Short-term improvements in the body schema can modulate pain perception in fibromyalgia syndrome

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Abstract

Objective

This study aimed to evaluate the pain perception and several aspects of disrupted body schema, in a sample of patients suffering from fibromyalgia (FM) syndrome.

Methods

Twenty-six patients were organised into two groups: the tactile discrimination group and control group (exposed to tactile stimulation alone). Outcome measures were the pain intensity in body regions commonly described as painful (visual analogue scale) and clinical status, body esteem scale (BES), interoceptive awareness. Tactile acuity was measured by the two-point discrimination test (TPD), hits in the location of the stimulus, the probe size discrimination and the graphesthesia task.

Results

The group exposed to tactile discrimination experienced a significant improvement in all tactile acuity outcome measures. The decrease of the Fibromyalgia Impact Questionnaire variable was relevant (81.58, SEM 3.29 vs. 72.91, SEM 6.43; p=0.07). Likewise, pain perception was lower in all of the body regions evaluated (reduction of 12.2% in the stimulated body region (cervical VAS) with a large effect size, a pain reduction of 11.3% in the wrists and 9.2% in the knees. The correlation index showed association between the cervical VAS and TPD (ϱ=0.53; p<0.05).

Conclusion

There was no improvement in pain scores in the control group but the TPD was decreased also. The BES scores did not show differences between groups. However, interoceptive awareness showed a slight reduction in the group exposed to tactile discrimination (3.68, SEM 0.15 vs. 3.35, SEM 0.19; p=0.01). After short-term tactile discrimination protocol, the group exposed to tactile discrimination experienced a significant improvement in all tactile acuity outcome measures: pain perception, tactile acuity and body perception, compatible with adjustments in the body schema. The tactile stimulation alone group did not show the same improvement.

Key words

fibromyalgia, distance perception, touch perception, body image, pain management

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Introduction

Tactile acuity refers to the precision through which we can perceive and recognise specific characteristics of tactile exteroceptive stimuli. Tactile-acuity disorders are directly associated to changes in the organisation of the somatosensory cortex (1-3). Furthermore, the extent of reorganisation is related to both the intensity of pain perception and the reduction in tactile acuity (4-7). This decrease is reported to set up in several chronic pain diseases including fibromyalgia (FM) syndrome (8); a highly prevalent chronic musculoskeletal condition characterised by widespread pain, body schema distortion (8, 9) and nociplastic pain (10). Correct and actual approach to fibromyalgia patients' treatment is necessary for pharmacological and non-pharmacological therapies (10, 11), underlying psychosocial variables such as emotional distress in individuals with FM (12).

This study raises the possibility that an improvement of tactile acuity could generate changes in the body schema and pain perception in a sample of FM patients. Our hypothesis is that the tactile discrimination condition, due to body schema reorganisation, would increase tactile acuity and decrease pain perception.

Methods and materials

Study participants and setting

The whole sample was composed initially by thirty women (there were 4 withdrawals) with a formal diagnosis of FM according to criteria of the American College of Rheumatology, match by age and pain clinical status at baseline (1st day). Pharmacological treatment such as antidepressants, benzodiazepines or the like were not an exclusion criterion, so that there may be bias for this reason on the outcome variables. The Ethical Review Board of the University of the Basque Country approved the study protocol IRB (CEISH 331-2015 AZKUE BARRENETXEA), and all participants provided written informed consent before taking part in the study. No participant has been exposed to a similar experimental procedure before.

The assignment to each group was randomised and masked for the participants. The tactile stimulation short-term programme consisted of a half hour daily session carried out at home with the help of an assistant/partner who had been previously trained by the researcher for three weeks. In the control group, exposed to tactile stimulation alone, each participant received the same tactile stimuli, except that they were not asked to concentrate on their tactile perception nor were they asked to identify the stimulus. All the evaluations were performed by the researcher at the Faculty of Medicine and Nursing of the University of the Basque Country UPV/EHU. Data collection took place over one year (between March 2016 and May 2017).

Detailed methodology about experimental and control group is in the Appendix 1.

Outcome variables evaluated

The evaluation consisted of an initial session in which the baseline data of the outcome variables related to tactile acuity, clinical variables, body esteem and interoceptive awareness were recorded. In a second intermediate session, after 10–11 days from the beginning of the programme, preliminary data was collected (which was not used in the final analysis of results) and doubts were resolved. Finally, in the third session (on the 21st day of the programme), credibility was recorded and the final data used were compared to the data obtained in the baseline for both experimental groups. Namely, a contrast analysis on differences in means between the two groups was performed at the beginning and at the end of the tactile stimuli programme.

- Pain and clinical status

Pain and clinical status were assessed using self-administered questionnaires. Participants provided an overall measure of pain severity and another specific visual analogue scale (VAS) for the cervical region (13, 14). In addition, the VAS obtained in the wrists and knees were evaluated, since they are two corporal regions commonly described as painful in FM syndrome (15). The impact of ongoing pain on daily function was evaluated by the Spanish ver-

Table I. Descriptive and statistical summary of the outcome variables.

Result variables	FM group subjected to tactile discrimination (n=13)				FM group exposed to tactile stimulation alone (n=13)				*p value*			
	Day 1		Day 21		Day 1		Day 21		Between groups		Intragroup (day 1 vs day 21)	
	M	SEM	M	SEM	M	SEM	M	SEM	Day 1	Day 21	Tactile discrimination group	Tactile stimulation group
Cervical VAS ("without pain" 0-10 cm "worst pain imaginable")	7.81	0.45	6.59	0.69	6.89	0.92	7.96	0.42	0.88[b]	0.16[b]	0.10[c]	0.72[c]
Wrist VAS	7.37	0.73	6.24	0.70	5.01	1.00	6.75	0.88	0.15[b]	0.33[b]	0.19[c]	0.13[c]
Knees VAS	6.98	0.58	6.06	0.58	6.88	0.89	7.01	0.80	0.80[b]	0.18[b]	0.38[c]	0.93[c]
General VAS	8.03	0.41	7.06	0.74	8.41	0.32	7.77	0.55	0.65[b]	0.76[b]	0.14[c]	0.46[c]
FIQ ("low impact of FMS"0-100 "maximum impact")	81.58	3.29	72.91	6.43	75.44	3.66	74.81	4.32	0.22[a]	0.80[a]	0.07[a]	0.85[a]
BPI-SF ("the pain does not interfere 0-10 "completely interferes")	7.07	0.32	6.66	0.49	6.80	0.29	6.74	0.51	0.61[b]	0.51[b]	0.40[c]	0.91[c]
BPQ *awareness domain* ("never" 1-5 "always")	3.66	0.15	3.35	0.19	3.42	0.12	3.40	0.15	0.30[a]	0.86[a]	0.01**[a]	0.87[a]
BES general score ("negative perception"1-5 "positive perception")	2.12	0.13	2.26	0.12	2.31	0.12	2.42	0.13	0.30[a]	0.40[a]	0.14[a]	0.40[a]
TPD (mm)	62.53	2.58	46.53	2.93	56.53	3.80	47.46	6.28	0.20[a]	0.89[a]	0.00**[a]	0.09[a]
Credibility ("nothing credible"0-10 cm "completely credible")	-		9.02	0.38	-		9.05	0.32	-		0.73[b]	-
Difficulty ("without difficulty" 0-10 cm "extreme difficulty")	-		0.21	0.07	-		0.86	0.40	-		0.95[b]	-

The means (M) are shown with their typical error of the mean (SEM) for the group exposed to tactile stimulation alone and the group subjected to tactile discrimination, on days 1th (baseline) and 21th (at the end of the programme). The statistical significance (*p*) of the mean contrast relative to the analysis between both groups and within the same group is shown. The *t-test*[a] was used as a parametric test and the non-parametric ones were *U de Man-Whitney*[b]/ Wilcoxon[c]. ***p*<0.01.

sion of the short form of the Brief Pain Inventory (BPI-SF) (16). The Spanish version of the Fibromyalgia Impact Questionnaire (FIQ) (17) was used to assess the spectrum of daily problems and symptoms related to FM.

- Body esteem and body awareness

Body esteem, an important dimension of self-esteem, was measured by the Body Esteem Scale (BES) (18). This test evaluates perception and self-evaluation of one's body by measuring the feeling towards various body parts and functions on a 5-point Likert scale (1 labelled as *very negative* and 5 as *very positive*). The Body Perception Questionnaire (BPQ) (19) was used as a measure of self-rated bodily awareness. This tool uses 5-point scoring scales (1 denoting no awareness at all, whereas 5 indicates permanent awareness) to assess body perception and interoceptive awareness. Only the awareness (perception of bodily processes, *e.g.* swallowing) subscale, a domain that is markedly altered in FM (20), was used in this study.

Data analysis and statistics

The present study can be considered as a pilot study (21, 22, 23). We determined our minimum sample size (24), ranging from 4 to 12 subjects with FMS (95% CI). We also determined the magnitude of the effect between the obtained means, represented as Cohen's *d* (25, 26) and its 95% confidence intervals (CIs). We used the statistical package SPSS® v. 22 (SPSS, Chicago, IL) to process the data.

Results

Thirteen women (average age 44.31 years, standard deviation 9.42) were assigned to the tactile discrimination group and 13 women (average age 50.69 years, standard deviation 7.69) were assigned to the tactile stimulation alone group (control group).

Pain and clinical status of FM patients

Pain and fibromyalgia symptoms decreased in the group exposed to tactile discrimination (Table I). This result showed a slight improvement in FIQ

(8.67% decrease throughout the 21 days; p=0.07 on the Student's t-test for independent samples), against the group exposed to tactile stimulation alone (0.63% decrease; Table I). That is to say, scores in FIQ reflect a better state of health, and denote less interference of symptoms in daily life tasks in the group subjected to tactile discrimination. Specifically, the pain perception in the cervical region in the group subjected to tactile discrimination was 7.81 (SEM 0.45) and after the programme, a score of 6.59 (SEM 0.69) was recorded, slightly lower than that obtained at the baseline status (Table I). In addition, the magnitude of the size effect recorded measured in the cervical VAS between baseline session and at the end of programme was relevant (value of 0.58 in the Cohen's d indicating moderate effect). Furthermore, although the above variables did not show statistical significance between the baseline *vs.* the 21st day session (Table I), a moderate decrease of similar magnitude can be observed in the intensity of pain perception in almost all body regions assessed in the group subjected to tactile discrimination (Table I). It is very interesting that the VAS recorded on the wrists and knees, body regions that were not directly stimulated, also decreased; a reduction of about 9.2% in the knees and 11.3% in the wrists, but changes in this aspect were not detected in the group exposed to tactile stimulation alone (Table I).

Increased tactile acuity in FM

In the two-point discrimination test, we obtained a very significant decrease in the threshold of the group subjected to tactile discrimination at the end of the programme (Table I). Meanwhile, the mean difference obtained in the group exposed to tactile stimulation alone, despite showing moderate improvement, was not significant (with a contrast power of 76%, α=0.05, bilateral). There was a moderate increase in tactile acuity in the control group, but in the group subjected to tactile discrimination, we recorded a remarkable improvement in the tactile acuity (TPD threshold, which was reduced in 16 mm; Table I). Further, there was a slight increase

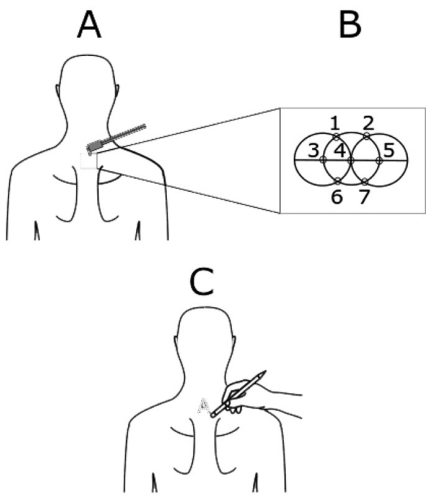

Fig. 1. Illustrative diagram of the tactile discrimination procedure.
A. The researcher establishes the two-point discrimination threshold in the cervical region. **B**. The researcher marks seven numbered and equidistant points, organised as hexagon's vertices adding a central point, and the separation between the points are equivalent to the TPD threshold. Then, he touches the skin of the cervical-scapular region with the probe in one of the seven points determined and the participant must concentrate on the tactile perception with the aim of identifying which of the seven points is receiving contact from the probe (probe location) and also, which of the two types of probe is used (probe size).
C. Graphesthesia consists of the identification throughout mental visualisation patterns of letters drawn on the skin.

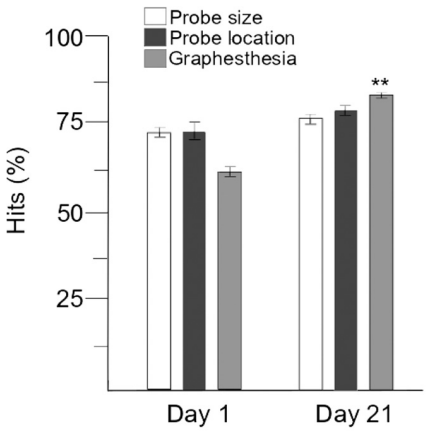

Fig. 2. Increase in tactile acuity in FMS patients. There was a slight enhance in the hits related to the location of the stimulation, in the perception of the probe size used, and a significant improvement in the graphesthesia task on day 21 (p<0.01 at the Student's-test, denoted by asterisks).

in the hits related to the location of the stimulation and hits in the perception of the size of the probe used (increase in hit on the probe location by 7.78%; p=0.06 and in hit on probe size by 5.77%; p=0.05; Fig. 2). The results of the graphesthesia task revealed a significant improvement at the end of the programme (increase in hits by 24.10%; p<0.01; Fig. 2). Finally, we evaluated if there was an association between the variable TPD and the intensity of the pain perception. We found a positive association (correlation coefficient of Spearman (rho) ϱ=0.53; p<0.05), with a medium strength association between both variables, at the end of the programme in the group subjected to tactile discrimination. In other words, the relationship indicates that the subject whose tactile acuity improves in a very significant way (considerable TPD threshold decrease) correlates with lower pain intensity perceived. We also observed a similar pattern in the group exposed to tactile stimulation alone, but with small association (ϱ=0.1), possibly because the decrease in the TPD threshold is considerably smaller and its effect on other variables is therefore less. In addition, at the beginning of the programme, the association between both variables was practically null ($\approx$0). Therefore, the results can be interpreted in such a way that if the increase in tactile acuity is greater (threshold decrease), its association with the variable pain perception intensity increases (lower pain perceived).

Evolution of variables related to body esteem and interoceptive awareness in FM

In order to evaluate the body satisfaction, Body Esteem Scale was used. We recorded a similar global mean BES score in both groups; at the beginning of the programme (2.12, SEM 0.13 in the group subjected to tactile discrimination and 2.31, SEM 0.11 in the control group) and at the end (2.26, SEM 0.12 with respect to 2.39, SEM 0.12); without finding significant differences (Table I and II). However, a slight improvement was observed in the degree of satisfaction in practically all the body parts evaluated in both groups once the programme concluded (Table II). In addition, the slight improvement was more striking in the group subjected to tactile discrimination since it showed an improvement in 68% of its total items (Table II).

Table II. Scores from FMS patients for the group exposed to tactile stimulation alone and for the group subjected to tactile discrimination on the Body Esteem Scale.

	Group subjected to tactile discrimination		Group exposed to tactile stimulation alone		Effect size
	Day 0	Day 21	Day 0	Day 21	
Body scent	2.69 (0.23)	3.07 (0.17)	3.54 (0.38)	3.46 (0.29)	-0.44 (-1.23, 0.35)
Appetite	2.77 (0.27)	2.46 (0.35)	2.46 (0.27)	2.23 (0.28)	0.20 (-0.58, 0.98)
Nose	2.84 (0.15)	3.00 (0.16)	3.30 (0.17)	2.92 (0.21)	-0.42 (-1.21, 0.37)
Physical stamina	1.15 (0.10)	1.30 (0.13)	1.38 (0.14)	1.69 (0.13)	-0.56 (-1.36, 0.24)
Reflexes	2.07 (0.26)	1.84 (0.19)	2.30 (0.36)	1.92 (0.31)	-0.08 (-0.86, 0.70)
Lips	3.00 (0.16)	3.15 (0.15)	3.46 (0.18)	3.46 (0.21)	-0.46 (-1.25, 0.33)
Muscular strength	1.30 (0.13)	1.23 (0.12)	1.58 (0.21)	1.46 (0.14)	-0.47 (-1.26, 0.32)
Waist	1.69 (0.21)	2.00 (0.25)	2.23 (0.28)	2.38 (0.24)	-0.42 (-1.21, 0.37)
Energy level	1.15 (0.10)	1.30 (0.13)	1.61 (0.26)	1.54 (0.18)	-0.41 (-1.20, 0.38)
Thighs	1.69 (0.21)	2.00 (0.25)	1.84 (0.33)	2.30 (0.26)	-0.32 (-1.11, 0.47)
Ears	3.07 (0.24)	3.07 (0.21)	3.46 (0.18)	3.50 (0.19)	-0.60 (-1.42, 0.22)
Biceps	2.07 (0.26)	2.38 (0.24)	1.69 (0.34)	2.38 (0.21)	0 (-0.78, 0.78)
Chin	3.07 (0.28)	3.00 (0.22)	2.84 (0.22)	3.08 (0.28)	-0.09 (-0.89, 0.71)
Body build	2.07 (0.28)	2.38 (0.26)	2.58 (0.28)	2.30 (0.30)	0.08 (-0.70, 0.86)
Physical coordination	1.77 (0.16)	1.92 (0.24)	1.61 (0.14)	1.61 (0.14)	0.44 (-0.35, 1.23)
Buttocks	2.30 (0.32)	2.30 (0.32)	2.75 (0.33)	2.54 (0.29)	-0.21 (-1.00, 0.57)
Agility	1.46 (0.24)	1.46 (0.18)	1.54 (0.18)	1.61 (0.14)	-0.25 (-1.03, 0.53)
Width of shoulders	2.61 (0.24)	2.69 (0.23)	2.84 (0.27)	2.69 (0.30)	0 (-0.78, 0.78)
Arms	2.30 (0.26)	2.46 (0.21)	2.00 (0.27)	2.07 (0.24)	-0.47 (-0.32, 1.26)
Chest or breasts	2.00 (0.29)	2.00 (0.29)	2.30 (0.32)	2.61 (0.29)	-0.57 (-1.37, 0.23)
Appearance of eyes	2.61 (0.31)	3.00 (0.22)	3.23 (0.34)	3.07 (0.28)	-0.07 (-0.85, 0.71)
Cheeks/cheekbones	3.00 (0.19)	2.84 (0.25)	3.38 (0.24)	3.46 (0.21)	-0.74 (-1.55, 0.07)
Hips	2.00 (0.25)	2.00 (0.25)	2.15 (0.27)	2.15 (0.22)	-0.17 (-0.95, 0.61)
Legs	2.00 (0.19)	2.07 (0.28)	1.84 (0.19)	1.84 (0.19)	0.26 (-0.52, 1.04)
Figure or physique	1.92 (0.21)	2.15 (0.22)	2.00 (0.29)	2.30 (0.23)	-0.18 (-0.96, 0.60)
Sex drive	2.15 (0.33)	2.54 (0.31)	2.07 (0.24)	2.23 (0.25)	0.30 (0.49, 1.09)
Feet	2.23 (0.25)	2.69 (0.21)	2.46 (0.33)	2.69 (0.21)	0 (-0.78, 0.78)
Sex organs	2.61 (0.24)	2.54 (0.21)	2.77 (0.25)	2.92 (0.21)	-0.49 (-1.28, 0.30)
Appearance of stomach	1.77 (0.16)	1.92 (0.26)	1.61 (0.33)	1.84 (0.22)	0.09 (-0.69, 0.87)
Health	1.07 (0.07)	1.30 (0.13)	1.46 (0.14)	1.46 (0.14)	-0.31 (-0.49, 1.31)
Sex activities	2.00 (0.27)	2.30 (0.36)	2.17 (0.24)	2.08 (0.28)	0.19 (-1.09, 0.48)
Body hair	2.46 (0.29)	2.77 (0.32)	2.69 (0.36)	3.00 (0.22)	-0.23 (-1.01, 0.55)
Physical condition	1.30 (0.13)	1.54 (0.14)	1.54 (0.14)	1.84 (0.15)	-0.56 (-1.36, 0.24)
Face	2.54 (0.24)	2.77 (0.25)	3.38 (0.35)	3.00 (0.30)	-0.23 (-1.01, 0.55)
Weight	1.69 (0.26)	1.84 (0.25)	2.07 (0.34)	2.07 (0.26)	-0.25 (-1.03, 0.53)

Data is presented as mean (SEM) for the group exposed to tactile stimulation alone and the group exposed to tactile discrimination for day 1 and day 21, and Cohen's d (95% CI) is provided as a measure of effect size between the two groups on day 21.

On the other hand, in order to evaluate body awareness, we used the body perception questionnaire (BPQ). Its dimension *awareness* composed of 45 questions that evaluate expressly the interoceptive perception of bodily processes. In this case, we found a significant decrease in the general value recorded at the end the programme with respect to the baseline session only in the group subjected to tactile discrimination (Table I), and there was also a decrease in practically all the items evaluated (Table III). Specifically, an average of 3.66 (SEM 0.15) per day 1 *versus* 3.35 (SEM 0.19) per 21st day was obtained ($p<0.01$; Table I). Conversely, in the group of tactile stimulation alone, at the beginning it showed an average of 3.42 (SEM 0.12) *versus* that obtained on the 21st day of 3.40 (SEM 0.15) ($p=0.87$; Table I).

The results show a moderate but significant decrease in interoceptive perception of bodily processes in the group subjected to tactile discrimination (Table I).

Methodology checking measures

There was no statistically significant difference between groups for the credibility of the stimuli programme and difficulty about the reproducibility of the programme (Table I). Both groups were very high with respect to the credibility of the programme and low values on the scale with respect to the assessment of difficulty (Table I).

Discussion

This study demonstrates for first time that discriminating the location and size of tactile stimuli linked to the identification by means of mental visualisation can decrease pain perception in FM patients. Moreover, the TPD threshold decreases whilst the interoceptive awareness of the body's own processes reduces. These improvements in pain perception, tactile acuity and body perception, after short-term tactile discrimination protocol, are compatible with online adjustments in the body schema.

Improved in pain-related variables in FM by tactile discrimination

Several studies have analysed that in a body part affected by pain there are

Table III. Scores from FM patients for the group exposed to tactile stimulation alone and for the group subjected to tactile discrimination across awareness sub-scale on the Body Perception Questionnaire.

"During most situations I am aware of:"					
Awareness subscale	Group subjected to tactile discrimination		Group exposed to tactile stimulation alone		Effect size
	Day 0	Day 21	Day 0	Day 21	
1.Swallowing frequently	2.84 (0.31)	3.07 (0.26)	3.16 (0.40)	3.54 (0.37)	-0.40 (-1.19, 0.39)
2. A ringing in my ears	3.46 (0.26)	3.30 (0.34)	3.84 (0.29)	3.38 (0.38)	-0.06 (-0.84,0.72)
3. An urge to cough to clear my throat	3.46 (0.24)	3.23 (0.28)	2.91 (0.31)	2.92 (0.28)	0.30 (-0.49, 1.09)
4. My body swaying when I am standing	3.77 (0.32)	3.92 (0.28)	3.77 (0.23)	3.61 (0.26)	0.31 (-0.48, 1.10)
5. My mouth being dry	4.23 (0.25)	3.76 (0.23)	4.07 (0.26)	3.69 (0.28)	0.08 (-0.70, 0.87)
6. How fast I am breathing	3.38 (0.31)	3.23 (0.16)	3.07 (0.13)	3.00 (0.25)	0.29 (-0.49, 1.07)
7. Watering or tearing of my eyes	2.92 (0.36)	2.84 (0.22)	3.38 (0.24)	3.00 (0.33)	-0.15 (-0.93, 0.63)
8. My skin itching	3.84 (0.22)	3.77 (0.25)	3.46 (0.18)	3.76 (0.27)	0 (-0.78, 0.78)
9. Noises associated with my digestion e	3.61 (0.36)	3.23 (0.34)	3.08 (0.25)	3.23 (0.16)	0 (-0.78, 0.78)
10. Eye fatigue or pain	3.84 (0.15)	3.23 (0.25)	3.92 (0.24)	3.61 (0.31)	-0.42 (-1.21, 0.37)
11. Muscle tension in my back and neck	4.69 (0.17)	4.38 (0.18)	4.77 (0.12)	4.46 (0.18)	-0.12 (-0.90, 0.66)
12. A swelling of my body or parts of my body	3.46 (0.26)	3.30 (0.28)	3.77 (0.23)	3.92 (0.31)	-0.57 (-1.37, 0.23)
13. An urge to urinate	3.61 (0.36)	3.23 (0.32)	3.66 (0.41)	4.00 (0.27)	-0.71 (-1.51, 0.09)
14. Tremor in my hands	3.53 (0.29)	3.15 (0.29)	2.92 (0.33)	3.00 (0.30)	0.14 (-0.64, 0.92)
15. An urge to defecate	2.92 (0.43)	2.92 (0.36)	2.30 (0.26)	2.46 (0.27)	0.39 (-0.40, 1.18)
16. Muscle tension in my arms and legs	4.38 (0.18)	4.15 (0.25)	4.30 (0.23)	4.07 (0.26)	0.08 (-0.70, 0.86)
17. A bloated feeling because of water retention	3.46 (0.38)	3.15 (0.46)	3.15 (0.40)	3.30 (0.34)	-0.10 (-0.88, 0.68)
18. Muscle tension in my face	3.92 (0.26)	3.23 (0.36)	3.83 (0.27)	3.38 (0.31)	-0.12 (-0.9, 0.66)
19. Goose bumps	3.07 (0.36)	2.61 (0.33)	3.38 (0.29)	3.15 (0.35)	-0.43 (-1.22, 0.36)
20. Facial twitches	3.23 (0.34)	2.84 (0.33)	2.92 (0.38)	2.53 (0.40)	-0.52 (-1.31, 0.27)
21. Being exhausted	4.83 (0.11)	4.53 (0.24)	4.75 (0.18)	4.77 (0.12)	-0.35 (-1.14, 0.44)
22. Stomach and gut pains	3.61 (0.29)	3.15 (0.33)	2.91 (0.28)	3.00 (0.30)	0.13 (-0.65, 0.91)
23. Rolling or fluttering my eyes	2.53 (0.40)	2.07 (0.36)	2.00 (0.34)	2.30 (0.39)	-0.16 (-0.94, 0.62)
24. Stomach distension or bloatedness	3.77 (0.30)	3.46 (0.38)	3.84 (0.29)	3.46 (0.18)	0 (-0.78, 0.78)
25. Palms sweating	2.61 (0.35)	2.54 (0.31)	2.46 (0.37)	2.46 (0.37)	-0.05 (-0.73, 0.83)
26. Sweat on my forehead	3.00 (0.34)	2.84 (0.31)	2.58 (0.33)	2.46 (0.35)	0.31 (-0.48, 1.10)
27. Clumsiness or bumping into people	3.84 (0.31)	3.53 (0.29)	3.30 (0.26)	3.30 (0.26)	0.23 (-0.55, 1.01)
28. Tremor in my lips	2.54 (0.33)	2.41 (0.33)	2.38 (0.41)	2.30 (0.41)	0.08 (-0.72, 0.88)
29. Sweat in my armpits	3.30 (0.32)	2.84 (0.37)	3.16 (0.32)	2.92 (0.26)	-0.07 (-0.85, 0.71)
30. Sensations of prickling, tingling, or numbness in my body	4.46 (0.14)	3.92 (0.26)	4.46 (0.14)	3.84 (0.25)	0.08 (-0.70, 0.86)
31. The temperature of my face (especially my ears)	3.15 (0.33)	3.00 (0.32)	3.00 (0.34)	2.77 (0.30)	0.20 (-0.58, 0.98)
32. Grinding my teeth	3.92 (0.33)	3.61 (0.33)	3.84 (0.29)	3.46 (0.43)	0.10 (-0.68, 0.88)
33. General jitteriness	4.15 (0.19)	4.00 (0.22)	3.69 (0.17)	3.69 (0.28)	0.33 (-0.46, 1.12)
34. Muscle pain	4.69 (0.17)	4.53 (0.24)	4.77 (0.12)	4.61 (0.14)	-0.11 (-0.89, 0.67)
35. Joint pain	4.92 (0.07)	4.46 (0.24)	4.69 (0.17)	4.41 (0.15)	0.07 (-0.73, 0.87)
36. Fullness of my bladder	3.77 (0.20)	3.46 (0.27)	4.08 (0.26)	3.61 (0.38)	-0.12 (-0.90, 0.66)
37. My eye movements	3.07 (0.33)	2.46 (0.35)	3.00 (0.48)	2.16 (0.40)	0.22 (-0.58, 1.02)
38. Back pain	4.69 (0.23)	4.69 (0.23)	4.54 (0.18)	4.77 (0.12)	-0.12 (-0.90, 0.66)
39. My nose itching	3.69 (0.28)	3.00 (0.32)	2.69 (0.39)	3.38 (0.36)	-0.30 (-1.09, 0.49)
40. The hair on the back of my neck "standing up"	2.84 (0.49)	2.38 (0.38)	2.61 (0.44)	2.23 (0.39)	0.10 (-0.68, 0.88)
41. Needing to rest	4.69 (0.13)	4.46 (0.18)	4.69 (0.17)	4.77 (0.12)	-0.55 (-1.35, 0.25)
42. Difficulty in focusing	4.61 (0.14)	4.38 (0.21)	3.92 (0.28)	4.54 (0.18)	-0.22 (-1.00, 0.57)
43. An urge to swallow	3.50 (0.33)	3.15 (0.25)	2.92 (0.31)	2.84 (0.33)	0.29 (-0.50, 1.08)
44. How hard my heart is beating	3.84 (0.22)	3.38 (0.18)	3.66 (0.18)	3.54 (0.29)	-0.18 (-0.96, 0.6)
45. Feeling constipated	4.15 (0.27)	3.92 (0.24)	3.23 (0.38)	3.46 (0.33)	0.44 (-0.35, 1.23)

Results reflects a slight decrease in almost all of the questions evaluated in the group subjected to tactile discrimination. Data is presented as mean (SEM) for the group exposed to tactile stimulation alone and the group exposed to tactile discrimination for day 1th and day 21th (before and at the end of the programme respectively), and Cohen's d (95% CI) is provided as a measure of effect size between the two groups on day 21.

changes in the somatosensory cortex organisation with a distortion of the body schema (4, 27, 28). This alteration correlates positively with the pain perceived and negatively with tactile acuity measures in patients who suffer from chronic pain (20, 29, 30) and also in FM (8, 9). Furthermore, it is widely known that during the execution of tasks in tactile discrimination, cortical reorganisation of S1 and S2 areas occurs along with increased tactile acuity (20, 28, 30-33). Here, we recorded substantial improvements in all tactile acuity variables (especially in the TPD) in FM patients exposed to tactile discrimination procedure, understood as an online modulation of the somatorepresentation in their distorted body schema. However, how does the body schema modulate pain perception? Several studies have reported that rehabilitation of tactile acuity can reduce pain in patients suffering from complex regional pain syndrome (CRPS), chronic low back pain or phantom limb pain (20, 32, 34-36). In the present work,

we showed a decrease in pain perception, especially in the stimulated body area, but only after applying the tactile discrimination protocol. Namely, we have registered that tactile stimulation alone cannot improve the pain perception despite registering an increase in tactile acuity. In addition, we have observed a pain decrease in remote areas of the body according to the location of the stimulus, *e.g.* a reduction of 9.2% in pain perception at the knees or 11.3% at the wrists. Based on these findings, the data suggest that the modulation of the body schema is supported by focused attention on tactile discrimination perception. In fact, several studies have reported that focused attention, among other aspects, relieves the pain perception (37-39), which does not happen when analgesia is recorded by the placebo effect (40). Moreover, therapeutical strategies aimed at modifying attentional biases prioritising peripheral afferent information, such as neurofeedback, significantly reduced the clinical pain perception in FM patients (41, 42). It is known that attention-related alterations in pain-evoked activity in the insular cortex correlated with activity in the superior parietal cortex (Brodmann area 7 (B7) (43).

No change in perceived body dissatisfaction

Extensive literature attests the existence of body image disorders in patients who suffer from chronic pain, and among other aspects, the FM patient is characterised by body dissatisfaction (8, 44, 45). Here, we found on the 35-item Body Esteem Scale low levels of satisfaction across the vast majority of body regions addressed in FM patients. Low body esteem indicated overall negative body perceptions and distorted body image in FM patient (8), and interestingly, although the tactile acuity is improved after the protocol, we did not find significant differences on BES scores. Furthermore, pain severity and negative body perception are correlated in patients with FM (8, 46), particularly in the body site regarded as the primary focus of ongoing clinical pain (8), and we have found that perceived pain decreased but body dissatisfaction did not change. Body image distortion is driven not only by body dissatisfaction but also by sensory inputs. For example, tactile body image disturbance is reported in anorexia nervosa, in which body dissatisfaction has a main role in the disorder (47-49) or in patients who suffer from FM (8). Therefore, taking the present results together, we suggest that body dissatisfaction is not malleable although the somato-sensory component of the body schema is being modulated. An explanation is that the bias towards body image is associated with the emotional-affective component of the experience of pain (47, 50) and not at all with the somato-sensory component or at least, in a strict way, and because of that, we do not appreciate better scores in the degree of body satisfaction during the improvement of tactile acuity and pain perception.

Decreased interoceptive awareness

Interoceptive awareness can be defined as the ability to become aware of internal body changes in response to internal and external stimuli (51, 52-54). In the aetiology and maintenance of persistent pain, interoception has a relevant role and is involved in the perception of pain (29, 55, 56). Patients with FM syndrome usually report difficulties in switching off from their body sensations and also in focusing on a specific task (57, 58-60). Nevertheless, we have shown a decreased interoceptive perception after a tactile acuity improvement, supporting the notion that awareness of internal bodily cues is decreasing in line with increasing tactile acuity. Moreover, the interoceptive awareness is related to a lower pain threshold and lower pain tolerance (61, 62) and we found that the general pain perceived decreased at the same time that the interoceptive awareness decreased. In line with this, several studies have shown tasks related to tactile acuity improvement that decrease the attention on physical body sensations. This fact could decrease pain hypervigilance (63-65) which is associated with greater clinical pain in FM (66) and not circumscribe increased attention to painful inputs but rather represent a generalised, perceptual style of amplification of a wide variety of sensory information (67, 68) including interoceptive awareness (8). Further, it is known that interoceptive awareness modulates the online integration of multisensory body stimuli (69) and can modify the body representation generated from exteroceptive information in FM patients (69). In this sense, our data support that tactile acuity and interoceptive body awareness are related. Moreover, the present results show for the first time that exteroception modulates interoception in FM patients. We suggest that the updating of somatosensory representation would lead to an attentional deficit to internal perception, interpreted here as a decrease in a general hypervigilance in FM subjects. That is, the changes in the body schema readjust interoceptive sensitivity in terms of mutual modulation between tactile and interoceptive perception and the decrease in hypervigilance diminished the pain perceived.

Limitations

Some limitations of this study need to be highlighted. First, in this pilot study a larger sample size could transform our improvement trends in terms of pain perception in statistical significance. However, the sample size was enough to explain the main tactile acuity variable that was the Two-point Discrimination Threshold (measured by the GRANMO calculator, described in the methods section). Second, we have not used a standardised questionnaire or scale to measure the attention in both experimental groups. However, in the tactile stimulation alone group (control group) they had to count the number of stimulations in order not to concentrate on the discrimination of the stimulus (location of the stimulus, probe's size). Conversely, in the tactile discrimination group an improvement in tactile acuity variables has been shown, which means that the subject exposed to these stimuli, paid enough attention to discriminate tactile acuity tasks. In order to pay attention, they had to visualise and identify the graphic character, locate the stimulus on a map of the cervical region and estimate probe size.

Conclusion

In conclusion, the principal outcome of this study suggests that the somatosensory component of pain experience in FM patients is malleable by updating the somatosensory cortex throughout an improvement in tactile acuity. Conversely, body dissatisfaction seems to be stable and was not found to be modified in a short-term trial as it was in the findings of this work. In addition, changes in body schema readjust the interoceptive awareness, decreasing the impact of the pathology and enhancing the therapeutic effect of the somatosensory dimension. The results show that tactile stimulation with attention focused on discrimination and its mental visualisation patterns (graphesthesia) can modulate the body schema. These adjustments in the body schema may activate the descending pain-control pathway in FM patients.

Self-management is an important component of the overall management strategy for people with long-term pathologies. Future recommendations are needed for pragmatic trials to assess the clinical effectiveness of a body schema intervention, so that an appropriate translation of research into practice can be made.

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