range of the dial.

It is important to note that PLI ratings for the two groups represent different qualities of sensation so that between-group comparisons of the intensity of phantom limb sensations are not meaningful. Group PLS was monitoring changes in the intensity of nonpainful paresthesias whereas Group PLP was monitoring pain intensity.

MPQ Pain Ratings

The McGill Pain Questionnaire (MPQ) was administered before and after each session in order to assess quantitative and qualitative changes in painful and nonpainful phantom limb sensations brought about by TENS versus the placebo control. Planned comparisons indicated that post-session ratings of the PRI-S and PRI-T from Group PLP were significantly lower than presession scores following TENS [$F(1,34) = 7.48$, $p < .01$ and $F(1,31) = 7.09$, $p < .01$, respectively]. Although the reduction in these MPQ classes is modest, they are statistically significant. These effects are displayed in Figure 3.

Table 1 shows the percentage of subjects in both groups reporting a decrease in the MPQ PRI-T and present pain intensity (PPI) of at least 33% after receiving TENS or placebo stimulation. A more detailed examination of the MPQ data can be found in Table 2 which contains the descriptors chosen by 33% or more of subjects in Groups PLP and PLS at each administration. Several points are noteworthy. The most salient feature is the greater number of descriptors endorsed by more subjects in Group PLP on both sessions, consistent with the higher PRI-T for this group. Second, a major difference between the groups can be found in the class of words used to describe their phantom limbs. Not one descriptor from any of the affective categories is endorsed by 33% or more of subjects in Group PLS whereas at least one third of Group PLP use some of these adjectives on both sessions. In addition, Group PLS shows remarkable consistency in their choice of descriptors within as well as between sessions, almost exclusively choosing descriptors from the class of sensory descriptors. Third, pre- versus poststimulation changes for Group PLP on the TENS session are most evident for adjectives which are frequently used to describe the "normal" nonpainful phantom (e.g., "pricking", "tingling", and "numb"). Fourth, there is a consistency in the choice of descriptors across groups. Every descriptor chosen by 33% or more of subjects in Group PLS was also chosen by 33% or more subjects in Group PLP, although there are other descriptors the latter group also endorses with greater frequency. This indicates that the phantom limb experiences of the two groups have in common a paresthetic quality although painful phantoms consist of more than this shared component.

Mood Ratings

Ratings from the MRS, SRS, and STAI-S obtained on each session before and after stimulation were entered as dependent variables into a 3-way MANOVA (Group × Session × Occasion). There were no significant main effects or inter-

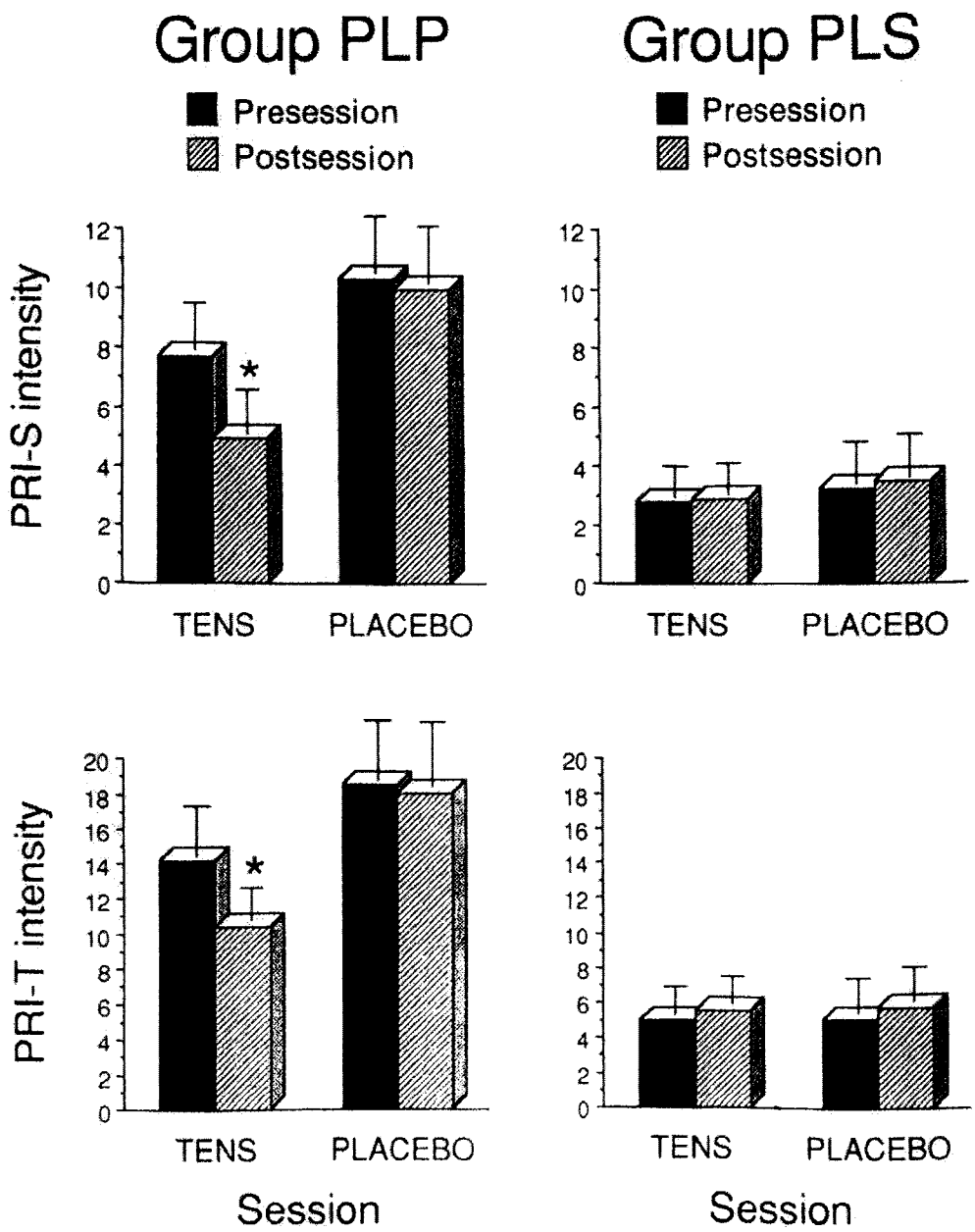

Fig. 3. McGill Pain Questionnaire pain rating indexes (PRI) for the sensory (S) and total (T) classes before and after stimulation on the TENS and placebo sessions shown for Groups PLP and PLS. Group PLP showed significant (* $p < .01$) decreases in PRI-S and PRI-T scores after the administration of auricular TENS. Post-session ratings were taken at the end of Period B2, 10 min after receiving BES. Note that PRI scores presented for Group PLS represent ratings of nonpainful phantom limb sensations.

actions, indicating that mean mood ratings were comparable between groups and remained virtually unchanged across sessions and test occasions (all $p > .05$). Thus, the post-TENS decrease in the MPQ PRI-S and PRI-T observed in Group PLP cannot be attributed to alterations in mood or mood-related states such as anxiety and sleepiness.

Referred Sensations

The audio portion of the videotapes from both sessions were transcribed verbatim for each subject. The transcripts were reviewed and each report of a referred sensation or pain was coded in terms of its quality and location in the body.

Sensations Referred to Regions Other than the Phantom Limb. Two subjects, both in Group No PL, reported feeling unusual sensations referred to regions other than the phantom limb. One (Case E25) noticed a "slight electric current inside the stump" on two occasions during BES on the TENS session. The sensation persisted for approximately 15 sec and was not painful. The subject claimed that she had never before

Table 1
Percentage of Subjects of Groups PLP and PLS Reporting Decreases in PRI-T and PPI of at Least 33% After Receiving TENS or Placebo Stimulation

	Session			
	TENS	Placebo	$\chi^2(1)$	p
Group PLP (n = 11)				
PRI-T	45	18	0.84	ns
PPI	36	36	0.20	ns
Group PLS (n = 9)				
PRI-T	22	22	0.32	ns
PPI	—	—		

experienced such a sensation. The second subject (Case E03) reported feeling a sharp pain under her left breast on three occasions during BES on the TENS session.

Sensations Referred to the Phantom Limb. The reported sensations obtained from the transcripts were grouped into eight categories as follows: (1) *paresthesias* (i.e., reports of numbness, tingling, prickling sensations, pins and needles, buzzing, and electric current), changes in (2) *heat intensity* (warm, hot, steaming, and burning), (3) *cold intensity* (cool, cold, freezing, and ice), (4) *pressure and constriction* (tight, squeezing, swollen, full, expanding), (5) *weight* (heaviness), (6) *posture* (immobility, paralyzed, stiff, clutching, and grabbing), (7) *somatosensory memories* (phantom pains and sensations which resemble preamputation experiences[21]), and (8) *other* sensations (throbbing, pulsating, pumping, twitching, sore, aching, shocks, and spasms).

Figure 4 shows the percentage of subjects in the two groups reporting at least one occurrence of each of the eight qualities of sensation summed across periods and sessions. Chi-square analyses using Yate's correction for continuity were computed to determine whether the two groups differed in the proportion of subjects reporting each type of sensation. Significant results were found for the categories describing sensations of pressure ($\chi^2(1) = 4.13$, $p < .05$) and "other" sensations ($\chi^2(1) = 6.87$, $p < .01$) indicating that proportionally more subjects in Group PLP reported these sensations. These results demonstrate that the qualities of sensation being monitored by subjects with phantom limb pain were more varied than those with nonpainful phantom limbs. They provide further support for the suggestion that

Table 2
Descriptors of the McGill Pain Questionnaire (MPQ) Chosen by 33% or More (Bold Type) of Subjects in Groups PLP and PLS Before and After Receiving TENS or Placebo. For Ease of Reading, Table Entries Have Been Omitted for a Given Session When Both Pre- and Postintervention Administrations Yielded Values Below 33%. Note that Unlike Group PLP, the MPQ Adjectives Chosen by Subjects in Group PLS do not Refer to Phantom limb Pain but Instead, Nonpainful Phantom Limb Sensations Defined Predominantly by Paresthesias.

		Group							
		Phantom limb pain (PLP) (n = 11)				Phantom limb sensation (PLS) (n = 9)			
		TENS		Placebo		TENS		Placebo	
MPQ Class	Descriptors	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Sensory	beating	—	—	27.3	36.4	—	—	—	—
	pricking	45.5	27.3	45.5	36.4	33.3	33.3	—	—
	cramping	—	—	36.4	18.2	—	—	—	—
	hot	—	—	36.4	36.4	—	—	—	—
	tingling	72.7	36.4	63.6	45.5	55.6	55.6	66.7	66.7
Affective	tiring	45.5	54.5	36.4	45.5	—	—	—	—
	sickening	—	—	36.4	27.3	—	—	—	—
	punishing	—	—	36.4	9.1	—	—	—	—
	wretched	—	—	36.4	27.3	—	—	—	—
Evaluative	annoying	72.7	72.7	54.5	45.5	—	—	66.7	66.7
Misc.	squeezing	36.4	18.2	9.1	36.4	—	—	—	—
	numb	27.3	45.5	63.6	27.3	33.3	33.3	33.3	33.3
	nagging	27.3	36.4	45.5	45.5	—	—	—	—
PPI	discomforting	63.6	45.5	36.4	45.4	—	—	—	—
	distressing	—	—	36.4	27.3	—	—	—	—

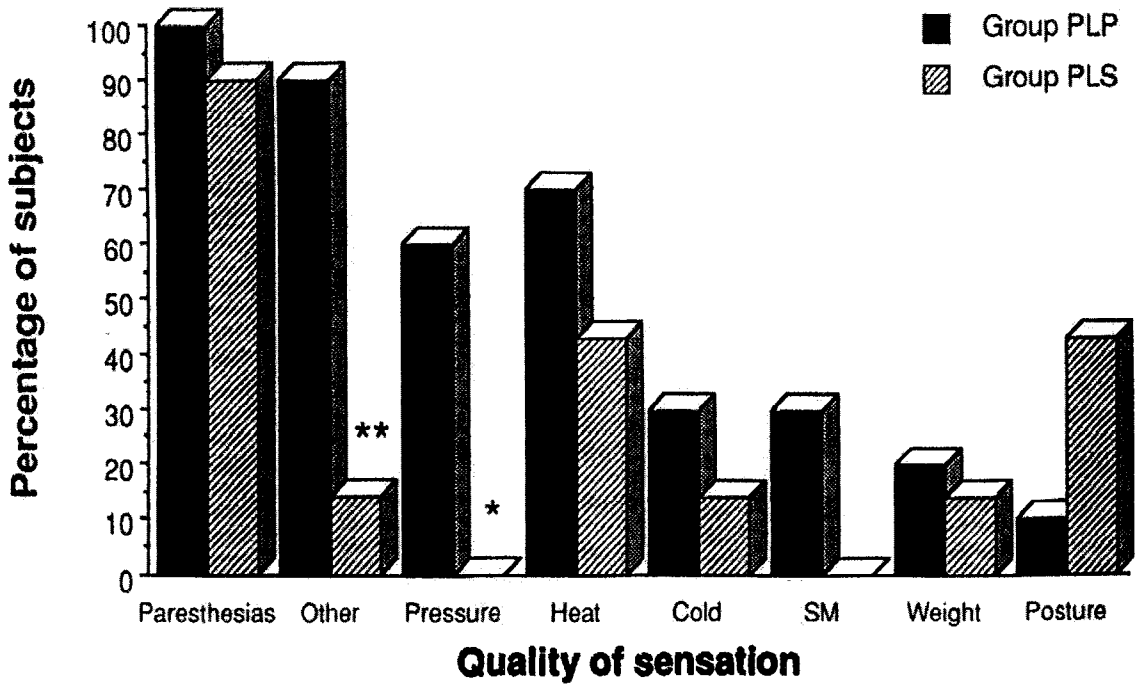

Fig. 4. Percentage of subjects in Groups PLP and PLS reporting various qualities of sensation referred to the phantom limb on both sessions (summed across periods). A significantly greater proportion of subjects in Group PLP reported phantom limb sensations of pressure (* $p < .05$) and "other" sensations (** $p < .01$) which include throbbing, pulsating, pumping and so forth. SM refers to somatosensory memory (see text for details).

the painful phantom limb embodies the same basic qualities of sensation as the painless phantom (i.e., paresthesias) and more (e.g., sensations of pressure and constriction, throbbing, pulsating, pumping sensations and somatosensory memories).

Discussion

Use of low frequency TENS applied at the outer ears appears to produce a modest, short-term reduction in the intensity of phantom limb pain and nonpainful phantom limb paresthesias. Mean levels of PLI were reduced significantly during BES for Group PLS and McGill Pain Questionnaire scores were significantly lower following TENS for Group PLP. Similar changes were not apparent for either group on the placebo session. Furthermore, ratings of mood state, sleepiness, and anxiety remained virtually unchanged across sessions and test occasions, thus ruling out the possibility that the decrease in pain was mediated by emotional factors.

The reduction in phantom limb intensity produced by TENS applied at the outer ears can be explained by a diffuse noxious inhibitory control[22] mechanism activated by a form of "hyperstimulation."[23] Moderate to intense stimulation, of various kinds, applied at sites distant from the region of pain is effective in relieving chronic pain.[24,25] Such stimulation activates brainstem structures that exert an inhibitory control over nociceptive neurons in the spinal cord dorsal horns.[22,23,25] The outer ear is richly innervated by somatic afferents, including five cranial and two cervical spinal nerves.[26,27] It is reasonable to assume that electrical stimulation applied to the outer ears produces its effects by activating this descending pain control system.

The observation that phantom limb intensity was reduced *during* but not *after* TENS in Group PLS, and *after* but not *during* TENS in Group PLP is interesting and can, in part, be explained by the basic difference between nonpainful[28] and painful[29,30] phantom limbs. The painless phantom is defined predominantly by its paresthetic quality[28] whereas the "painful" phantom is a less homogeneous entity, and while many sufferers describe a paresthetic or dysesthetic component, most patients are beset by other types of pain as well.[29,30] Evidence for this basic difference between the painful and painless phantom in the present study can be found in Table 2 which shows that Group PLP endorsed more MPQ descriptors from a wider range of classes than Group PLS. In addition, Group

PLP reported significantly more sensations of pressure as well as "jabs," throbbing, pulsating, and so forth (Figure 4) when monitoring their phantom limbs.

The results suggest that auricular TENS decreased the intensity of the paresthetic component of the phantom limb in both groups. However, it may be hypothesized that for Group PLP the proportion of the total pain experience which was reduced during Period BES on the TENS session was minimal in relation to that which remained. Thus, these subjects registered relatively small changes in PLI when using the dial (Figures 1 and 2) but the more sensitive measure of pain using the MPQ revealed a significant post-TENS reduction in words which are frequently used to describe paresthesias (Table 2). This hypothesis explains why Group PLP showed a reduction in PLP after but not during TENS and why Group PLS showed a reduction during TENS, but it is difficult to account for the difference in the duration of the effect for the two groups. Nevertheless, it appears safe to conclude that the duration of pain relief brought about by auricular TENS is quite short. Although we did not evaluate phantom limb pain intensity beyond the 10 min (B2) period, it is our impression that the effect was transient and did not last much longer.

The positive results of the present study conflict with our past placebo-controlled trials with auricular TENS[8,31] and may be explained by differences in sample characteristics and electrical stimulation parameters. The inclusion by Melzack and Katz[8] of patients with a variety of pain disorders (and none with phantom limb pain) may have increased the variability and diluted the size of the effect of TENS, thus leading to the negative result. A second difference concerns the pulse width which was long (125 msec) in our previous studies,[8,31] and short (100 μ sec) in the present study. Only one other controlled study has demonstrated auricular TENS to be effective in a clinical setting on patients with chronic pain but pulse width was not specified.[7] A study comparing short and long pulse widths might shed some light on this issue.

Group No PL was included to determine what effect (if any) auricular TENS would have on subjects who reported no phantom limb at the time of testing. Our previous work[8,9] demonstrated that between 30% and 40% of chronic pain patients report sensations referred to a variety of body locations during auricular TENS. In addition, amputees often report that many stimuli can result in the return of the phantom limb once it has disappeared.[32] In the present study not one subject reported a return of the phantom on either session, but it is interesting that the only subjects to report sensations referred to regions of the body other than the phantom limb were from Group No PL, and they did so only during Period BES on the TENS session.

In conclusion, the results of the present study suggest that auricular TENS may be helpful in reducing the intensity of phantom limb pain and dysesthesias but further placebo-controlled trials of auricular TENS are needed before it can be recommended for clinical use. In particular, the clinical importance of this procedure needs to be established with respect to (1) efficacy (given the modest reduction in pain we observed), (2) duration beyond 10 min, and (3) effective stimulation parameters such as pulse width and rate. In a recent controlled study,[33] TENS was applied at the residual limb for 30 min twice a day during the 2-wk postoperative period following amputation. The incidence of phantom limb pain among patients treated with TENS was significantly lower than sham treated control patients at a 4-wk follow-up but not 1 yr later. This study points to the importance of conducting long-term follow-up interviews in clinical trials. This was not a feature of the present design. Future studies might consider evaluating the efficacy of auricular TENS applied during the postoperative period when the intensity of phantom limb pain is often at a peak.

The potential practical importance of auricular TENS should not be overlooked since it is a noninvasive treatment with few indications to the contrary. Furthermore, most patients who have had an arm amputated are dependent on others to administer TENS at the stump since only the most dexterous can apply the conductive gel and affix the electrodes with one hand alone. The advantage of auricular TENS is that simple, clip-on ear electrodes can be easily attached by the patients themselves. The benefits of such a self-treatment program include increased autonomy and independence for the patient and more efficient use of time for the treating health professional. The realization of these potential benefits awaits the results of futher placebo-controlled clinical trials.

Finally, the remarkable diversity in the qual-

ity, location, and intensity of painful and nonpainful phantom limb sensations deserves comment. The pattern of changes in PLI (Figure 1), the choice of MPQ descriptors (Table 2) and the reported qualities of sensations (Figure 4) make it clear that the painful and nonpainful phantom limb is not perceived as a static, fixed entity, but a fluid, frequently changing perceptual experience characterized by fluctuations in tactile, thermal, kinesthetic, and proprioceptive sensibility. Subjects reported sensations that ranged from simple diffuse paresthesias to perceptually complex experiences of pains and lesions that were originally felt in the limb prior to the amputation. The various qualities of sensation referred to the phantom limb are no different from those experienced in the intact limb prior to amputation because they both reflect coordinated activity among the same neural networks in the brain.[32,34]

Acknowledgements

The authors thank the staff and patients of the following hospitals and institutions for their kind and helpful cooperation: Catherine Booth Hospital Centre, Fédération des Personnes Amputées du Québec, J.E. Hanger Inc., Montreal Convalescent Hospital Centre, Montreal General Hospital, Orthomedics Inc., Royal Victoria Hospital, Ste. Anne's Veterans Hospital.

This research project was supported by Grant A7891 from the National Sciences and Engineering Research Council of Canada to Ronald Melzack, and by postgraduate scholarships from the Medical Research Council of Canada, the Fonds FCAC pour l'Aide et le Soutien à la Recherche (Quebec Government), and a Fellowship from the Health Research Personnel Development Program of the Ontario Ministry of Health to Joel Katz. The results and conclusions derived herein are those of the authors, and no official endorsement by the Ontario Ministry of Health is intended or should be inferred. This paper is derived, in part, from the first author's Ph.D. dissertation.

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