Central pain sensitization is a common manifestation of long-standing psychosomatic pain, which increases the risk of developing pain spread and fibromyalgia [10]. An increased deep pain sensitivity in patients with persistent musculoskeletal pain has been shown, but not in regular recurrent pain patients or in acute pain [11]. A possibility for muscular psychosomatic pain is a lowered pain threshold *via* hyperalgesic priming elicited by stress [12].

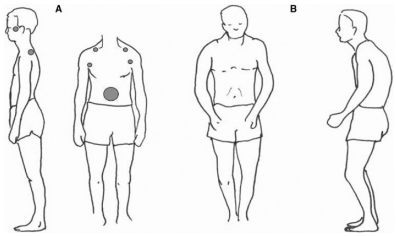

Figure 1: Stress tender points and typical startle reaction position. (A) From a photo of an adolescent with long-standing recurrent psychosomatic pain. Typical stress tender point pattern shown as grey dots, cf. (B) Hunt and Landis classical picture from 1936 of a person in startle after unexpected pistol shot near the ear with a typical crouch, cf Figure 1A.

The nipping test is a standardized easy examination, for which no equipment is needed, to test for of allodynia in the cutis and sub cutis, a sign of sensitization. This test can be executed in less than a minute in the clinic practice. A low level of pressure, which would not normally elicit pain, is applied by nipping a layer of a small area of the cutis/subcutis between the thumb and index finger, with nails cut short; see Figure 2 . The nipping test has been validated for recurrent psychosomatic abdominal pain [4]. The subcutis is easily distinguished from the underlying muscles by the muscle fascia. The pressure applied is calibrated to be not higher than approximately 125 kPa/cm2 by using an algometer; a pressure below the normal pain threshold [9]. A pressure below pain threshold to be applied on the Nipple test can be found in a more practical way, but less scientific, by nipping a person without pain problems, i.e. the physician him/herself.

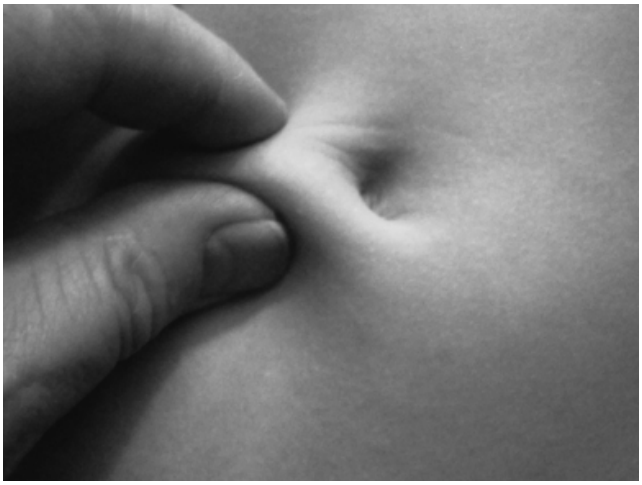

Figure 2: Photograph showing the nipping test for allodynia in the cutis/subcutis near the navel.

AN EPIDEMIC ASPECT

Two or several pains in one and the same person is common found among children with psychosomatic pain pointing at a common central origin [2,3,8,13]. One central mechanism for the recurrent psychosomatic pain is the startle reflex, which has been documented in an EMG-study, se next paragraph. In the exploration for the origin of pain, the result of multiple locations, related to muscle activated by the startle reflex, may support for an etiology of negative stress. The startle reaction affects muscles in the head, temporal region, neck, shoulder, abdomen and back.

An EMG study presented below supports the clinical hypothesis that the startle reflex is the pathophysiological mechanism behind the pattern of tense and tender muscle and the recurrent pain [2].

A case–control study, 21 matched healthy controls (CON) were compared to 19 children fulfilling the criteria for psychosomatic pain (PAIN). These children had a pain duration in mean of 37 months. All reported recurrent headache, 18 abdominal pain, five backache and three shoulder pain.

The acoustic startle reaction was elicited by a short signal of white noise of 105 dB *via* ear-phones on eight occasions, and the response measured with electromyography (EMG). The muscles studied were the orbicularis oculi, temporal, trapezius, great pectoral near shoulder, abdominal wall near the umbilicus and the lumbar erector spine, that is sites for recurrent pain and stress tender points (Figures 2 and 3). All but one of the children had nine tender points, the exception having seven [9].

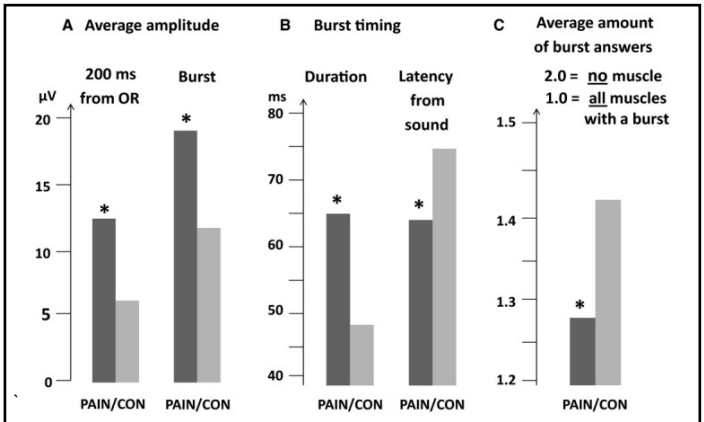

Figure 3: Average for all eight startle sound events together, including all six muscles, for: (A) Mean amplitude during 200 ms from OR-activity-start and during burst, (B) Burst duration and -latency (ms) from sound to muscle-activity-start (≥ 10 µV), (C) Average amount of bursts:–mean of 1.0=all muscles burst (peak ≥ 10 µV) and 2.0=no muscle had burst (peak ≥ 10 µV) in any of the eight stimuli. PAIN versus CON showed significant differences (star*). [OR, orbicularis occuli, ref. 2].

The Pain group showed significantly higher resting activity and higher acoustic startle response values ($p<0,05$), than the CON group, for all six muscles together regarding the mean amplitude in the initial 200 ms, and during the burst of activity (start ≥ 10 µV, end<10 µV), as well as longer burst duration and shorter burst latency (ms). These results are based on average for all

eight startle sound events (ASR) together. For PAIN compared to CON, all separate muscles showed generally higher values of EMG amplitudes and burst durations as well as shorter latencies for the burst onset in all measures; with statistically significant differences or strong trends for several parameters and muscles [2].

Stress, increased muscle excitability, brain regions, pain and its relation to the startle reaction

An increased excitability in the α-motor neurons in the spinal cord can be due to supraspinal projections, and also by higher γ-motor activity and muscle-spindle input (Ia, II) and other afferents (III, IV) contributing to chronic hyper tonicity and pain [14-18]. Here, stimulus from by different local chemo-nociceptors may contribute (i.e. prostaglandins, bradykinin, arachidonic acid, lactic acid and potassium).

In chronic muscular pain, mental stressors can cause long-lasting hypersensitivity of nociceptors in reaction to a subsequent exposure to a low concentration of inflammatory mediators [12]. An investigation in rat revealed that unexpected short white noise at 105 dB, the same as utilized in our study [2], elicits hyperalgesic priming in the masseter muscle, known to be a part of the startle response. This will lower the pain threshold [19]. *Via* CNS feedback loops, such lowering of pain threshold can heighten the level of muscle activity and promote startle reactions.

Increased muscle excitability/tension seems to have a central role for the origin of recurrent pain of stress origin [2]. An important stress center in the brain, the amygdala, can be activated by mental stress from the anterior cingulate cortex, which is a neurobhiological center for behavior and motivation [20]. Thus, chronic stress may cause an increased neuromuscular excitability (both under resting conditions and during provocation tests such as the startle reflex) *via* altered descending neural activity from higher brain centers such as the anterior cingulate cortex and the amygdala [2, 20, 21].

Thus, the increased neuromuscular tension and excitability in children exposed to persistent stress with repeated pain can be caused by change of activity in a variety of brain regions. Prolonged stress has been described to make amygdala overactive and reduce the prefrontal cortex control over amygdala [22]. Also, the thalamo-amygdala and cortical regions can be involved in a dynamic interplay, which can be disturbed, seen similarly in different neuropsychiatric syndromes [23]. Consequently, various repetitive and prolonged stressful events have been described to be related with changes of activity, connectivity and size in various brain regions [8].

HORMONAL DEVIATIONS

Oxytocin is significantly lowered according to two studies [6,24]. Here we report about 32 children 6-15 years old with psychosomatic abdominal pain had a mean oxytocin concentration of 30.5 pmol/L (95% confidence interval 24.6–36.5), which was significantly lower than the control mean of 45.0 pmol/L (41.6–48.4), ($p<0.0001$)

Cortisol is significantly increased according to two studies with 17 respectively 35 children and when added together we found that the 52 children with psychosomatic pain had in mean a cortisol concentration in saliva 12.2 (3–42.7) n-mol/L and 296 controls in mean 8.5;(1.8–83.1) n-mol/L which was significant $p<0.0001$ (5). The decreased oxytocin and the increased cortisol are in accordance with right brain dominance in stress [20].

Antinociceptive fatty acid patterns differ in children with psychosomatic recurrent abdominal pain and healthy controls. This was shown in a study where 22 children 6-16 years were compared to a control group of 100 children [25]. Omega-3 was lower resulting to a higher ratio arachidonic acid to eicosapentaenoic acid despite lower arachidoic acid $p<0.001$ [25]. The deviations of the phospholipids omega-3 and omega-6 found in this study may be of importance for pain mechanisms in psychosomatic recurrent abdominal pain.

TREATMENT

We have done three treatment studies [4,26,27]. In the second study children had recurrent psychosomatic pain since 28.9 (3–108) months and number of pain locations with a mean=2.5 (range 1–5). In this study clinical signs of activated startle reaction secondary to stress, the nine stress TP, as well as tender points fibromyalgia were studied at time zero and at follow up after one year. The children underwent treatment by a physiotherapist with psychosomatic education and experience. Before treatment stress TP was in mean 8,6 out of 9 and fibromyalgia TP was in mean 10,4 out of 18. At follow up 1 y 25 out of 44 were pain free with significant reduced tender points, for stress TP 2,8 and fibromyalgia TP 2,1.

DISCUSSION

Our experience is that in severe psychosomatic state there is a sever risk of developing fibromyalgia. This indicates that early detection of recurrent psychosomatic pain is need to prevent fibromyalgia with serious consequences.

Treatment recommended for psychosomatic pain is based on a shared knowledge between the physician/caregiver and the patient including members of the family, of the relation between negative stress and psychosomatic symptoms. The mechanism how stress causes muscular tension, pain, hormonal deviation, and effects on emotional and cognitive processes are clarified. The stress tender pattern in the affected child is demonstrated, and the family gets a concrete picture and a better understanding of the stress reaction and how it affects the body.

How to get stress reduction and improved stress-handling are clarified. Guidance for a shift from right to left dominance in the bicameral brain with improved breathing, relaxation and release of startle tensions in muscles is given. A special trained physiotherapist or psychologist in psychosomatic treatment is often needed [27].

CONCLUSION

Observation Depression, attention deficit disorder and other neuro-psychiatric disorder often increase the susceptibility and

the risk for stress and psychosomatic disorder. Our experience is that if treated as described in reference 4 and 26 the prognosis with treatment is good in most cases not affected by fibromyalgia.

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