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Pelvic floor muscle morphology and its impact on urinary incontinence and faecal incontinence

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Abstract

Health problems related to pelvic floor muscles, as faecal incontinence (FI), urinary incontinence (UI) and constipation have a significant negative impact on a person's life. The disease is accompanied by a serious symptoms, which exclude the patient from the local community. It is noteworthy that FI and UI involve increased financial outlays for the treatment of these disorders.

Definition of the faecal incontinence is an uncontrolled passage of faecal materials that has occurred at least two to four times within four weeks of the last six months.

Anatomy of pelvic fundus is strictly corelated with those diseases, because ability to contract and relax the muscles of the pelvic floor helps with the body's daily basic functions.

Risk factors of FI/UI include age, gender, comorbidities such as diabetes and irritable bowel syndrome, and obstetric factors. It could be treated with physiotherapy, pharmacotherapy or invasive treatment.

A review of the literature indicates that the problem of FI/UI is a significant clinical issue of concern to clinicians due to very limited treatment techniques. There is a lack of primary research covering this issue in the world literature. The authors of this paper therefore believe that a holistic view of the subject based on the latest scientific data is necessary.

Running title: Pelvic floor muscle morphology

Keywords: urinary incontinence, faecal incontinence, pelvic floor muscles, pelvic floor fascia, urogenital diaphragm, perineum

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Introduction

Faecal incontinence (FI), urinary incontinence (UI) and constipation have a significant negative impact on a person's functioning and can lead to social isolation, embarrassment, job loss and lower self-esteem [1].

FI and UI significantly impair the patient's quality of life. It becomes a challenge to leave the house or organize a meeting with close family or friends. The disease is accompanied by a significant burden of unwanted odor symptoms, which exclude the patient from the local community. Aware of their body's limitations, the patient gives up social gatherings, avoids visits to public places and gradually "escapes" into isolation.

It is estimated that approximately 8.3% of adults in the USA have faecal incontinence disorders, while available literature data indicate that, faecal incontinence affects approximately 0.25%-6% of the entire world population [2,3].

It is noteworthy that FI and UI not only represent a challenge for the patient or their careers, but also involve increased financial outlays for the treatment of these disorders. Recent scientific data highlight the high systemic economic burden as patients with FI/UI are associated with 55% higher annual healthcare costs compared to those free of these diseases.

It is thought that one of the causes of FI/UI may be an impairment of the structural integrity and neuromuscular function of the pelvic floor muscles (MDM) and the rectum [4].

In this article, we will focus on the role of the MDM in faecal and urinary incontinence. However, the topic has not been comprehensively evaluated and contradictory findings are present in the available literature. The authors of this paper therefore believe that a holistic view of the subject based on the latest scientific data is necessary.

Epidemiology

Nowadays, expert consensus-based guidelines are used to diagnose functional gastrointestinal disorders (FIGD). The most recent guidelines (the so-called IV Rome Criteria) [5] define faecal incontinence as uncontrolled passage of faecal materials that has occurred at least two to four times within four weeks of the last six months [6].

During the medical interview, patients are unlikely to admit the problem themselves [7].

Scientific data indicate, that female patients affected by Fl in 51% of cases communicate about it with close family or friends and only 10-30% of women report the problem to the physician. It seems, therefore, that one of the doctor's tasks is to gain the patient's trust in order to create a strong and effective relationship so that the patient can talk about his/her condition without shame [1].

The available scientific data indicate that the frequency of Fl/UI increases with age and is one of the most important reasons for geriatric patients being admitted to nursing homes. It is noteworthy that Fl also occurs in children, with boys being more likely to suffer from it [8].

The anatomy of the pelvic fundus

The muscles of the pelvic floor are anatomically divided into three layers: external, intermediate and internal. The outer layer is made up mainly of muscles, surrounding the body orifices (urethra, vagina, anus). These muscles include the ischiocavernosus muscle (surrounds the clitoris), the bulbocavernosus muscle (surrounds the vaginal entrance above the Bartolini gland) and the external anal sphincter muscle (surrounds the anal orifice). The above-mentioned muscles are involved in the opening and closing of these openings. The intermediate layer, together with the external layer, forms the urogenital diaphragm. The intermediate layer includes the deep transverse perineal muscle and the superficial transverse perineal muscle [9].

The internal layer, on the other hand, is simultaneously the innermost layer of the pelvic floor and is made up of two muscles: the levator ani muscle and the coccygeal muscle [10].

The muscles of the second and third groups are primarily responsible for the support function for the organs of the lesser pelvis.

The pelvic floor, from an anatomical point of view, can be divided into 4 compartments according to Bordoni et al. [11]:

- anterior or urinary (bladder and urethra),
- intermediate or genital (vagina and uterus in women, prostate in men),
- posterior or rectal (rectum, anal canal, sigmoid colon and rectum),
- peritoneal (intramural fascia and perineal membrane).

Muscle control - the ability to contract and relax the muscles of the pelvic floor - helps with the body's daily basic functions. The pelvic floor muscles work with organs such as the urethra and rectum. They contribute to urinary and faecal continence and to sexual functions of arousal and orgasm [12].

The functional classification of the pelvis is as follows [13]:

- Diaphragm or pelvic floor (ischiofemoral muscle and levator ani muscle), closed above by the intrapelvic fascia.
- The urogenital diaphragm (triangular ligament or carcassonne fascia) is located caudally between the ischial and pubic conjunctiva and crosses the urethra and vagina.
- The perineal or perineal membrane is a continuation of the carcassonne fascia, connecting

the deep layer of pelvic floor muscles, the coccyx and the anal sphincter.

The urogenital diaphragm, located beneath the pelvic floor, is made up of the perineal fascia, including the deep transverse perineal muscle [14].

Conversely, this muscle is the reinforcement that connects the pelvic diaphragm to the perineum. Its anterior part crosses the urinary tract and genitalia, lying between the two ischial rami and pointing at the apex towards the pubic symphysis.

The area anterior to the urethra, or transverse perineal ligament, maintains contact with the ischial rami and the obturator band, while the retro-urethral area is divided into 2 layers (upper and lower), with the deep transverse perineal muscle located in between [15].

The upper lamina of the aponeurosis continues towards the transverse perineal muscle, while the deep lamina connects to the band of Denonviller, whereby the later one overlies the prostate and seminal vesicles. Through adequate tension, the deep transverse perineal muscle holds the reproductive organs, thus preventing urinary, gas and faecal incontinence [15].

Perineum

The perineum is a particular continuation of the urogenital diaphragm. It lies backwards from it. It is connected by muscular fibres to the urethra, the vagina or prostate and the rectum extending to the coccyx to form the rectococcygeal raphe [16].

Some authors argue that the muscular and fascial structures of the perineum are related to other connective tissue elements of the pelvis.

The muscles and viscera are immersed in a network of connective tissue or fascia, which in turn is a mechanical instrument of force transmission that encompasses the entire body system.

For example, the movement of cervix uteri flexion, which involves the deep fascia located in the region of the internal female genitalia, can affect the tension of the fascia of the lower limbs [11].

Of course, the question of the cause of this phenomenon remains. It is apparent that there is a lack of clinical research linking physiotherapeutic interventions to medical procedures.

Intra-pelvic fascia

Below the peritoneum is the intrapelvic fascia, which covers the upper part of the pelvic floor encompassing the obturator internus muscle, the piriformis muscle, the levator ani muscle to continue with a transverse band connecting to the pubic periosteum. Then, on its way, it connects to the pubococcygeal ligament posteriorly and continues to cover the entire musculoskeletal structure of the pelvic floor, urogenital diaphragm and perineal area. The intrapelvic fascia surrounds the viscera of the pelvic floor, additionally connecting it to the muscular and bony structures. It is therefore important in protecting the organs of the lower pelvis from prolapse [11].

The problem of faecal and urinary incontinence

The problem of faecal and urinary incontinence is a debilitating condition, both physically and psychologically, that has a significant negative impact on quality of life [17].

Risk factors include age, gender, comorbidities such as diabetes and irritable bowel syndrome, and obstetric factors such as multiple births, home birth, first vaginal delivery and forceps delivery [18,19].

In a healthy person, the pelvic floor muscles contract and relax automatically. However, in cases of pelvic floor dysfunction (PFD), a number of different symptoms and anatomical changes associated with abnormal MDM function occur. Abnormal function can mean either increased activity, decreased activity or abnormal coordination of the pelvic floor muscles. PFD can result in urological (lower urinary tract), gynecological (sexual dysfunction) or bowel disorders and are often associated with each other [18].

Pelvic floor dysfunction can be divided into two broad categories: relaxing and non-relaxing dysfunction.

Relaxing-type pelvic floor disorders are much more commonly recognized and manifest as incontinence and prolapse of pelvic structures [20].

Less common non-relaxing type is characterized by the pelvic floor muscles remaining in a contracted state, causing increased pressure and pain. The pain is persistent and usually increases during the day and with daily activities such as walking, physical activity and bowel movements [21].

Defecation is a complex process involving synchronization between increased intra-abdominal pressure and relaxation of the pelvic floor and anal sphincter complex, which requires intact rectal sensation and proprioception [22].

The main role of the rectum is stool storage or expulsion, both of which require cortical sensory awareness operating in conjunction with intramedullary and medullary reflexes that ensure timely defecation [23].

The anal sphincters function individually, so during bowel movements in response to rectal distension and the sensation of rectal filling, stimulation of puborectalis muscle and anal sphincter relaxation will be initiated to allow evacuation [23].

The puborectalis muscle is responsible for maintaining the anal angle. When this muscle is hypertonic, the anal angle becomes sharper, which can lead to bowel dysfunction and resultant faecal incontinence [6].

If the puborectalis muscle is weakened, the anal angle becomes more blunt and fecal incontinence can also occur, but due to reduced resistance between the rectum and anal canal [6].

The reduced resistance results in rapid delivery of rectal contents into the anal canal without prior activation of the rectal inhibitory reflex to contract the external anal sphincter. In fact, various disruptions of the pubo-rectal or anal sphincter can lead to faecal incontinence. These injuries can be caused by spontaneous vaginal delivery, but are more common with forceps-assisted surgical delivery [24].

Even in the absence of obstetric anal sphincter injury, childbirth itself already causes ischaemia, stretching and compression of the neuromuscular tissues that contribute to incontinence [25].

Women may be asymptomatic for many years after an anal sphincter injury or after birth because they have compensatory mechanisms to maintain stool [26].

It would be appropriate to mention not only the damage but also the physiological process that is aging of the body.

With age, there is a loss of muscle mass and an increase in comorbidities that undermine the mechanism of abstinence. The presence of a rectal diverticulum can lead to stool entrapment with subsequent incontinence [6].

In contrast, rectal prolapse can result in urinary incontinence because the rectal mucosa and muscles carry stool outside the anus, and chronic rectal prolapse can lead to dilation and poor function of the anal sphincter complex [26].

Pharmacological and invasive treatment

Patients with faecal incontinence who are characterised by quite unusual symptoms such as frequent bowel movements and loose stool (Bristol scale 5 to 7). In such a case, there is the possibility of non-invasive pharmacological treatment aimed at putting patients into a state of pseudo-constipation, but without causing any of the characteristic symptoms of constipation, such as abdominal pain, abdominal distension and fecal difficulties. Current recommendations are calcium polycarbophil, loperamide hydrochloride, and ramosetron hydrochloride. The aim of such intervention is to reduce colonic motility [27].

Alternatively, for patients with concomitant functional bowel disorders, centrally acting drugs such as amitriptyline or chlordiazepoxide can be used for treatment. Scientific data indicate that they reduce the amplitude and frequency of the colonic motor complexes leading to the formation of harder stools, which are passed less frequently. These actions may also be responsible for improving urinary continence [28].

Patients with rectal hyposensibility as a result of, for example, spinal cord impairment or ageing. They do not feel the urge to defecate, even when the rectum is filled with stool, which can often lead to faecal incontinence. Periodic rectal emptying through the use of suppositories and/or enemas is then recommended for this type of patient [29].

In terms of invasive techniques, the first recommended method is to treat faecal incontinence by stimulating the tibial nerve. It is believed that this technique works by electrically stimulating the sacral nerve plexus, as the tibial nerve originates from the sacral nerve. Although it is clear that TNS is cheaper and less invasive with fewer adverse events compared to other stimulation techniques. However, there are no data in the current guidelines to show unequivocally the efficacy of this treatment technique. One of the reasons for this uncertainty is the lack of consensus on the optimal pacing conditions and technicalities of this therapy [27].

The second popular method is electrical anal stimulation, although recent guidelines question the efficacy of this therapy for the treatment of faecal incontinence as the level of evidence for its effectiveness is low, although it is a low-cost and minimally invasive therapy.

Rectal electrical stimulation is defined as a therapy used to treat faecal incontinence by electrically stimulating the anal sphincter with an anal plug electrode inserted into the anal canal. The lack of clinical data confirming the efficacy of this technique suggests that any such procedure should be conducted as part of research projects [27].

Another treatment for faecal incontinence is sacral nerve stimulation (SNS), studies have shown favorable results in both medium and long-term follow-up. The mechanism of action of SNS is primarily due to modulation of the activity of the supply nerve, rather than a motor effect on the anal sphincter itself [30].

Currently, attempts are being made to use minimally invasive procedures to treat FI/UI. One of the more interesting ones seems to be the SECCA procedure. It involves the delivery of temperature-controlled energy to the rectum. Although technically a non-surgical procedure, the mechanism of action - tissue damage and wound healing - is considered invasive. The procedure causes tissue damage, remodeling, scarring and shrinkage, which can cause narrowing of the anal canal and is intended - not fully clinically confirmed - to lead to a reduction in the severity of Fl symptoms [31].

Physiotherapy treatment

In the treatment of faecal and urinary incontinence, physiotherapy in the broadest sense of the term is used, which includes kinesitherapy and biological feedback -biofeedback.

Within kinesitherapy, Kegel exercises are used. It is the simplest and most recognized method of non-invasive treatment of FL/UI due to its uncomplicated technique and easy repetition. The number of contractions, duration of the procedure and sets of exercises vary depending on the type and extent of tissue damage. Currently, there is no established protocol for the physiotherapeutic treatment of FL/UI [32,33].

Kegel exercises have been shown to have a positive effect on faecal incontinence by increasing the contractile function of the external anal sphincter and pelvic floor muscles, including the levator ani. This type of contraction training has also been shown to be beneficial in 41%-66% of urinary incontinence cases [27,34].

The standard training scheme consists of 3 sets of 8 to 12 contractions for 8 to 10 seconds, performed 3 times a day. Patients are advised to perform this protocol daily. The recommended treatment duration is a minimum of 15 to 20 weeks. Specific exercise regimens vary widely in frequency and intensity, and the ideal exercise regimen has yet to be defined.

One randomized clinical trial using the Kegel technique has been conducted in recent years. It was analyzed in a group of sixty patients after radical prostatectomy (30 patients in the experimental group and 30 patients in the control group) and proved the effectiveness of physiotherapy in this group of patients [35].

A second, frequently used form of physiotherapy treatment is Biofeedback Therapy. This is a technique in which neuromuscular and autonomic activity is monitored, amplified and transmitted to the patient as visual or acoustic signals. In the case of urinary incontinence, this method involves placing a pressure sensor in the vagina, which measures the pressure and provides audible or visual feedback on the strength of contraction of the pelvic floor muscles [36,37].

For faecal incontinence, a pressure transducer, perfused catheter or balloon is inserted into the anal canal to measure the pressure in the anal canal and the force of contraction and relaxation of the pelvic floor muscles.

The aim of these measures is to strengthen the anal sphincter in order to restore a normal bowel movement pattern.

Following a study by Wu XD et al, biofeedback training with pelvic floor muscle exercises was shown to be an effective non-invasive technique for the treatment of Fi/Ui [38].

Conclusions

A review of the literature indicates that the problem of FI/UI is a significant clinical issue of concern to clinicians due to very limited treatment techniques. There is a lack of primary research covering this issue in the world literature. The available physiological studies are of relatively limited relevance due to the small number of cases analysed or an overly one-sided and single-pronged view of the topic. Following the example of fetal work carried out on other material [39,40], it would seem advisable to extend basic research to include an anatomical evaluation of the fascia of the pelvic floor and also to extend microscopic examination. Perhaps, however, it is only research based on an assessment of cell biology that will allow us to understand the ultimate causes of FI/IU and, on the basis of this, effective treatment methods - especially non-invasive treatment - can be developed [41,42].

After all, most cases of FI/UI affect elderly patients, where there are many contraindications to complex surgical interventions.

Ethical approval

The conducted research is not related to either human or animal use.

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Conflicts of interest

The authors declare they have no conflict of interest.

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