5 DIAGNOSIS AND THERAPY OF DIAPHRAGM DISORDERS IN PATIENTS WITH OBESITY

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Every healthy individual performs approximately 20,000 respiratory movements within a day, primarily regulated by the diaphragm. This muscle is twice as vascularized as other striated skeletal muscles in humans and continuously functions from birth to death. Besides its respiratory role, the diaphragm plays a part in maintaining body posture, proper functioning of the vascular and lymphatic systems, and is involved in gastrointestinal activities such as swallowing, vomiting, acting as an anti-reflux barrier. The diaphragm influences the functioning of all abdominal organs (Bordoni et.al., 2016). The interdependence of the diaphragm with various structures in the human body results in dysfunctions leading to discomfort in different areas of the body.

5.1 Anatomy of the diaphragm

5.1.1 Diaphragm structure

The diaphragm constitutes a transverse partition dividing the torso into the chest and abdominal cavities. It has the shape of a dome, with its upper part forming the floor of the pleural cavity, and its lower part creating the vault of the abdominal cavity (Kokatnur, & Rudrappa, 2018).

The central part of this dome (the center of the diaphragm), situated highest in the chest, with fibres running horizontally, forms the central tendon composed of a fibrous layer that creates three leaflets (divisions): anterior (rich in lymphatic vessels), right lateral, and left lateral

The peripheral part of the dome consists of muscle fibres that are arranged radially around the chest. It is divided into sections:

- Sternal part: Connects to the xiphoid process of the sternum and the aponeurosis of the transversus abdominis muscle.
- Costal (lateral) part: Attaches to the cartilage of the sixth to seventh rib, interlocking with the attachments of the transversus abdominis muscle.
- Lumbar (posterior) part: Comprising two crura and arcuate ligaments:

- The right crus attach to the L1-L4 vertebral bodies, intervertebral discs, and the anterior longitudinal ligament. During growth, the right crus gives branches to the esophageal hiatus and serves as a natural element functioning as the sphincter of the cardiac orifice of the stomach.

- The left crus attach to the L1-L2 vertebral bodies and the anterior longitudinal ligament.

- The median arcuate ligament (lumbocostal arch) runs from the transverse process of L1 to the vertebral body, above the upper part of the psoas major muscle, connecting with its fascia.

- The lateral arcuate ligament (lumbocostal arch) extends between the transverse process of L1 and the apex of the 11th and 12th ribs. It covers the transverse process, then, connecting with the transversalis fascia, runs toward the abdomen, where it transitions into the pelvic fascia (Lierse 1990). The costolumbar hiatus is formed from this ligament.

5.1.2 Diaphragmatic apertures

In the diaphragm, there are apertures through which structures from the abdominal cavity pass into the chest (Bochenek 1990).

Three main physiological openings:

- Aortic hiatus (descending aorta, thoracic duct): Located in the lumbar part, medially between the crura of the diaphragm and reinforced by the middle arcuate ligaments.

- Esophageal hiatus (esophagus, vagus nerves, branches of the left phrenic nerve): Located in the lumbar part in the right crus, entirely surrounded by muscles.

- caval opening (inferior vena cava and branches of the right phrenic nerve): Positioned on the right side, ventrally in the area of the central tendon.

Other anatomical openings:

- sternocostal triangle, Larrey's space (superior epigastric artery and vein): Located in the sternal and costal parts.

- Lumbocostal triangle:

- Medial part (greater and lesser splanchnic nerves, azygos vein, and hemiazygos vein): Located in the lumbar part.

- Lateral part (sympathetic trunk): Positioned in the lumbar part, between the medial and lateral parts.

5.1.3 Innervation of the diaphragm

Diaphragmatic innervation is multi-neural:

- Central tendon (originating from the transverse septum): Phrenic nerve.
- Muscular domes (partially originating from the transverse septum and partially from the muscular walls of the trunk): Intercostal nerves innervate the lateral portion.
- The crura of the diaphragm (originating from the dorsal attachment of the esophagus - vagus nerve).

Course of the phrenic nerve

The phrenic nerve, arising from the C3/C4/C5 level, carries sensory, motor, and sympathetic fibers. After leaving the cervical plexus, it travels along the anterior scalene muscle between the subclavian artery and vein. It then passes between the mediastinal pleura and the pericardium, where it branches to supply the pericardium and pleura. It branches out to innervate the upper parts of the diaphragm, and after piercing it, it supplies the lower part (Bordoni 2016), (Bordoni, 2020). The phrenic nerve then runs towards the liver, stomach, and kidneys through its phrenic-abdominal branches, partially innervating them sensorially (Bochenek & Reicher, 1990). Irritation of the phrenic nerve leads to unilateral elevation of the diaphragm, impairing respiration. Bilateral phrenic nerve irritation is very rare.

Intercostal nerves

Intercostal nerves consist of motor and sensory fibres, originating from the anterior branches of spinal nerves and running within the intercostal spaces. They motorically innervate the intercostal muscles, serratus posterior superior muscle, subcostal muscles, and the transversus thoracis muscle. The lower intercostal nerves also supply the abdominal muscles. Sensory fibres run to the diaphragm and innervate the anterior part of the thorax and abdomen as cutaneous branches (Bordoni, 2020).

5.1.4 Blood supply to the diaphragm

The diaphragm is supplied with blood by the:

- Superior phrenic arteries
- Inferior phrenic arteries

- Pericardiophrenic artery
- Musculophrenic artery

Most of the arterial blood is supplied by the inferior phrenic arteries, which arise directly from the abdominal aorta (Bochenek & Reicher, 1990). The remaining blood supply comes from the superior phrenic artery, pericardiophrenic artery, and musculophrenic artery, which arises from the internal thoracic artery. The costal part of the diaphragm is supplied by the subcostal arteries and the five pairs of lower intercostal arteries.

The veins draining blood from the diaphragm include:

- Superior phrenic veins
- Inferior phrenic veins
- Pericardiophrenic vein
- Musculophrenic vein

Venous drainage from the upper part of the diaphragm comes from the superior phrenic, pericardiophrenic, and musculophrenic veins. The lower surface of the diaphragm is drained by the left and right inferior phrenic veins.

5.1.5 Lymphatic pathways of the diaphragm

The lymph nodes directly associated with the diaphragm are:

- Superior phrenic lymph nodes
- Inferior phrenic lymph nodes

The diaphragm is a crucial lymphatic center, possessing its own lymphatic vessels connected to the mediastinum and abdominal cavity (Kocjan et.al. 2017). The diaphragmatic lymphatic network is unique due to its location at the boundary of different hydrostatic pressures: negative pressure in the pleural cavity and positive pressure in the peritoneal cavity (Schumpelick, et.al., 2000). The lymphatic vessels form a drainage system parallel to the blood vessels, responsible for removing interstitial fluid (or extracellular fluid), cellular debris, and introducing it into the venous system as lymph. The lymph from the diaphragm is abundant and drains into the mediastinal lymph nodes, connecting with the bloodstream through the thoracic duct. Lymph absorption depends on the respiratory rhythm and diaphragm stretching, intra-abdominal pressure, and body posture. Dysfunction in any of these factors can cause diaphragmatic disorders, negatively impacting the lymphatic system.

5.1.6 Diaphragmatic ligaments

Supradiaphragmatic attachments include:

- Phrenicopericardial ligaments connecting the diaphragm with the fibrous pericardium
- Phrenicoesophageal ligaments connecting the diaphragm with the esophagus and the right and left diaphragmatic domes
- Inferior pulmonary ligaments, thickened pleura connecting the diaphragm with the lung hilum; the right ligament is near the inferior vena cava, and the left is near the descending aorta (Bordoni & Zanier, 2013)

Subdiaphragmatic attachments include:

- Falciform ligament of the liver, extending in two layers from the superior surface of the liver to the anterior abdominal wall and diaphragm
- Coronary ligaments, anterior and posterior, surrounding the bare area of the liver on both sides
- Triangular ligaments, arising from the coronary ligaments, connect the right diaphragmatic dome with the right liver lobe and the left diaphragmatic dome with the left liver lobe, preventing intestinal structures from being wedged between the liver and diaphragm
- Gastrodiaphragmatic ligament connecting the stomach to the diaphragm
- Phrenicocolic ligament connecting the splenic flexure of the colon to the diaphragm at the level of the 11th rib
- Ligament of Treitz connecting the duodenojejunal junction to the right diaphragmatic crus (Bordoni & Zanier, 2013)

The diaphragm also connects functionally through fascia with:

- The pubic bone via the linea alba
- The bladder via the falciform ligament of the liver and the round ligament, running to the umbilicus and further to the bladder through the vesicoumbilical ligament
- The skull via the pericardium, carotid sheath to the temporal, mandibular, and occipital bones

5.1.7 Functions of the diaphragm

The diaphragm serves various crucial roles in the body:

- Respiratory function: the diaphragm plays a vital role in breathing, satisfying approximately 80% of the body's oxygen demand.
- Enhancement of spinal stability: contraction of the diaphragm contributes to increased intra-abdominal pressure, thereby improving the stability of the spine.
- Improvement of motor control of the spine.
- Facilitation of fluid flow.
- Barrier to microbial spread: it acts as a barrier, preventing the spread of microorganisms between two body cavities.
- Activation of abdominal organs: through the fascial system, the diaphragm activates abdominal organs by transmitting the force of its contraction to individual organs.
- All the functions of the diaphragm in the human body are not fully understood, and ongoing medical research continues to explore and deepen our understanding of its multifaceted roles (Stephens, et.al., 2017).

5.1.8 Clinical symptoms of diaphragm dysfunction

Clinically, symptoms of diaphragm dysfunction may manifest as:

- Pain or tension in the thoracolumbar junction
- Pain below the costal arch
- Postural Disturbances
- Respiratory system disorders: conditions affecting the respiratory system, including bronchitis, bronchial asthma, and sinusitis.
- Gastrointestinal system disorders: conditions related to the gastrointestinal system, as the abdominal organs have direct or indirect ligamentous connections with the diaphragm.
- Peripheral circulation disorders of the lower limbs: associated with pathology of the inferior vena cava and abdominal aorta.
- Lymphatic circulation disorders: including swelling in the lower limbs and abdomen.

- Urinary-genital system disorders: the kidneys have a direct relationship with the diaphragm.
- Instability in the L5-S1 vertebrae.
- Developing disc herniation.
- Diaphragmatic hernia: symptoms may include heartburn, eructation, and substernal pain.
- Signs of quadratus lumborum muscle weakness.
- Manifestations of iliopsoas muscle weakness.

5.1.9 Consequences of respiratory failure

Respiratory failure can cause:

- Autonomic imbalance: compression of the vagus nerve leading to disturbances in organ trophics.
- Variable activity in the craniosacral rhythm: each phase of respiration influencing the activity of specific cranial bones.
- Esophageal widening: resulting in pressure on the cardiac portion of the stomach, disrupting its main function of breaking down complex proteins into simple amino acids, leading to impaired protein digestion.
- Decreased tone of the lumbar-pelvic muscle (incorporated in the diaphragm crura): leading to nephroptosis.
- Instability in the cervical spine: overloading the central part of the cervical spine, compression of the phrenic nerves.

Points of Reference (Picture1.) - Vertebral Levels of Selected Anatomical Structures for Examining a Patient with Normal Body Weight (Schumpelick et. al., 2000, Bordoni, 2020).

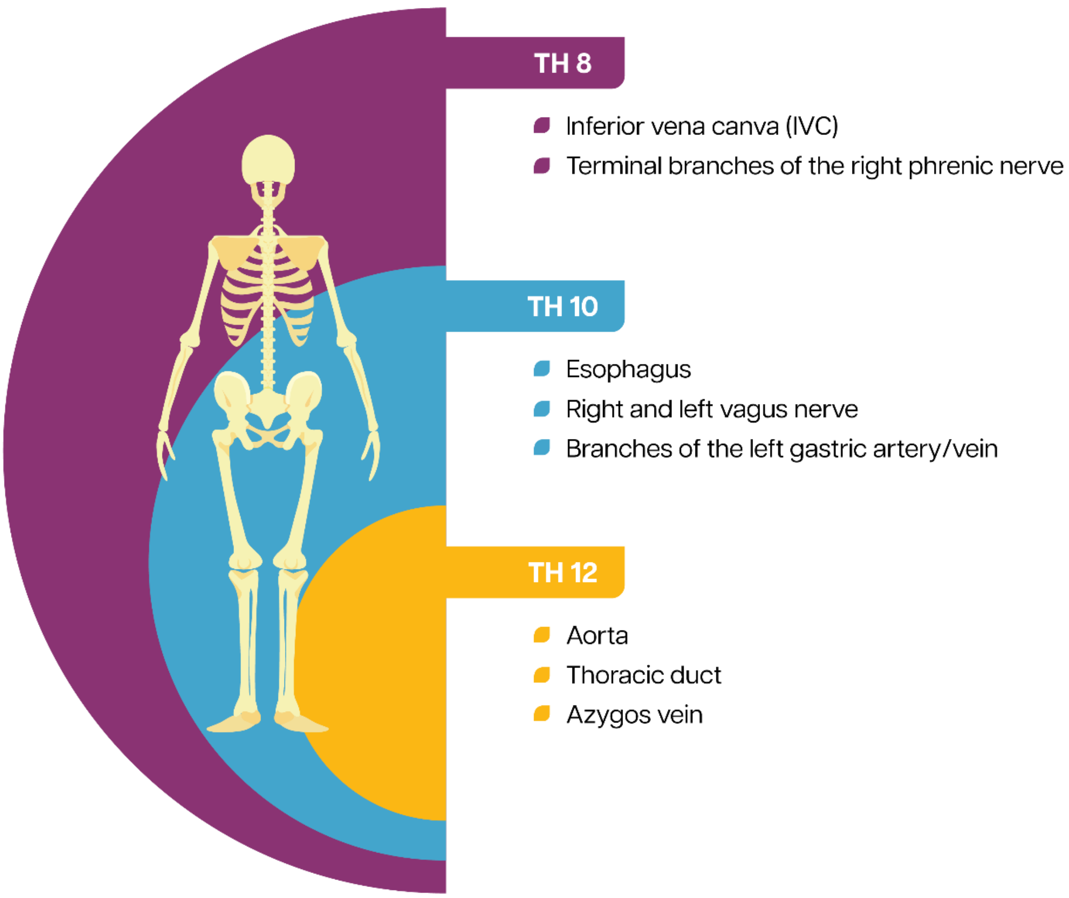


Figure 8 Location of selected anatomical structures in relation to reference points on the spine. Own source.

The diaphragm, besides its vital functions such as breathing and metabolism, also plays a significant role in maintaining proper body silhouette (Schwind, 2006), (Kocjan, et.al. 2017). When examining patients with excessive body mass, it is important to consider that the architecture of internal structures is disrupted due to increased adipose tissue in the abdominal cavity, chest, neck, and throat areas. Therefore, the anatomical layout described above may not correspond to the actual positioning of these structures.

During normal breathing, the diaphragm contracts, pushing the contents of the abdominal cavity downwards and forwards, while the external intercostal muscles contract, pulling the ribs upwards and forwards (De Troyer, 2016). Individuals with excess body weight have this mechanism disrupted because adipose tissue mechanically reduces the mobility of the ribs, diaphragm, and spine. Excess adipose tissue also unfavorably affects the patient's silhouette, leading to a Picturegraphic posture that alters the muscle length involved in the breathing process. Proper muscle length ensures their correct activation; otherwise, it can adversely affect the strength of respiratory muscle contractions, leading to changes in breathing depth and rate.

Studies show that diaphragmatic breathing forms the basis for functional movement (Fernandez-Lopez, et.al., 2021), (Rocha, et.al. 2015). Ineffective breathing can modify movement through muscle imbalance, changes in motor control, and physiological adaptations. The altered architecture of internal organs in the chest and abdominal cavities due to the accumulation of excessive adipose tissue leads to the development of compensatory breathing patterns that are difficult to reverse through physiotherapy if the patient does not reduce their body weight.

5.2 Respiratory muscles

The diaphragm is the main respiratory muscle but is assisted in the breathing process by other muscles (Table 1). The intercostal muscles attach to the ribs, while the abdominal muscles, the dorsal widest muscle or the quadratus lumborum have a connection to both the pelvic girdle and the ribs (Downey, 2011). In turn, muscles such as the scalene and sternocleidomastoid muscles, which attach to both the ribs and the cervical spine, take an active part in preparing the thorax for gas exchange (Bochenek & Reicher, 1990). Also, very important in this process are the muscles of the larynx and the muscles of the oral cavity and pharynx, which influence the resistance to gas flow through the upper airway both on inspiration and expiration. It should be remembered that some of these muscles also have a major contribution to a number of other functions, such as speaking, chewing, swallowing, coughing, postural functions.

Table 8 Respiratory muscles are divided into inspiratory and expiratory muscles.

	Inspiratory muscles	Expiratory muscles
Primary respiratory muscles	Diaphragm (diaphragma) - flattens, extending the vertical dimension of the thoracic cavity. External intercostal muscles - elevate the ribs and sternum, increasing the anteroposterior dimension of the thoracic cavity. Scalene muscles - when their attachment in the cervical region is stabilized, they elevate the upper ribs, assisting in inspiration.	The expiratory mechanism is ensured by: - Elastic recoil of non-muscular tissues: The expanded lung tissue returns to its original size, involving the pleura and costal cartilages. - Relaxation of expiratory muscles: -- The diaphragm relaxes, returning to its resting position, and the vertical dimension of the thoracic cavity decreases. -- The external intercostal muscles relax, lowering the ribs and sternum, decreasing the anteroposterior dimension of the thoracic cavity.

Accessory respiratory muscles:	Sternocleidomastoid - With a stabilized proximal attachment on the cervical spine, they elevate the sternum. Serratus posterior superior - Elevates the upper ribs, connecting the lower cervical spine and the upper thoracic spine to the ribs. Serratus posterior inferior - Connects the thoracolumbar fascia of the thoracic and lumbar spine to the ribs, pulling the ribs down to assist in expiration, and stabilizing the lower ribs to provide attachment stability for the diaphragm during inspiration. Pectoralis major - With fixed arms, both pectoral muscles participate in inspiration. Pectoralis minor - With a stabilized shoulder girdle, it serves as an accessory inspiratory muscle. Subclavius - Lowers the clavicle and moves it forward, expanding the subclavian vein during arm elevation. Quadratus lumborum - Pulls the rib cage downward and backward through the twelfth rib, assisting in expiration.	Internal intercostal muscles - Lower the ribs, aiding in expiration. Transversus thoracis - Located behind the sternum, it runs obliquely downward from the costal cartilage to the sternum. During contraction, it moves the costal cartilages down, assisting in expiration. Subcostal muscles - Located in the posterior part of the thorax, connecting two or three adjacent ribs, they assist in expiration. Transversus abdominis - Is the main muscle forming the abdominal press with the other abdominal muscles, diaphragm, and pelvic floor muscles. It brings the ribs closer to the median plane, narrowing the thoracic cavity. External and internal oblique abdominal muscles - Form the abdominal press in cooperation with the other abdominal muscles, diaphragm, and pelvic floor muscles. Rectus abdominis - Lowers the ribs and works with the other abdominal muscles, diaphragm, and pelvic floor muscles to form the abdominal press, aiding in expiration. Iliocostalis lumborum - Assists in expiration by pulling the ribs down along with the deep back muscles, the longest lumbar and lower thoracic sections. Latissimus dorsi - The rib portion assists in expiration, stabilizing the ribs during coughing and acting as a fixed attachment for the diaphragm, aiding in expiration.

5.3 Complications of obesity

Approximately one-third of the global population is currently suffering from overweight or obesity (www.who.int/news-room/fact-sheets/detail/obesity-and-overweight). In a medical sense, scientific studies confirm that excessive body weight is one of the most serious health threats worldwide, constituting a significant risk factor for non-communicable diseases such as type 2 diabetes, hypertension, cardiovascular diseases, and certain types of cancers. The obesity epidemic is a global issue affecting both children and adults.

An incorrect position of the diaphragm can cause dysfunctions in organs such as the kidneys, liver, or stomach due to their direct proximity. It can also cause dysfunction in the diaphragm itself due to pathological processes in these organs. Excessive body weight can change the position of both the diaphragm and organs, leading to respiratory disorders (the diaphragmatic recess can fill with fat, the intestines may swell, etc.) (Xiang, et.al., 2023), (Bordoni, et.al., 2024).

Obesity is accompanied by complications affecting various organs and tissues (Ataey, et.al., 2020). These complications include both mechanical changes to surrounding tissues caused by excess adipose tissue and the maintenance of pro-inflammatory states, leading to adverse changes in organ physiology. Adipose tissue is an endocrine and paracrine organ, producing numerous cytokines and bioactive mediators, contributing to a pro-inflammatory state (Coelho, et.al., 2013), (Palma, et.al., 2021).

The most commonly mentioned complications of obesity include:

- Cardiovascular System: hypertension, coronary artery disease, varicose veins, stroke.
- Digestive System: gastroesophageal reflux disease (GERD), gallstones, non-alcoholic fatty liver disease (NAFLD), erosive esophagitis, and esophageal adenocarcinoma.
- Musculoskeletal System: osteoarthritis of the hip and knee joints, degenerative changes in the spinal joints in all sections, degenerative changes in the carpometacarpal joints, flat feet.
- Reproductive System: infertility in women, polycystic ovary syndrome (PCOS), erectile dysfunction in men.

Respiratory System: asthma, chronic obstructive pulmonary disease (COPD), sleep apnea. Excess body weight has adverse effects on the function of the respiratory system (Boussuges, et.al., 2021) (Nobre e Souz, et.al., 2013). Functional lung changes are caused by the pressure of additional adipose tissue on the chest wall, abdominal cavity, diaphragm, and lungs, particularly worsening parameters such as:

- FRC (Functional Residual Capacity): the volume of air remaining in the lungs after normal expiration.
- FVC (Forced Vital Capacity): the total amount of air that can be forcibly exhaled after full inhalation.

- ERV (Expiratory Reserve Volume): the additional amount of air that can be forcibly exhaled after the expiration of a normal tidal volume.
- FEV1 (Forced Expiratory Volume in the 1st Second): the volume of air exhaled in the first second of a forced exhalation.

Increased adipose tissue volume in the pharyngeal and neck areas can directly reduce the airway lumen, making breathing difficult, and even leading to apnea, resulting in hypoxemia (low oxygen levels in the blood). Hypoxemia stimulates the sympathetic nervous system, potentially leading to complications such as hypertension, arrhythmia, myocardial infarction, or stroke. People with sleep apnea experience shallow breathing and disrupted deep sleep and REM phases, causing them to wake up feeling tired.

Additionally, there is a strong correlation between obesity and type 2 diabetes, dyslipidemia, and the occurrence of cancers (colon, breast, esophagus, gallbladder, pancreas, liver, thyroid, ovaries, kidneys).

Severe obesity is a disabling disease that severely negatively impacts lung function, respiratory muscle work, and quality of life. Ali & Duruturk (2022) consider diaphragm mobilization techniques to be a safe physiotherapy method for obese individuals. These techniques improve respiratory parameters, chest mobility, and diaphragm movement. They emphasize the need for increased research in the future regarding the effects of diaphragm mobilization techniques.

When examining obesity from a cross-cultural perspective, the situation is not as straightforward in considering it a disease. Research indicates that in poor regions where access to food is challenging, overweight is seen as a sign of prosperity, wealth, health, and fertility. There are also areas where food is currently abundant, such as in China, where obesity is historically rooted in prosperity, and individuals with excess weight exhibit better mental well-being and are better perceived socially.

A different pattern prevails in Europe and North America, where obesity is perceived as a health problem, and preference is often given to individuals with a slender physique. Patients with obesity face stigmatization not only from society but also from healthcare workers due to their weight (Groven, & Heggen, 2018). Negative attitudes towards obesity have been documented among medical and physiotherapy students, active physiotherapists (Elboim-Gabyzon , et.al., 2020), and doctors (Huizinga, et.al., 2009).

Patients emphasize the negative attitude of physiotherapists towards them, as therapists often emphasize body weight, especially when applying techniques to exposed body parts. As a result, individuals with obesity typically avoid healthcare systems, receive less preventive care, and obtain less health education. It is important not to use stigmatizing language such as "obese," "fat," "chubby," and many other stigmatizing words used in various parts of the world when discussing with patients with excess body weight.

Current research results suggest using terminology like "weight," "increased weight," or "unhealthy weight" in conversations. However, it should be noted that there is no single terminology that would be the best, and physiotherapists must consider the patient's background, gender, social status, financial status, and many other factors. It seems reasonable to inquire about the language preferences of patients, especially younger individuals - teenagers.

Therefore, clinical physiotherapists must develop their own ways of communicating with obese patients to help them understand that obesity is a health issue to be addressed, not a failure. Building trust and good relationships between physiotherapists and patients with excess body weight will allow for a discussion about weight without discouraging the patient from therapy. Based on their experience, the therapist must assess the appropriate moment to initiate a conversation about increased body weight, and it is often not during the first visit but in subsequent sessions.

It is essential to pay special attention to the above aspects and maintain sensitivity in both health communication and therapy. The application of therapeutic techniques requires direct and close physical contact with the abdomen and chest area, for which the patient's consent is necessary. Therefore, it is crucial to explain to the patient beforehand why palpation and the use of such techniques in the torso area are necessary to avoid unnecessary stress, frustration, reluctance to therapy, and ultimately its discontinuation.

5.4 Communication with the patient

Here is a summary of some practical suggestions for the physiotherapist to overcome communication barriers and ensure respectful physical contact during the assessment:

Before the examination:

- Clearly explain the purpose of the breathing assessment and the areas that will require physical contact.
- Offer the option to have a chaperone present during the examination, especially if the patient feels more comfortable.
- Provide appropriate draping to ensure the patient feels covered and respected throughout the assessment.

If you are a male physiotherapist dealing with a female patient or client, consider offering a female colleague to perform the assessment if the patient expresses discomfort.

During the Examination:

- Use respectful language and address the patient by their preferred title (e.g., Ms., Mrs.).
- Always obtain verbal consent before any physical touch. Explain exactly where and how you will be making contact.
- Use a gentle, non-invasive touch when assessing the chest and abdomen. Focus on essential areas only.
- Offer the patient options for positioning that maintains comfort and privacy. For example, they might sit upright or lie down with a strategically placed sheet.
- If explaining breathing techniques, utilize visual aids like diagrams or demonstrations instead of solely relying on hand placement.
- Frame the discussion around positive outcomes and the potential benefits of physiotherapy for managing obesity.
- Avoid using weight-stigmatizing language. Focus on neutral terms like "body composition" or "weight management goals."
- Encourage the patient to ask questions and actively participate in their treatment plan.

Cultural Considerations (Polish Context):

- Polish culture generally values direct communication. Explain information clearly but remain sensitive to potential anxieties about weight.
- Maintain a comfortable distance while still being close enough for effective communication. Be mindful of individual preferences.
- Privacy and respect are valued in Polish culture Ensure the examination area is private and minimize distractions.

By following these suggestions, the physiotherapist can create a safe and respectful environment for the patient. Remember, clear communication, informed consent, and sensitive touch are crucial for building trust and promoting successful therapeutic interactions (Auckburally, et.al., 2021), (Huizinga, et.al., 2009), (Sato, 2020), (Puhl, 2020).

1. What similarities have you noticed in your culture?

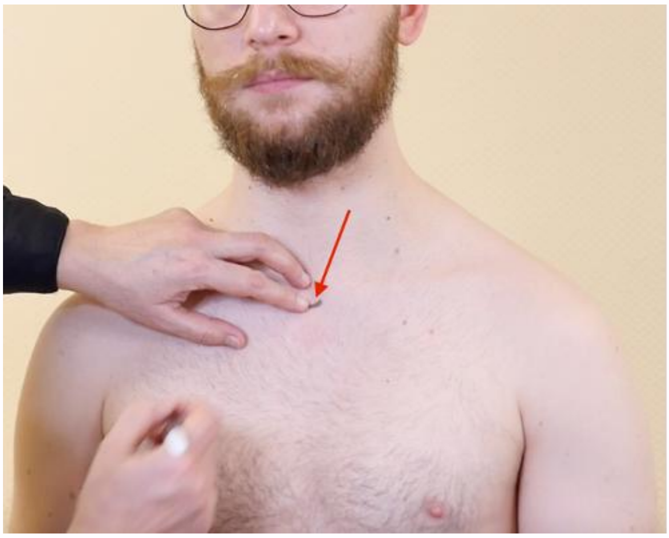
2. What differences have you noticed in your culture?

3. What should you pay attention to when caring for a patient with different cultural values?

5.5 Palpation of the diaphragm and associated structures, assessment of breathing patterns and diaphragm mobilisation techniques in normal weight subjects

5.5.1 Palpation of anatomical bone points needed to locate the lung and diaphragm area

To determine the bony points by which we will locate the lung and diaphragm area, gently but firmly place the pad of your index finger on the sternal notch (Picture 1.). Point downwards where the handle joins the sternum shaft to form the sternal angle. Then move your fingers laterally and locate the second rib, which is attached to the transition between the handle and the sternum shaft. Palpating downwards along the sternum, locate the 5th rib on the right side and the 6th rib on the left side (Picture 2.). The diaphragm should be at this height under normal conditions.



Picture1. Location of the second rib at the height of the sternal angle

Picture 2. Location of the diaphragm at the level of the fifth rib on the right and the left rib on the left side of the sternum

5.5.2 Determination of the thoracic-abdominal boundary in the supine position

Lay your hands flat on the patient's chest with your thumbs joined at the midline of the sternum at the level of the space between the 5th and 6th ribs. (Picture 3.). The left hand is above the diaphragm, where there is a negative pressure of minus 5 cm of water column, and the right hand is below the diaphragm, where there is a positive pressure of 15 cm of water column (1 metre of water column produces a hydrostatic pressure of approximately 0.1 bar). Ask your patient to take an inhalation. If you have positioned your thumbs correctly above and below the thorax, the changing pressure inside the thorax and abdominal cavity will push your thumbs away from each other to a small extent (Picture 4.). If you position your thumbs incorrectly, that is, in an area of equal pressure, inspiration will not change the alignment of your fingers.

Picture 3. Determination of the thoracic-abdominal boundary - placing the hands in the starting position

Picture 4. Delineation of the thoracic-abdominal boundary - visible slight distancing of the thumbs in response to inspiration

5.5.3 Assessment of respiratory movement at the thoracic-abdominal interface in the sitting position

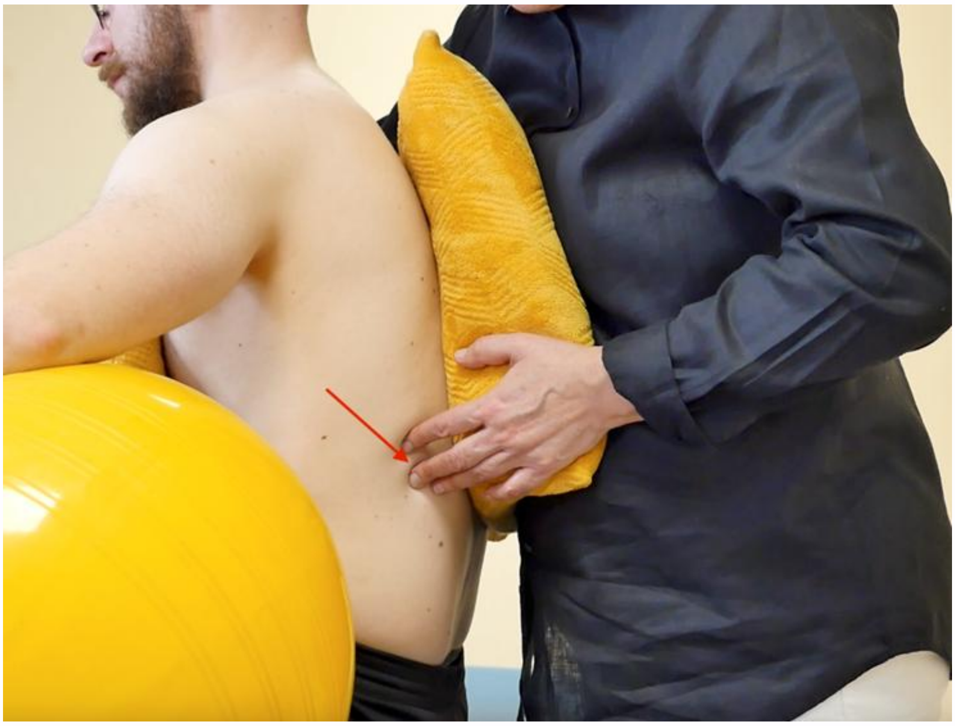
The therapist sits behind the patient, placing the whole hands in the lateral axillary line with the fingers pointing towards the midline of the body. The grip is firm, but does not restrict the respiratory movements of the area under examination (Picture 5.). The index and middle finger cover the last ribs, the fourth and fifth fingers are positioned below the rib arch (Picture 6.). During free breathing, observe whether the movement of the ribs is symmetrical on both sides, whether the curvatures of the liver and stomach move downwards and inwards widening the intercostal spaces (Schwind, 2006).

Picture 5. Assessment of respiratory movement at the thoracic-abdominal border - hand positioning

Picture 6. Assessment of respiratory movement at the thoracic-abdominal border - finger placement

5.5.4 Assessment of respiratory movement of the eleventh and twelfth ribs in the sitting position

An important part of assessing the breathing pattern is to examine the mobility of the lower ribs related to the work of the inferior cervical muscles, which are the muscles that lower the ribs by directing them to the side during inspiration. Palpate the top of the hip plate and move the index and middle fingers to the 11th and 12th ribs at the lateral edge of the dorsal extensor. As you inhale freely, observe that the ribs deviate to the side. Stabilise the patient with your torso without losing contact with the ribs. You can place a pillow between your torso and the patient's torso. Now relieve the pressure on the lower ribs by slightly flexing your torso and rotating at the level of the lower rib joints. Ask the patient to direct the breath towards your fingers giving feedback in the form of pressing your fingertips against the ribs. Repeat this sequence until you feel the posterior inferior serratus muscle has taken up function.

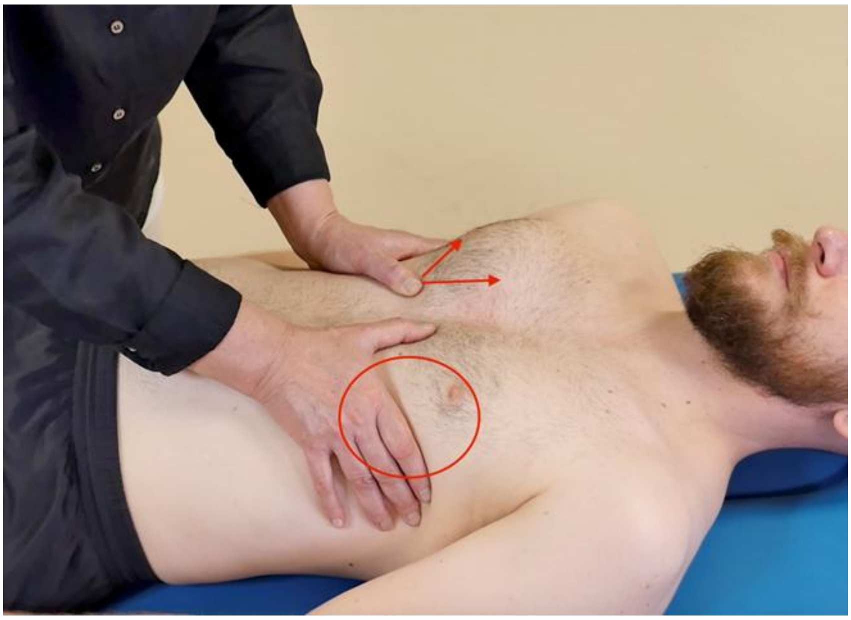


Picture 7. Assessment of respiratory movement of the eleventh and twelfth ribs - finger positioning

5.5.5 Assessment of respiratory movement and diaphragm relaxation in the supine position

This technique is used to assess and improve reduced mobility of the diaphragm domes. The therapist sets the height of the top of the diaphragm dome and places the hands on the lateral side of the lower ribs. The thumbs are positioned at the height of the seventh rib cartilage (Picture 8.). Ask the patient to breathe a little deeper and try to feel which side has less mobility. The patient you see in the Picture has slightly reduced inspiratory mobility on the left side. The therapist's right hand compresses the lower rib quadrant below the diaphragmatic arch, while the left hand allows free movement (Picture 9.). When you notice a reduced resistance of the tissues under your hand when the patient exhales, help to lift and expand the ribs laterally and cephalad. Maintain this position for several inhalations.

Picture 8. Height of the top of the diaphragm dome



Picture 9. Stimulation of respiratory mobility of the chest on the (left) side of restriction

5.5.6 Relaxation of one dome of the diaphragm in the supine position

The technique is performed with reduced diaphragmatic mobility in people with abdominal organ dysfunction. This technique has a significant effect not only on the diaphragm, but also on the structures under the therapist's hands. Thus, in the example below, on the left side, the area around the stomach, spleen, lung capsule and colon are treated. When the therapist works on the opposite side, the area around the lung, liver and colon will be treated. Stand on the side of the patient opposite the dome to be treated (Picture 10.). Arrange the hands so that the thumbs are positioned under the ribcage and the fingers are pointing parallel to the course of the ribs. During exhalation, press the entire rib arch with the fingers towards the patient's navel. During inhalation, maintain the position obtained. When you notice a greater tenderness of the tissue to relax, you can increase the pressure of the rib arch towards the navel while moving the thumbs slightly in the opposite direction.

Picture 10. Unilateral relaxation of the dome of the diaphragm

5.5.7 Assessment of breathing movements and diaphragm relaxation in supine position

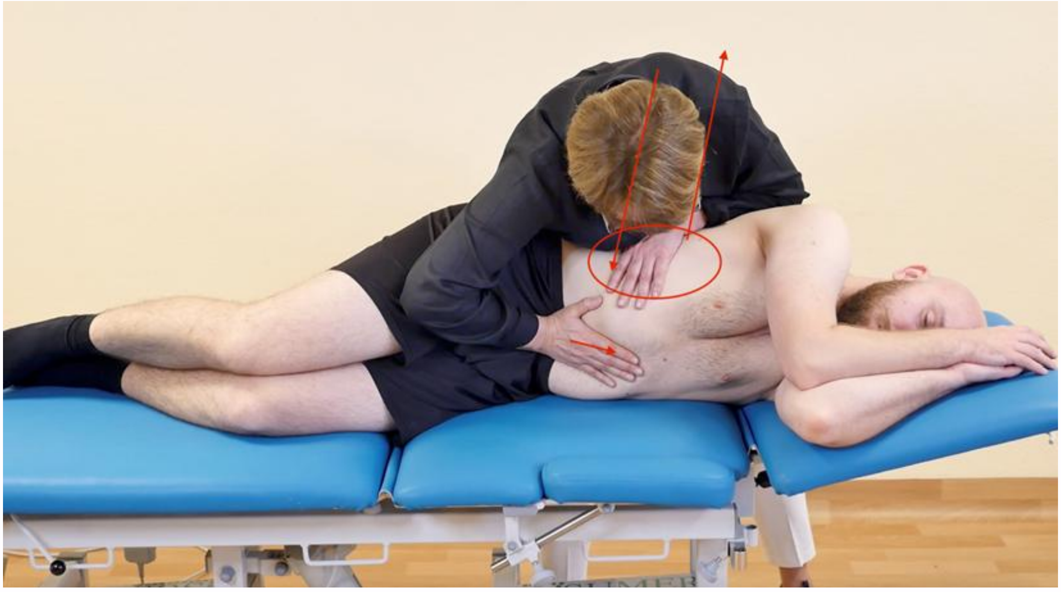
The technique is used to improve the glide of the tissues lying below the lower limit of the diaphragm. The therapist sits on the side of the area to be treated, facing the patient's face. He or she places his or her left hand on the lower ribs, introducing a slight uplift in the thoracolumbar transition (Picture 11.). At the same time, the therapist's right hand is placed in the lateral axillary line and directed towards the anterior surface of the shaft of the twelfth thoracic vertebra introducing pressure (Picture 12.). Maintain compression of the lower ribs until you feel reduced tissue resistance (Schwind, 2006).

Picture 11. Introduction of a slight extension in the thoracolumbar transition

Picture 12. Relaxing the diaphragm in the supine position

5.5.8 Relaxing one dome of the diaphragm while lying on your side

If your patient presents with a left diaphragmatic dome tension pattern in the inspiratory position, place the patient in the left side lying position with the hip and knee joints slightly flexed. Place your right hand on the patient's abdomen and point cephalad and laterally. Place your left hand in the area of the lower ribs on the right side of the patient's body. Lean in using trunk work during inhalation and exhalation. During exhalation, use your right hand to push the abdominal tissues towards the left shoulder, at the same time compressing the right half of the patient's chest laterally. During inhalation, reduce the pressure on the chest (Picture 13.). The sequence is repeated until you feel the diaphragm dome relax (Liem, et.al., 2017). Do everything in a natural breathing rhythm without forcing the patient's breathing rate or depth.

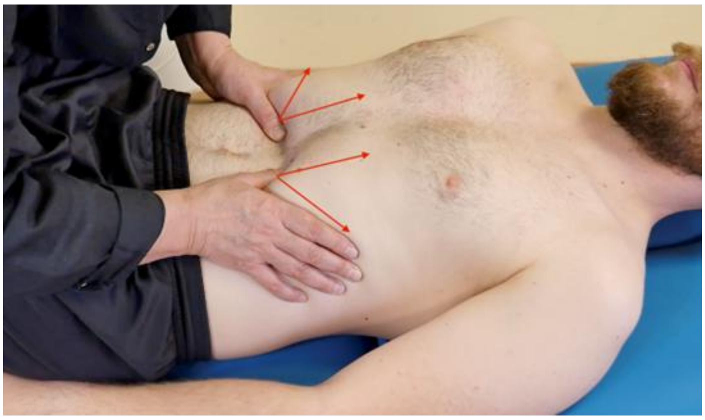


Picture 13. Relaxation of the left dome of the diaphragm while lying on the side

5.5.9 Relaxation of the lower thoracic regions and diaphragm according to Russoe'a

The technique is performed in states of diaphragm tension, abdominal stasis or organ dysfunctions. The therapist stands to the side of the patient, bends his/her lower limbs bringing the heels as close as possible to the buttocks and, leaning with his/her torso, performs traction along the long axis of the spine. The therapist's hands are placed on the lower ribs, with the thumbs at the level of the eighth rib cartilage (Picture 14.). Traction should be maintained throughout the technique. During exhalation, the patient consciously draws in the abdomen and the therapist's hands move to the side and upwards to relax the diaphragm (Picture15.) (Liem, et.al., 2017).

Picture 14. Relaxation of the lower thoracic and diaphragm areas according to Russoe'a - direction of traction



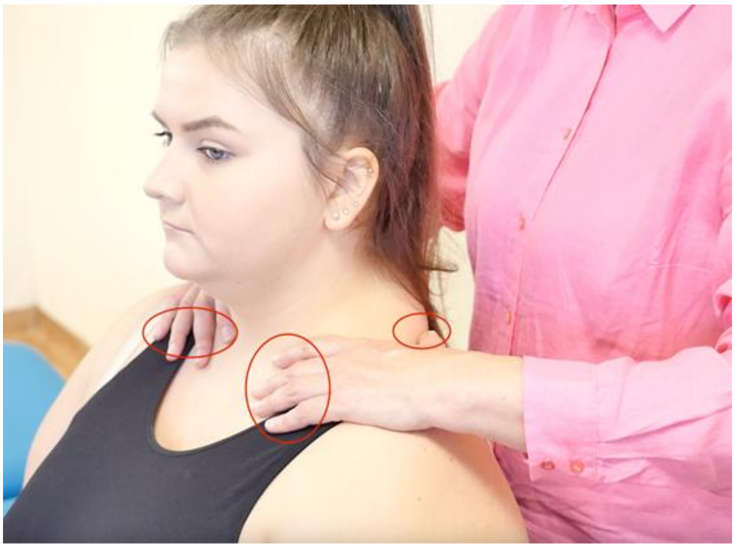
Picture 15. Relaxation of the lower chest and diaphragm areas according to Russoe'a – positioning of the therapist's hands

5.6 Palpation of the diaphragm and associated structures, assessment of breathing patterns and diaphragm mobilisation techniques in people with excess body weight

Palpation of bony structures in people with increased body weight is difficult and requires more focus from the therapist. Explain to your patient that some grasps may be uncomfortable because you have to use a little more force to feel bony elements such as the ribs or the clavicle. Also inform your patient how important it is to assess their breathing pattern for their health. Also explain that in order to properly assess the respiratory pattern it is necessary to palpate the neck, chest and abdominal areas. If your patient agrees to this, you can proceed. If, due to the patient's excessive weight, you are unable to palpate the bony elements directly, do not give up on assessing the respiratory pattern but try to do so indirectly. Feel the way the soft tissue moves under your hands and assess the respiratory movement in that area.

5.6.1 Assessment of respiratory movement at the neck/chest transition in the sagittal plane in an overweight patient in the sitting position

If you are assessing respiratory movements of the upper thoracic aperture region and your patient's weight does not allow your fingers to reliably touch the first rib and the clavicle, you need to assess the behaviour of the soft tissue lying above these points. This requires the therapist to be more focused and the patient to be fully relaxed. Arrange your hands according to the diagram shown in the Picture (Picture 16.). and ask the patient to breathe freely. The thumbs are stationary and serve as reference points for the other fingers, which assess the tissues lying above and below the clavicle and the 1st rib (we try to catch asymmetry in muscle tone between the right and left sides of the body, over-activation of the muscles, and assess the mobility/lack of movement of the 1st rib and the clavicle).



Picture 16. Assessment of respiratory movements in the upper thoracic orifice region - therapist hand positioning

5.6.2 Assess respiratory movement of the eleventh and twelfth ribs in an overweight person in a sitting position

If you do not sense respiratory movement at the eleventh and twelfth ribs, try to cover a larger area of tissue in the lateral line of the body with your hands and assess the movement of the soft tissues over the ribs. Evaluate the symmetry of tissue movement on both sides of the lower ribs (Pictures 17 and 18.). If possible, we assess the activation of the posterior inferior serratus muscle connecting the thoracolumbar fascia to the ribs. Under normal conditions, the XI and XII ribs should lift slightly upwards and laterally during inspiration

Picture 17. Assessment of respiratory movements at eleventh and twelfth rib height - finger placement

Picture 18. Assessment of respiratory movements at eleventh and twelfth rib height - finger placement, side view

5.6.3 Assessment of respiratory movement and diaphragm relaxation in the supine position in an overweight person

The technique presented here affects the diaphragm and the structures underlying the therapist's hands - stomach, spleen, recessus pleurales, colon. During exhalation, press the entire rib arch towards the patient's navel; during inhalation, maintain the achieved position (Picture 19.). If you feel that your pressure is too weak, perform the technique standing on the opposite side and push the entire ribcage towards the navel with your hands (Picture 20.). Ask the patient to relax completely and explain that this pressure may cause internal distension in the bowels, but not pain. Occasionally, gas expulsion may occur, but this should not be a source of stress as it is a ‘normal’ reaction.

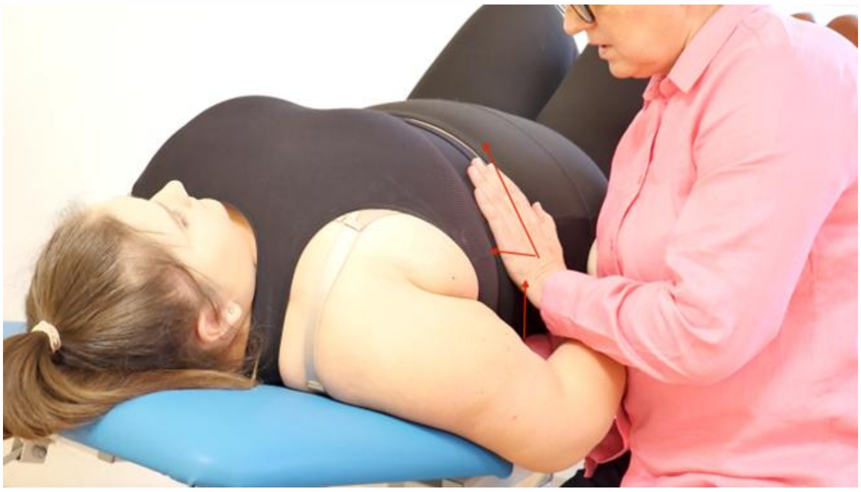
Picture 19. Assessment of respiratory movement and diaphragm relaxation - therapist hand positioning

Picture 20. Assessment of respiratory movement and diaphragm relaxation - alternative therapist position

5.6.4 Relaxing one dome of the diaphragm in the supine position in a person with excessive body weight (Schwind, 2006)

The technique presented here requires the therapist to place your hand and forearm on the lower ribs and introduce a gentle upright in the thoracolumbar transition in the patient throughout the technique (Pictures 21 and 22.). Assure the patient that their pressure on your hand and forearm is not painful for you. Such information can help to allay the patient's unspoken fear that they are pressing too hard on your hand. For a full description of the technique, see above, section 5.9.8 Assess respiratory movement and diaphragm relaxation in the supine position.

Picture 21.Position of the therapist's hand in the thoracolumbar transition



Picture 22. Unilateral relaxation of one diaphragm dome while lying backwards

5.6.5 Relaxing one dome of the diaphragm while lying on your side in an overweight patient

If your overweight patient presents with a left diaphragmatic dome tension pattern in the inspiratory position, place him in the left side lying position with the hip and knee joints slightly flexed. Ask him or her to assist you by completely relaxing the abdominal muscles. Explain that the essential part of the diaphragm relaxation technique is done by compressing the abdominal fascia, which must be completely relaxed so that the therapist can vary the direction and strength of this compression to relax the diaphragm lying in the chest (Picture 23.). A full description of the technique can be found above in section 5.5.8. Relaxing one dome of the diaphragm while lying on your side (Liem, et.al., 2017).

Picture 23. Unilateral relaxation of one diaphragm dome while lying on your side

5.6.6 Relaxation of the lower thoracic regions and diaphragm according to Rousse'a in a person with excessive body weight

If your patient is a person with a high body mass, you can ask them to actively participate in performing the procedure so that they feel more comfortable. Share the areas of action - ask the patient to place his hands on his ribs and teach him to draw in his abdomen and direct his hands to the side and upwards as he exhales (Picture 24.). During this time, you will perform spinal traction through the patient's lower limbs (Picture 25.) This joint action will allow the patient to relax the diaphragm. For detailed instructions on how to perform the technique, see section 5.5.9. Relaxing the lower chest and diaphragm according to Russoe'a (Liem, et.al., 2017).

Picture 24. Patient's hand position and direction during expiration

Picture 25. Direction of spinal traction performed by the therapist

5.6.7 Diaphragm relaxation in supine position - Recoil in an overweight patient

Diaphragm relaxation using the recoil technique requires the therapist's hands to be placed on the patient's chest. If it is difficult to avoid contact with, for example, the patient's breasts when performing this technique, for her comfort, let her know what movements you will perform and indicate that you will stop immediately if it is uncomfortable, or she feels pain due to chest compression. Place your hands over the sternocostal joints below the clavicles. You need to experiment with the positioning of your hands so that this is comfortable for the patient and does not cause pain to the tissues being compressed (Picture26 and 27.). During exhalation, compress the sternum in a dorso-caudal direction. During inhalation, maintain the achieved position without allowing the chest to expand. On the next exhalation, repeat the action - compress the sternum in a dorso-caudal direction until you reach the final limit that will not allow you to perform any more compressions (Picture 28.). As the patient begins to take another inhalation, pull your hands away from the chest at a high rate of speed, causing the chest expansion rapidly (Picture 29.).

Picture 26. Example of position of therapist's hands - contact of both hands with the chest

Picture 27. Example of therapist hand positioning - one hand in contact with the chest

Picture 28. Direction of chest compression during patient expiration

Picture29. Detachment of the therapist's hands

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