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34

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PHYSIOLOGY: RESPIRATION AND PAIN

Pain and faulty breathing: a pilot study

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Abstract The purpose of this pilot study was to observe both relaxed and deep breathing patterns in a convenience sample to determine the incidence of normal versus faulty patterns of respiration. These observations were then combined with respondent answers to a survey on pain history to determine if there is any correlation between faulty breathing and musculo-skeletal pain patterns. If such a correlation can be made, then we propose that clinicians working with chronic pain patients may have improved outcomes if they address and correct faulty breathing patterns. Based on this study, it is suggested to include the evaluation and treatment of faulty respiration in the rehabilitation of chronic musculo-skeletal conditions, most notably cervical pain.

Introduction

Breathing with normal respiratory mechanics has a potent role in the neuro-musculo-skeletal system. Respiratory mechanics play a key role in both posture and spinal stabilization. Far beyond simply breathing correctly while performing a stabilization exercise; respiratory mechanics must be intact for both normal posture and spinal stabilization to be possible. In essence, the dynamic interaction between the key muscles of respiration must be functioning normally and most importantly, a normal motor program for respiration must be cortically set in the nervous system.

Chaitow, Bradley and Gilbert state, "Nowhere in the body is the axiom of structure governing function more apparent than in its relation to respiration. Ultimately, the self-perpetuating cycle of functional change—creating structural modification—leading to reinforced dysfunctional tendencies can become complete, from whichever direction dysfunction arrives." (Chaitow et al., 2002).

Breathing mechanics are influenced directly by

- Bio-mechanical factors such as rib head fixations or classical upper/lower crossed patterns of muscle imbalance.
- Biochemical factors involving anything that affects the body's delicate pH balance including allergy, infection, poor diet, hormonal influences or kidney dysfunction.
- Psychosocial factors such as chronic anxiety, anger or depression.

The important link respiration has with health lies in its role as a doorway to the autonomic nervous system. One explanation is the essential function CO^2 has in maintaining the body's acid-base balance. Subtle changes in the acid-base

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51

balance can have tremendous effects on the endocrine and immune systems, muscle function, pain perception and emotional lability.

The body will increase or decrease respiration to compensate for changes in pH. For example, ketoacidosis, a byproduct of a very popular diet which promotes high protein/low carbohydrate intake, increases the acidic state of the blood which will promote deeper, faster breathing (the higher CO^2 content stimulates the breathing drive). Corrective over-breathing is also commonly seen after the acidosis that results from prolonged diarrhea or as a response to increased progesterone levels. Use of steroids and diuretics as well as excessive vomiting causes alkalosis which suppresses the breathing drive in an attempt to bring the pH back to a normal level (Chaitow et al., 2002).

Habitual chronic over-breathing (hyperventilation) increases the amount of carbon dioxide (CO^2) exhaled, leading to respiratory alkalosis. Alkalosis causes a decrease in the threshold of peripheral nerve firing, an increase in muscular tension, muscle spasm, spinal reflexes and significantly heightened perception of pain, light and sound. Alkalosis can also result in emotional lability and produce a sense of apprehension and anxiety that frequently leads to panic attacks and phobic behavior (Chaitow et al., 2002; Chaitow, 2000).

Review of respiratory mechanics

The primary muscles responsible for respiration are the diaphragm, inter-costal muscles, scalenes, transverse abdominus, muscles of pelvic floor and the deep intrinsic muscles of the spine (Acland, 1998; Hruska, 1997). Each of these muscles, in addition to respiration, serves a dual role in postural function as a core stabilizer. The scalene muscles lift and expand the rib cage during inspiration and are active at a low level during every inspiratory effort and are therefore considered a primary, not an accessory muscle (De Troyer and Estenne, 1984).

Minor activity of the scalenes occurs with even a light breath, but more obvious visual and palpable activity occurs when demand is increased (De Troyer and Estenne, 1984). The scalenes and accessory muscles including the SCM and upper trapezius musculature are activated normally upon high levels of ventilatory demand or at high lung volumes such as in hyperinflation (Gray's, 1995).

During inspiration, the diaphragm contracts, the central tendon becomes more fixed as the dome flattens and moves downwards. This increases the pressure in the abdominal cavity while decreasing its volume and causes the vaulting outward of the abdominal wall (Kendall and Kendall, 1993).

With continued contraction, the vertical fibers attached to the lower ribs expand them open in a horizontal direction commonly termed "bucket handle" motion (see Figs 1 and 2). The dimensions of the thorax are enlarged in all directions as in the filling up of a balloon. With each normal (resting) breath this bucket handle movement occurs at every rib level, which has a gentle micro-massaging effect maintaining healthy spinal movement, blood and nutritional flow to the musculo-skeletal structures.

Movement of the upper ribs develops in the last phase of inspiration and is commonly known as "pump handle" motion (see Fig 3). The parasternal and scalene muscles play an important stabilizing role during inspiration to counteract the expiratory action of the diaphragm on the upper rib

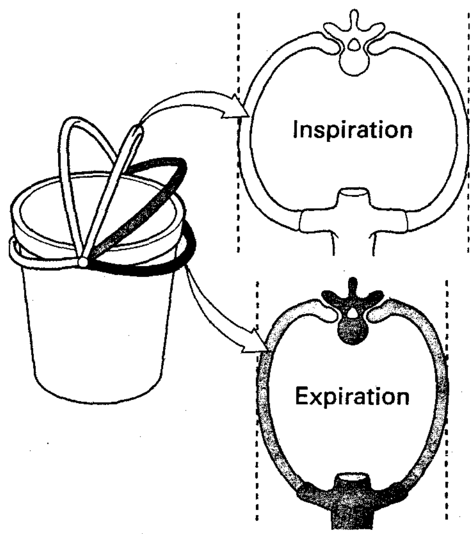

Figure 1 Normal bucket handle motion of the lower ribs during respiration. Note the horizontal widening during inspiration.

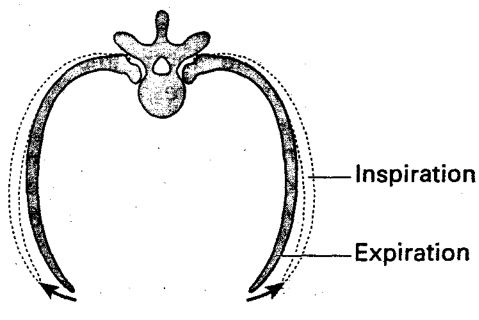

Figure 2 Horizontal motion (widening) of the lower ribs during respiration. Note the horizontal widening during inspiration.

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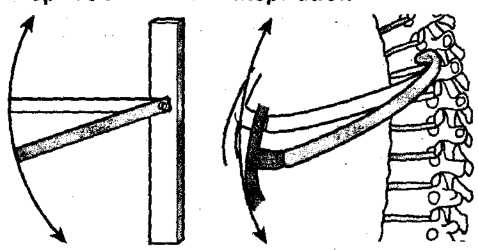

Figure 3 Normal pump handle motion of the upper ribs during respiration. Note the normal expansion during inspiration.

cage. As the diaphragm descends, it decreases the pleural pressure necessary for inspiration. The decrease in pleural pressure is greatest in the cephalad regions around the apex of the lung. If unopposed by the contraction of the para-sternals and scalenes, the upper rib cage moves inward in the direction that is reflexive of expiration (De Troyer and Estenne, 1985). Normal movement in the upper ribs is an integral part of normal respiration and varies in response to the intensity of imposed physical demand. Recruiting the scalenes and the accessory muscles is normal as physical demand increases. Upper chest lifting is not normal during relaxed breathing, where a fanning open motion should be observed.

The faulty pattern of lifting up of the sternum vertically during inspiration, instead of widening in the horizontal plane, occurs due to bilateral overactivity in the scalene, trapezius and levator scapulae musculature. This faulty pattern termed "chest breathing" (see Fig. 4) is the most common fault in respiration. Chronic cervical overstrain, diminished activity of inter-costal muscles and reduced rib motion commonly results. Although the pectoralis major, pectoralis minor, latissimus dorsi, serratus anterior and trapezius are not typically considered accessory respiratory muscles, they assume a more respiratory than postural function in the dysfunctional or paradoxical breather and contribute to the faulty pattern of lifting the ribcage up during inspiration (Hruska, 1997).

When chest lifting becomes a faulty breathing pattern, chronic lifting of the clavicles creates the appearance of deep clavicular grooves as seen in Fig. 5 (Lewit, 1999).

During expiration, the reverse occurs as in inspiration. In quiet respiration, expiration is produced passively by elastic forces from the abdominal wall, costal cartilages and lungs. The diaphragm relaxes and ascends. The abdominal wall is drawn in toward the spine and the ribs and

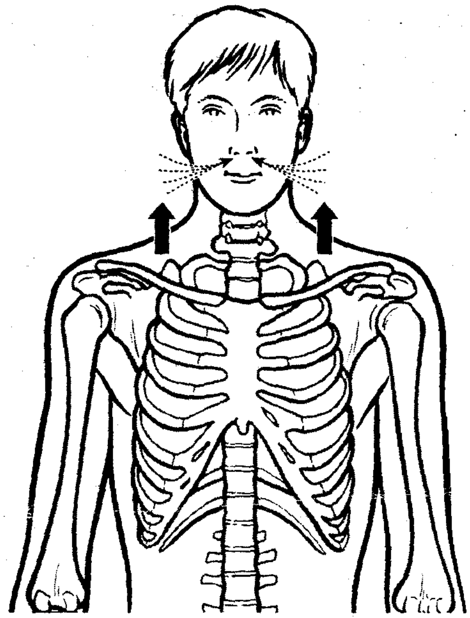

Figure 4 Faulty pattern of "upper chest" breathing. Note the vertical lifting of the chest and rib cage.

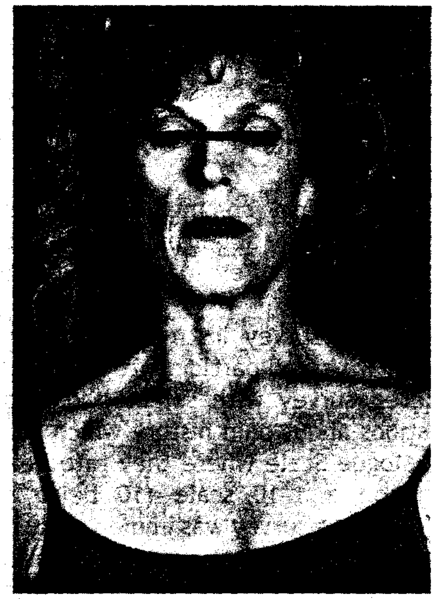

Figure 5 Deep clavicular grooves resulting from chronic faulty upper chest breathing with clavicals that are lifted vertically and overact SCM, trapezius and scalene musculature.

thorax move down and in. Expiration is faulty when the breath is held and not fully exhaled, rib motion is reduced or paradoxical breathing occurs.

The most severe dysfunction is paradoxical breathing, where the abdomen is drawn in during inhalation and out during exhalation. It may occur as a temporary reaction when bracing for anticipated action. The chronic pattern may be related to stress, severe COPD or simply result from the habit of holding the abdomen rigid in an attempt to have the appearance of a flat stomach.

Primary respiratory faults:

(a) Chest movements predominate.
(b) Lifting "up" motion of the upper chest during inspiration occurs.
(c) Absence of or lifting up motion of the lateral ribs occurs.
(d) Abdominal movement is rigid or paradoxical.

The purpose of this study

The purpose of this pilot study was to observe both relaxed and deep breathing patterns in a convenience sample to determine the incidence of normal versus faulty patterns of respiration. These observations were then combined with respondent answers to questions about respiratory health and pain history to determine if a correlation could be made between faulty breathing and musculo-skeletal pain patterns.

Methods

Survey instruments

Members of a local community were asked to participate in a study about pain that involved a 4 page survey and a brief evaluation. Respiration was not mentioned.

We used two survey instruments for the pilot study. First, we asked participants to fill out a self-administered survey with selected demographics and questions about pain history which included a Visual Analogue Scale where they rated each pain complaint on a 1–10 scale (10 being severe). Completion of the survey was immediately followed by a brief physical exam executed in the following manner. While the participant was standing, relaxed respiration was first observed without awareness by the participant that the exam had begun. The participant was then asked to take several normal breaths in and out. Next, he or she was asked to take several long, slow breaths in and out. No distinction was made between nose and mouth breathing. Abdominal and chest breathing were assessed by observation only. Abdominal versus chest initiation of inhalation was noted as well as the presence of upper chest lifting and clavicular grooves. Lateral rib expansion was assessed by observation as well as light palpation and no motion, normal motion or lifting motion was noted. All testing was done by a single skilled examiner who was unaware of the responses to the self-administered survey.

Determining an ideal test position

During a validation of the physical exam testing procedure, 15 participants, ages 12–67, were examined in three positions: supine, seated, and standing. The goal was to determine the ideal test position for the pilot study. Although less movement was observed in the standing position due to the postural reaction to gravity, there was no difference in the incidence of normal versus faulty breathing in the different positions with the exception of six yoga students. All six students regularly practiced breathing exercises in the supine position. All had normal respiratory patterns in the supine position and abnormal respiratory patterns in the seated and standing positions. It was a poignant lesson that, ideally, assessment must be made in various positions. However, for ease of evaluation during the pilot study, because breathing exercises are rarely practiced in standing positions, and because subtleties of "minor" dysfunction are less observable in standing than supine positions, the standing position was chosen for this study.

Participants

One hundred and eleven (111) members of a local community were asked to participate in the pilot study and made up a convenience sample. Of these, 94 participants fully completed the self-administered survey and physical exam and were used in the correlational calculations. In total, 68% of the participants were women and 32% were men. The overwhelming majority (97%) was Caucasian, 2% was African American, and 1% was Hispanic. Ages ranged from 11 to 80 years old. See Fig. 1 for the age distribution.

Variables of Interest

From the survey

The self-administered survey captured information on musculo-skeletal pain patterns for the head, neck, middle back, lower back, buttocks, arms (radiating to hand), and legs (radiating to foot). Participants who were currently experiencing one of these pains were asked to report on the start of the current episode—within the past week, 1 to 6 weeks ago, 6 weeks to 3 months ago, 3 months to a year ago. Participants who reported having had the pain in the past were asked about total number of episodes (1 to 3, 4 or more) and when in life the first symptoms appeared (less than 6 months ago, 6 months to a year ago, more than a year ago). Levels of pain were recorded on a scale from 0 (no pain) to 10 (unbearable pain) for pain at the moment, on average, at best, and at worst. This information was combined to create a scale of "Total Pain" for participants (on a scale from 0 to 40). Finally, a variable of "Average Pain" was created by dividing total pain by four (for the four different scales used).

Defining "normal"

In order to evaluate the data collected, it was important to define normal verses faulty motor patterns of respiration. There are numerous variables and no widely accepted standard of normal, so we created a simplified rating system based on the following accepted beliefs:

1. Abdominal, not chest breathing should initiate inhalation.
2. Lifting the chest "up" is faulty.
3. Lack of or a lifting "up" motion of the lateral ribs is faulty.
4. Chronic chest lifting will result in clavicular grooves.
5. Paradoxical breathing is faulty.

(Acland, 1998; Hruska, 1997; Kendall and Kendall, 1993; Lewit, 1980, 1999; Travel and Simons, 1992) (Fig. 6.)

The same criteria were applied for normal (relaxed) breathing as for deep breathing. A "normal" breath according to these criteria would:

1. Initiate in the abdomen, which would expand outward during inhalation and inward during exhalation.
2. Have some degree of horizontal lower rib motion (even if slight).
3. Have no lifting up motion in the upper ribs.
4. Have no clavicular grooves.

From the physical exam

During the physical exam, the following observations were recorded as dichotomous variables for both relaxed (normal) and deep breathing: (1) upward or absent lateral rib motion; (2) lifting of the collar bones; (3) deep clavicular groves and/or paradoxical breathing.

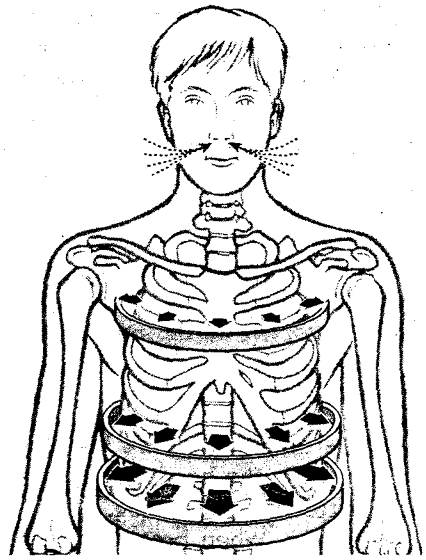

Figure 6 Normal pattern of inspiration. Note the expansion, like a balloon in all directions initiating in the abdomen, moving to the lower ribs and then in the upper chest.

Because upward or lack of lower lateral rib motion is a mild finding of faulty breathing, lifting the collar bones is a moderate finding, and deep clavicular grooves and/or paradoxical breathing are a severe finding, the observations were also coded on an ordinal scale (1, 2, and 3, respectively.) Two variables were then created to capture the degree (from 0 to 6) of faulty breathing for both normal and deep breaths. For example, if a participant had only upward or absent lateral rib motion, she would score a 1. If she had upward rib motion and deep clavicular grooves, she would score a 4 on the scale. Finally, a variable was created by adding the scores of the previous two variables together, to create a scale of "Total Faulty Breathing" for participants (from 0 to 12.)

Analysis

Statistical analysis was performed using SPSS 10.1 software. First, descriptive statistics were analyzed to determine the prevalence of pain and faulty breathing in the participants. Next, relationships between each specific musculo-skeletal pain and faulty breathing patterns were explored using Pearson's correlation coefficient. This analysis highlighted one particular pain as especially problematic. For that specific pain, chi-square tests were conducted to test for independence and Pearson's r tests were used to measure the strength of relationships between levels of pain and degrees of faulty breathing. Finally, regression was performed on the simplified linear expression:

Total Faulty Breathing (Relaxed + Deep) = Average Pain + Current Neck Pain + Past Neck Pain + Number of Episodes of Neck Pain + When in Life First Symptoms Appeared

Results

Descriptive statistics

Pain. Of our participants, 87.2% had experienced some kind of pain in the head, neck, middle back, lower back, buttocks, arm, or leg.

Faulty breathing. When breathing was relaxed, 56.4% exhibited faulty breathing. The total increased to 75% when participants were asked to take a deep breath. Table 1 presents cross-tabulations of these results broken down further by type of pain and selected demographics.

Correlations with faulty breathing

Specific musculo-skeletal pain

Only one type of pain had a statistically significant relationship with faulty breathing—neck pain (see Table 2 below). Further analysis with the χ^2-test produced a probability of $P = 0.039$, resulting in a rejection of the hypothesis that the two phenomena are independent at the $P<0.05$ level.

Characteristics of neck pain

Overall, faulty breathing was significantly (positively) correlated with six of the seven different characteristics of neck pain on which the participants were asked to report. Total faulty breathing (a measure of the severity of faulty normal and deep breathing combined) correlated with having neck pain at the time of participating in the study, having had neck pain in the past, the number of episodes of neck pain, the time in life that symptoms first appeared, and total neck pain (an additive measure of neck pain levels for pain at the moment, at best, at worst, and on average). Table 3 presents the correlation coefficients and significance level for each variable.

A linear model of neck pain

Only one variable was statistically significant in a linear regression test that modeled faulty breathing as a function of current neck pain, past neck pain, number of episodes of neck pain, when in life first symptoms appeared, and average pain. Average pain, with a coefficient of 0.420 and standard error of 0.188 was significantly correlated at the $P<0.05$ level. Thus, controlling for other factors, faulty

Table 1 Pain, faulty breathing, and demographic data.

	Percent of participants	Percent with faulty breathing
No pain	12.8	33.3
Musclo-skeletal pain		
Head (including migraines)	53.1	76.5
Neck	38.5	83.8
Middle back	30.5	75.9
Lower back	64.6	75.8
Buttocks	11.7	81.8
Arm (radiating to the shoulder or hand)	26.3	76.0
Leg (radiating to the groin or foot)	12.8	79.2
Demographics		
Men	33.3	64.5
Women	66.7	80.7
10–20 years old	9.5	55.6
21–30 years old	3.2	100.0
31–40 years old	15.8	73.3
41–50 years old	30.5	72.4
51–60 years old	22.1	81.0
61–70 years old	12.6	83.3
71 years and older	4.2	75.0

Table 2 Correlation between specific musculo-skeletal pain and faulty breathing (Pearson's *r*).

	Total faulty breathing
Headaches (including migraines)	0.009±0.108*
Neck pain	0.243±0.100†
Middle back pain	0.012±0.096*
Lower back pain	0.094±0.101*
Buttocks pain	0.082±0.099*
Arm pain (radiating to the shoulder or hand)	0.091±0.097*
Leg pain (radiating to the groin or foot)	0.143±0.101*

*Not significant
†$P<0.05$.

Table 3 Correlations between characteristics of neck pain and faulty breathing (Pearson's *r*).

	Total faulty breathing
Neck pain currently	0.218*
Length of current episode	0.151†
Neck pain in the past	0.247*
Neck pain current and past	0.255*
Number of episodes of neck pain	0.277‡
When in life FIRST symptoms encountered	0.238*
Total neck pain (Scale 0 to 40)	0.354‡

*$P<0.05$.
†Not significant.
‡$P<0.01$.

breathing increases by almost 50% when averaged neck pain experienced increases by a unit of one.

Discussion

Other research supports the high incidence of faulty breathing and it's effect on health. The incidence of breathing pattern disorders as a primary diagnosis in general internal medicine practice is reported to be up to 10% of all patients. (Chaitow et al., 2002) According to another researcher, there is a female preponderance in hyperventilation syndrome/breathing pattern disorder that ranges from 2:1 to 7:1 (Damas-Mora et al., 1980). Another study reported a series of 45 patients with chest pain who were ultimately diagnosed with hyperventilation syndrome after more serious pathology was ruled out (Newton, 2000).

Since the time of the Civil war a barrage of symptoms initially labeled "irritable heart", later in the 1940s called "soldier's heart" has been linked with hyperventilation and respiratory alkalosis. In the 1970s and 1980s breathing pattern disorders/hyperventilation syndrome was accepted in America as being of psychiatric origin (not tight jeans). Chest physician Claude Lum brought assessment and treatment programs in the 1970s and 1980s to the medical practitioners of the UK. Respiration training has growing acceptance in cardiac medicine for it is role to reduce "angina" symptoms (Chaitow et al., 2002). Karel Lewit for decades has been emphatic in his belief that "respiration must be corrected first, before other faulty movement patterns can be successfully addressed" (Lewit, 1980, 1999). To date, the key role that breathing pattern disorders play in musculo-skeletal pain syndromes is not well established in the literature.

Descriptive statistics

This study showed that 87.2% of the participants have experienced some sort of musculo-skeletal pain. This high percentage is no surprise. What was remarkable were the high percentages of this sample population with faulty breathing mechanics; 56.4% of the population studied had faulty relaxed breathing and 75% showed faulty breathing when taking a deep breath. The question that arises with such a high percentage of abnormal is whether the criteria for "faulty" is what is at fault. It must be pointed out that there is a wide spectrum of dysfunction from minor to major breathing pattern disorders that are included in this category of faulty breathing. Do we need to revise our criteria for normal versus abnormal because faulty patterns may be more common? Could these high findings simply be the result of examiner error?

Admittedly there are variables that have been omitted for simplicity of evaluation which could have effected these results; for example, nose and mouth breathing was not distinguished. Also, findings were scored separately, without consideration of their combined effect or lack of. Lack of lateral rib motion was scored the same whether abdominal breathing was normal or not, when clinically we would expect more correlation with to create muscle hypertonicity in a predicable pattern across the occipital ridge and across the trapezius musculature (Janda, 1990, 1978). These are normal reactions to stimuli which become problematic when they become ingrained in the nervous system and accessed even under relaxed conditions when the initial trigger is no longer present.

Characteristics of neck pain

Having pain currently, having had it in the past, and when in life first symptoms appeared all are correlated significantly with faulty breathing. It is no surprise that these factors would be significant. What's interesting is that the number of episodes (0.277) and the total pain score (0.354) were even more significantly correlated. The strengths of the relationships are strong; the number of 0.354 being considerable for a correlation coefficient. Also, the fact that average pain came out significant in the linear regression directly points to the fact that the *amount* of pain experienced directly impacted breathing patterns. This study clearly shows a correlation between high VAS ratings for neck pain and significantly "more dysfunctional" respiratory mechanics.

Conclusion

This study has shown that normal patterns of breathing are the exception rather than the rule. An overwhelming 75% of those studied exhibited faulty breathing mechanics. If the results of this study reflect the general population, as clinicians, your chances are 3 in 4 that the new patient you see today will have faulty breathing patterns. This really begs the question of "Is there a direct correlation between faulty breathing mechanics and the experience of pain". And an even more significant question of "Will correcting faulty breathing affect the experience of pain?"

The relationship between chest breathing and a history of chronic cervical pain was found to be statistically significant. What's interesting is that not a great number of people in our study experienced neck pain—only 38% compared to headaches at 53% and lower back pain at 65%. Still, the number of faulty breathers who had experienced neck pain was an overwhelming 83%.

Faulty respiration may also play a larger part in the perpetuation of middle and low back pain as well as radicular arm and leg pain than previously attributed. Based on this study, it can be suggested that evaluation and treatment of breathing pattern disorders must not be overlooked especially in the rehabilitation of chronic cervical pain.

Although interesting, this study has several key limitations. It was not designed or intended to be a reliability study. Its methods have no proven reliability. Future research is needed to validate the inter-examiner reliability of our methods of assessing breathing mechanics and our criteria of normal and faulty patterns of respiration. Research which explores the strong correlation between chronic neck pain and faulty breathing mechanics, especially in women is indicated. Outcome studies incorporating respiratory re-training along with manual medicine techniques in the treatment of chronic musculo-skeletal pain syndromes are also necessary.

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