Chapter

Therapeutic Effect of Magnetic Stimulation Therapy on Pelvic Floor Muscle Dysfunction

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Abstract

Pelvic bottom dysfunction includes sexual dysfunction, lower urinary tract dysfunction, defecation dysfunction, etc., and the quality of daily life is significantly impaired. Although drug based and surgical therapies exist as treatment methods, non-invasive treatment methods for pelvic floor dysfunction are highly desired, and magnetic stimulation therapy is attracting attention as a potential new approach. Magnetic stimulation therapy can generate deeper stimulations as compared to electrical stimulation therapy, is less painful, and can be performed while wearing clothes. In addition, it is a very safe treatment method with only few reports of side effects. From nocturnal enuresis in children to middle-aged sexual dysfunction and urinary incontinence in the elderly, therapeutic effects on various pelvic floor dysfunctions have been confirmed regardless of age and gender. It is expected that magnetic therapy will continue to develop as a new therapy in the futures. This chapter first describes the pelvic floor muscles and the principles of anatomy and magnetic therapy. In addition, the therapeutic effects of magnetic therapy will be explained in detail one by one. We will also explain the potential application of magnetic therapy for sarcopenia, which is a problem in our aging society.

Keywords: magnetic stimulation therapy, pelvic floor muscles, urinary incontinence, men's health, sarcopenia

1. Introduction

The pelvis contains organs such as the bladder, prostate, (uterus in women), and rectum, and the pelvic floor muscles are the underlying muscles. The pelvic floor muscles wrap around the pelvic bones and support several organs. Some pelvic floor muscles form a sling around the rectum for greater stability. The functioning of these pelvic floor muscles maintains urination, defecation, and sexual life. However, if the muscles at the bottom of the pelvis cannot be properly relaxed during urination or defecation, urinary incontinence, fecal incontinence, ED, and women will experience pain during sexual intercourse.

Pelvic bottom dysfunction (PFD) is a disease caused by damage, dysfunction, and degeneration of pelvic bottom supporting tissue, which is advocated by the International Urological Society (IUGA) and the International Continence Society (ICS). It mainly includes pelvic organ prolapse (POP), pelvic pain, sexual dysfunction, lower urinary tract (LUT) abnormality, and defecation dysfunction. The causes of such pelvic floor muscle dysfunction are not known at all, but aging, obesity, pregnancy, pelvic surgery, etc. are known as factors.

The first non-invasive treatment proposed for pelvic floor muscle dysfunction is pelvic floor muscle training (PFMT), but the results are inconsistent. Systematic review and meta-analysis of non-surgical treatments for urinary incontinence, examining combinations of five common interventions: PFMT, electrical stimulation (ES), vaginal cone (VC), bladder training (BT), and serotonin-noradrenaline reuptake inhibitors (SNRIs). This study reported that more intense PFMT was an effective treatment, but incontinence assessment methods and intervention protocols differed between studies, and further research is needed [1]. Given the difficulty and effectiveness of sustaining PFMT, new conservative therapies are needed to replace pelvic floor muscle training.

In recent years, the US Food and Drug Administration has approved magnetic stimulation as a new non-invasive treatment method for pelvic floor muscle dysfunction. Magnetic stimulation therapy is a method of non-invasively stimulating central nerves and peripheral nerves using electric current generated by magnetism. This method was previously used in the fields of neurology and orthopedics as transcranial magnetic stimulation and skeletal muscle magnetic stimulation, but in the field of urology, it is mainly used for the treatment of urinary incontinence. Furthermore, magnetic stimulation therapy has been found to be effective not only in urinary incontinence but also in a series of diseases related to the pelvic floor muscles.

This paper focuses on magnetic stimulation therapy and introduces various therapeutic effects on pelvic floor muscle disorders.

2. Functional anatomy of the pelvic floor muscles

The bottom of the pelvis has a three-layer structure from the upper part to the visceral pelvic diaphragm, the pelvic diaphragm, and the urogenital diaphragm. The target approach to the pelvic floor muscles is the muscles in the second layer of the pelvic diaphragm. The pelvic diaphragm mainly consists of the levator ani and coccygeus muscles. The levator ani muscle consists of medial and lateral muscles, and the medial pubococcygeus is inside the levator ani tendon arch, originating from the pelvic fascial tendon arch, supporting the outside of the vagina and rectum, and attaches to the anterior sacrococcygeal ligament. The lateral iliococccygeus muscle begins at the levator ani tendon arch and attaches to the tip and lateral edge of the coccyx. The levator ani and coccygeus muscles form the pelvic diaphragm and close the pelvic outlet. The left and right levator ani muscles do not intersect in the center and form a fissure that penetrates the urethra, vagina, and rectum. On the other hand, the coccygeus muscle covers the inner surface of the ischial spine to the inner surface of the sacral ligament and attaches to the lower part of the sacrum and the outer edge of the coccyx.

3. Motor function of the pelvic floor muscles

The pelvic floor muscles support the organs and are active at rest. Therefore, the pelvic floor muscle group is composed of slow muscle fibers that act as posture maintenance at a high rate. Furthermore, the pelvic floor muscles do not work alone, and when the pelvic floor muscles are contracted, the abdominal muscles contract, and conversely, when the abdominal muscles are contracted, the pelvic floor muscles are also activated. When the abdominal pressure rises, the pelvic floor muscles and abdominal muscles move inward. However, in cases of dysfunction of the pelvic floor muscle group such as urinary incontinence, the pelvic floor muscle group and the abdominal muscle move outward [2].

4. What is magnetic stimulation therapy?

4.1 Principle of magnetic stimulation therapy

When an electric current is passed through the coil, a magnetic field is generated along the coil axis. An electric field is induced in proportion to the rate of change of the magnetic field, stimulating skeletal muscle, the autonomic nervous system, and the somatic nervous system. When a pulsed current is passed through the coil of a chair, a pulsed magnetic field is generated in the pelvis and an eddy current is generated. The eddy current stimulates the pelvic floor muscles, which are mainly the pelvic nerve, and suppresses the pelvic nerve and stimulates the lower abdominal nerve via the afferent fibers of the pelvic nerve and bladder, and the urinary muscle. As a result, the pressure in the urethra increases and bladder contraction is suppressed.

4.2 Advantages and disadvantages of magnetic stimulation therapy

There are three major advantages of magnetic stimulation therapy compared to electrical stimulation therapy. One is the depth of stimulation. Magnetic stimulation therapy can stimulate nerves deeper than electrical stimulation. Currently, in Japan, a chair-type stimulator that magnetically stimulates the area around the anus is used. Such stimulation of deep nerves is difficult to reproduce with electrical stimulation therapy.

The second is that it can be done non-invasively. Since the magnetic stimulation penetrates clothes, skin, bones, etc., it can be performed while wearing clothes without inserting an anus or vaginal electrodes. Therefore, this treatment method is more comfortable and less embarrassing. Furthermore, the targets to be stimulated are the sacral nerve and the pelvic floor, but treatment can be performed without pain often observed in electrical stimulation.

The third is safety. Magnetic stimulation therapy is considered to be an extremely safe and side-effect-free treatment. In a multicenter, randomized, sham-controlled trial, magnetic stimulation therapy did not show any adverse events compared to the placebo group [3]. This data suggests that magnetic stimulation is safer than electrical stimulation associated with side effects such as abdominal pain and diarrhea [4].

However, there are two major disadvantages. One is the need to go to the hospital. Magnetic therapy does not end with just one treatment, and requires about 8–16 visits in 1 to 2 months. Depending on access to the hospital and the patient's health condition, this might be challenging. The second disadvantage is that this can be a difficult intervention in certain patients. For example, in patients with a pacemaker,

Pros	Cons
• stimulation of nerves in deep muscles • no requirement for dressing change • minimal side effects	• difficult to perform on patients who is with tattoo or a pacemaker.

Table 1.
Pros and cons of magnetic stimulation therapy.

magnetic therapy can cause malfunctions, and in patients with tattoos, the likelihood of burns increases (**Table 1**).

5. Therapeutic effect of magnetic therapy

5.1 Effect on urinary incontinence

Urinary incontinence (UI) is a common urinary disease and is usually defined as involuntary urine leakage due to weakening of the urethral sphincter and pelvic floor muscles without the need for urination [5]. According to the International Continence Association (ICS), urinary incontinence affects more than 200 million people worldwide, primarily women. Half of women may not report UI, perhaps because of embarrassment, lack of knowledge about treatments, and the belief that UI is normal with age. Urinary incontinence can be divided into (i) stress incontinence (ii) urge incontinence (iii) mixed incontinence, which is a combination of the two types. Stress urinary incontinence accounts for 29–75% of women, urge incontinence accounts for 7–33% of the population, and mixed urinary incontinence accounts for 14–61% of the population. Men may also develop urinary incontinence due to urethral sphincter deficiency after radical prostatectomy, adversely affecting the patient's quality of life [6]. Controlling urinary incontinence is also an important issue for extending healthy life expectancy. It is known that the prevalence of urinary incontinence increases with age in the elderly. A large database analysis in Northern California found that the risk of admission to a long-term care facility after diagnosis of urinary incontinence was twice as high for women and 3.2 times for men, and increased the risk of hospitalization [7].

Various research reports have been published on the therapeutic effect of magnetic stimulation on stress urinary incontinence (SUI). In a randomized, double-blind, sham controlled trial of 120 female patients with SUI, the treatment group received magnetic stimulation twice a week for a total of 16 times over a two-month period. When the primary endpoint is a decrease in the score of ICIQ-UI SF (International Consultation on Incontinence Questionnaire for Urinary Incontinence-Short Form) by 5 points as the therapeutic response, the therapeutic response in the magnetic therapy group is 3.46 times that in the placebo group. The total score of ICIQ-UI SF decreased significantly. There was also a consistent significant improvement in score between 1 and 2 months, indicating that 8-week PMS was more effective than 4-week. An additional year of follow-up suggested that the effect was long-lasting [8]. In a pilot study comparing 52 randomized patients with SUI, the treatment group showed lower myostatin levels and improved UI severity ratings (The Revised Urinary Incontinence Scale) and depression severity (Beck Depression Inventory) before and after treatment [9]. In a randomized, sham-controlled trial of 30 female SUI patients resistant to pelvic floor muscle training, magnetic stimulation significantly improved ICIQ-SF and the abdominal leak point pressure (ALPP) in the treatment group compared to baseline, with significant differences between groups ($P < 0.05$). In addition, self-efficacy beliefs (GSES) improved in the magnetic therapy group, and the authors reported that there were effects of magnetic therapy on both physical and psychosocial aspects [10]. In a randomized controlled trial of three groups of women with SUI: a pelvic floor muscle training and extracorporeal magnetic therapy group and a control group, the two treatment groups showed a decrease in depressive symptoms (BDI-II) and significant improvements in an improvement in urinary incontinence severity (RUIS) and several quality of life items (KHQ). Moreover, GSES improved in the extracorporeal magnetic therapy group [11]. A study was also conducted to evaluate the effect of sacral magnetic stimulation (SMS) on functional and urodynamic improvement in patients 45–75 years of age with refractory SUI. This study was a sham-controlled, double-blind, parallel study with a follow-up of 4.5 months [12]. Compared to the sham group, the experimental group showed significant improvement in Urge-Urinary Distress Inventory and Overactive Bladder Questionnaire (OAB-q) scores after the intervention and also at follow-up. In addition, there were significant increases in bladder capacity, urethral functional length, and pressure transmission ratio after the intervention. The response to SMS was greater in patients with severe SUI than in patients with mild symptoms, confirming the effectiveness of SMS in the treatment of SUI. In another study, a total of 75 patients with stress urinary incontinence were subjected to repetitive magnetic stimulation of 15 Hz. at the sacral root at 50% intensity output for 30 minutes with a duration of 5 seconds per minute. As a result, an obvious increase in urethral closing pressure and a significant increase in bladder capacity after stimulation were observed in the sacral stimulation group. In addition, the number of urine leaks and urine volume in the pad test were significantly decreased in the active stimulation group than in the sham stimulation group, and the QOL score was also significantly improved. The improvement rate of the active stimulation group was 74%, which was significantly higher than that of the sham stimulation group (32%) [13]. A randomized controlled trial investigating the short- and long-term effects of repetitive magnetic stimulation on the sacral root observed an improvement in the quality of life of patients with abdominal stress urinary incontinence at one week after stimulation [14].

Some studies have reported therapeutic effects on urge and mixed urinary incontinence. In a multicenter, randomized, single-blind, controlled trial of 151 women with urge incontinence with overactive bladder, armchair-type magnetic stimulators were used to stimulate magnetically twice a week for 25 minutes. As a result, the number of urine leaks / week according to the bladder diary was significantly improved in the treatment group, and the urgency within 24 hours and the average excretion amount were also significantly improved. In addition, the change in total OABSS from baseline was significantly lower in the treatment group than in the sham group, and the change in mean IPSS-QOL score was also significantly lower in the treatment group [3]. A retrospective study conducted in Italy examined the effects of magnetic therapy on 20 men and women with stress incontinence, urge incontinence, and mixed incontinence. The treatment was performed using a functional magnetic stimulator and a magnetic coil installed under the seating surface of the chair. During treatment, the patient was instructed to sit in a chair so that the perineum was centered on the coil and that muscle contractions (pelvic floor and sphincter contractions) were felt during stimulation. Patients were treated for 20 minutes / session, twice a week for 3 weeks (6 times in total). The stimulation frequency was fixed at 10 Hz for 10 minutes and at 35 Hz for another 10 minutes, and the activity time and rest time were 6 seconds each. As a result, micturition frequency and nocturia were significantly reduced before and after treatment, and bladder capacity was significantly increased [15]. A study of 82 female patients with various urinary incontinences in Slovenia received 10 magnetic stimuli over a 4-week period. As a result, in urge incontinence and mixed incontinence, the frequency of urinary incontinence, the number of daily urinary incontinence, and the decrease in the number of urination were statistically observed [16].

5.1.1 Postoperative urinary incontinence of prostate cancer

Prostate cancer is the number one cancer in Europe and the United States that affects men. Surgery and radiation therapy are used for localized prostate cancer. Although surgical invasion has been significantly reduced due to the spread of surgical robot Da Vinci technique in recent years, postoperative stress urinary incontinence caused by removal of the prostate reduces the patient's QOL. In a multicenter study in the United States, 46% of patients required a urinary incontinence pad 6 months after surgery, and urinary incontinence often persists long after surgery [17]. In a previous study, 10 patients who had been suffering from urinary incontinence for more than 12 months after radical prostatectomy were treated with magnetic therapy for 20 minutes, twice a week for 2 months. The pulsed field frequency was 10 Hz for 10 minutes, followed by a second treatment at 50 Hz for 10 minutes. As objective and subjective evaluations, a micturition diary, a 1-hour pad weight test, and a quality of life survey were performed 1, 2, 3, and 6 months after the start of treatment. As a result, 30% of patients became dry and 30% showed improvement. In the 1-hour pad weight test, the average pad weight decreased from 25 to 10.3 g, and the QOL score improved significantly 2 months after treatment. In addition, the number of urine leaks per day decreased from 5.0 before treatment to 1.9 after treatment [18]. Although robotic surgery has improved the degree of urinary incontinence, 14% of patients in our department still use two or more urinary incontinence pads/day after 6 months post surgery. In order to improve this annoying complication after surgery, our facility is currently actively adopting magnetic therapy.

5.2 Effect on detrusor overactivity

Detrusor overactivity is a common cause of urge incontinence in elderly and young patients. It occurs when the detrusor muscle contracts intermittently for no apparent reason when the bladder is partially or almost completely filled. Detrusor overactivity can be idiopathic or due to dysfunction of the detrusor center of the frontal lobe (generally due to age-related changes, dementia, or stroke) or lower urinary tract obstruction. Urinary muscle overactivity with contractile force disorder is a variant of urgency urinary incontinence, characterized by urinary urgency, pollakiuria, decreased urinary retention, urinary retention, bladder pillar formation, and post-micturition residual urine volume of over 50 mL. In a study comparing magnetic therapy with the placebo group for idiopathic detrusor hyperactivity, the magnetic therapy group significantly reduced the number of micturitions per day compared to the placebo group. It was also confirmed that the number of urination and QOL per day improved although the sample size was not sufficient [19].

In a randomized controlled trial of 32 men and women comparing the effects of magnetic and electrical stimulation, a significant increase in bladder capacity was found in the magnetic stimulation group [20].

5.3 Effect on neurogenic overactive bladder

Neurogenic bladder is a lower urinary tract dysfunction caused by a neurological disorder, and the diagnosis is based on urodynamic testing. When the upper part of the pontine detrusor center existing in the brain stem is damaged, neurogenic detrusor overactivity causes the bladder to contract involuntarily against the intention of the person occurs, resulting in urge incontinence and pollakiuria. In a study comparing the effects of pulsed electromagnetic field therapy (PEMFT) and transcutaneous electrical nerve stimulation (TENS) on neuropathic overactive bladder dysfunction in patients with spinal cord injury (SCI), 50 male and 30 female patients (average age of 40 years) with secondary neuropathic overactive bladder due to spinal cord injury were recruited. Urinary tract dynamics (UDS) were performed before and after treatment. 40 patients received TENS (10 Hz, 700 second pulse) 3 times/week, for a total of 20 times and the remaining 40 patients received PEMFT (15 Hz, 50% intensity 5) 3 times/week, for a total of 20 times. As a result, the maximum cystometric capacity, volume at first uninhibited detrusor contraction, and maximum urinary flow rate were significantly increased in the PEMFT group, indicating that PEMFT is superior to TENS in terms of therapeutic effect [21].

5.4 Effect on bedwetting

Nocturnal enuresis is usually the involuntary urination during sleep after the age at which bladder control begins. According to the American Psychiatric Association's DSM-IV, primary nocturnal enuresis (PNE) was described as "children 5 years and older who repeatedly urinate in bed and clothing twice a week for at least 3 consecutive months, not resulting from side effects and medical conditions of drugs. " Nocturnal urine in children and adults causes mental stress and sometimes causes complications such as urinary tract infections. A study evaluating the potential clinical and urodynamic effects of functional magnetic stimulation (FMS) in the treatment of girls with primary nocturnal enuresis (PNE) compared to placebo reported the effects of magnetic therapy. 20 PNE girls (average age of 10.8 years) were given a magnetic stimulator for 2 months day and night, the number of episodes of nocturnal urine decreased from 3.1 to 1.3 times a week in the magnetic therapy group before and after treatment. In addition, the bladder volume at the strong desire to void increased significantly compared with the placebo group [22].

Monosymptomatic nocturnal enuresis (MNE) refers to patients with nocturnal enuresis without other lower urinary tract symptoms such as daytime urinary incontinence and urgency. In a study that randomly assigned 44 patients with MNE to receive 10 sets of repetitive sacral root magnetic stimulation (rSMS), the treatment group significantly improved the mean nocturnal urine per week compared to the placebo group. The effect was maintained even 1 month after the treatment. The treatment group also showed improvement in visual analog scale (VAS) and quality of life [23].

5.5 Effect on chronic pelvic pain syndrome

Chronic pelvic pain syndrome includes inflammation of the prostate gland, pain from the lower abdomen to the lower body, discomfort around the pelvic body, urinary symptoms such as close urine and feeling of residual urine, discomfort during ejaculation, and erectile dysfunction. It is a disease reminding of sexual dysfunction. Although the exact causes have not been clarified yet, blood flow disorders and autoimmune reactions around the prostate gland, urine reflux into the prostate gland due to dysuria, sensory nerve abnormalities in the pelvis and lower body, adrenal gland hormones and abnormalities in sex hormones are believed to be the causes. It is often seen in relatively young people (late teens to 40s), and the symptoms worsen when the perineal area is compressed by a long sitting posture (desk work, driving a car, bicycle, motorcycle, etc.).

In addition, psychological stress, fatigue, smoking, excessive drinking, and poor circulation are also factors that worsen the symptoms. It is characterized by the absence of typical symptoms but various symptoms from the lower abdomen to the lower body start to appear. Pain may be felt not only in the perineum near the prostate, but also in areas not related to the prostate, such as the lower back, urethra, groin, thighs, and lower abdomen. In addition, it may be accompanied by urinary symptoms such as close urine, feeling of residual urine, weak urine momentum, pain in the urethra when urinating, and sexual dysfunction such as discomfort during ejaculation and erectile disorder.

A randomized, placebo-controlled, double-blind study of 60 men with refractory chronic pelvic pain syndrome evaluated improvement in the Chronic Prostatic Inflammatory Symptom Index (NIH-CPSI) of the National Institutes of Health. The QOL score was significantly improved 12 weeks after treatment compared to the placebo group. In addition, patients with persistent symptoms of 1 year or less were more effective than patients with long-lasting symptoms [24].

On the other hand, there are also studies in which randomized, double-blind, placebo-controlled treatment was used for chronic pelvic pain in women. In this study, 32 patients with chronic pelvic pain were treated with active magnets (500G) or placebo magnets 24 hours a day at trigger points in the abdomen. After 1 month of treatment, McGill Pain Questionnaire, Pain Disability Index and Clinical Global Impressions Scale were evaluated. As a result, the Pain Disability Index, Clinical Global Impressions-Severity, and Clinical Global Impressions-Improvement were significantly lower in the treatment group than in the placebo group, demonstrating the therapeutic effect of magnetic therapy [25].

5.6 Effect on fecal incontinence

Fecal incontinence is defined as an involuntary leak of liquid or solid stool that poses a social or hygienic problem. Fecal incontinence is not life-threatening, but it is an intolerable symptom for patients and significantly impairs their quality of life. The prevalence of fecal incontinence over the age of 65 in Japan is 8.7% for men and 6.6% for women. In the elderly, the onset of fecal incontinence often triggers admission to a facility, and it is thought that even for home care recipients, the most worrying thing about caregivers is receiving excretory care. Fecal incontinence is classified into leaky fecal incontinence, in which stool leaks without being noticed, urgent fecal incontinence, in which stool leaks without being able to endure the toilet, and mixed fecal incontinence, which is a mixture of both. It is roughly divided into. Leaky fecal incontinence is more likely to occur when the internal anal sphincter is impaired, and urgent fecal incontinence is more likely to occur when the external anal sphincter is impaired. The internal anal sphincter muscles often weaken with age, and the external anal sphincter muscles are often injured by labor or surgery for rectal cancer.

Surgical treatments for fecal incontinence include sacral stimulation therapy, anal sphincter plasty, and stoma construction. From the viewpoint of evidence and invasiveness, it is desirable to try non-invasive therapies first. Non-invasive therapies include diet / lifestyle / defecation habit guidance, drug therapy, pelvic floor muscle training, biofeedback therapy, butt plugs, and retrograde intestinal lavage (irrigation defecation). The objectives are fecal solidification, increased contractility of the pelvic floor muscles, including the external anal sphincter, normalization of rectal sensation, and regular emptiness of the rectum and colon.

In a study reporting the effects of magnetic therapy on fecal incontinence, 10 patients with fecal incontinence with an average age of 57 years received perineal magnetic stimulation (10 Hz and 50 Hz) twice weekly for 5 weeks. Both 10 Hz and 50 Hz stimulation significantly increased anal pressure compared to baseline rest. After treatment, anal pressure increased significantly and the score for fecal incontinence improved significantly [26].

6. Application to men's health

Erectile dysfunction (ED), one of the male sexual dysfunctions, is defined as persistent or recurrent erections that are insufficient or unsustainable for satisfactory sexual activity. ED is the second most common sexual problem in men after premature ejaculation, and epidemiological studies indicate that it affects 30 million people in the United States. ED has a strong negative impact on self-esteem and self-confidence, can reduce the quality of life for men and their partners, and can affect all aspects of life. The pathophysiology of ED includes angiogenic, neurogenic, anatomical, hormonal, drug-induced, and / or psychogenic causes.

Risk factors for ED include aging, diabetes, obesity and lack of exercise, cardiovascular disease and hypertension, smoking, chronic kidney disease, lower urinary tract symptoms, neurological disorders, depressive symptoms, drugs, sleep apnea syndrome, etc. As a treatment, oral preparations such as sildenafil and intraspinal injection are used. However, patients often change treatment methods due to lack of therapeutic effects and the high costs. Therefore, a therapeutic approach that emphasizes long-term satisfaction is needed.

The magnetic field induces an alternating current in the electrolyte in the body, which affects the water content of cells, mitochondrial function, nutrition, oxygen, amino acid uptake, energy production, etc. Appropriate magnetic fields can increase the uptake of oxygen by cells, promote blood circulation, and restore dysfunction. In a canine study, magnetic stimulation of the corpus cavernosum nerve increased intracavitary pressure, resulting in a complete penis erection after an incubation period of approximately 8 seconds. Upon discontinuation of stimulation, erection and intracavitary pressure returned to baseline after an average of 14 seconds [27]. In a study of 32 neuropathic ED patients and 20 healthy volunteers, a magnetic coil was placed on the dorsal side of the penis near the symphysis pubis, with 40% strength, 20 Hz frequency, and 50 seconds of magnetism. The stimulation was performed, and 50 seconds later, the magnetic stimulation was stopped. As a result, the magnetic therapy group was able to induce penile stiffness non-invasively without side effects [28]. A double-blind, placebo-controlled trial evaluating the effectiveness of impulse magnetic-field therapy for psychogenic erectile dysfunction or orgasmic disorders has also been reported [29]. Twenty men between the ages of 30 and 60 who suffered from ED and orgasm dysfunction were treated with Impulse magnetic-field therapy for 3 weeks, and the treatment group showed improved erection intensity, duration, well-being and sexual activity as compared to the placebo group [29]. No side effects from treatment were reported.

The data above supports the effectiveness of magnetic therapy for various types of ED, drawing more and more attention to magnetic therapy in the men's health community.

7. Frail and sarcopenia

Frail is a state that shows vulnerability to external stress with aging, and is said to be different from the state requiring nursing care. There is no global definition of frailty or diagnostic criteria, but Fried's criteria are widely adopted [30]. It has been pointed out that the onset of frailty is related to the decrease in hormone levels such as sex hormones and vitamin D, nutritional status and nutrient intake, and the relationship between low testosterone status and frailty syndrome, physical function, and fall risk [31]. In addition, a study analyzing the relationship between frailty and urinary incontinence in 300 elderly people in Italy found that elderly people with urinary incontinence were at significantly higher risk of being classified as frailty, and urinary incontinence is a marker of frailty in the elderly [32].

Sarcopenia's pathology is similar to the frailty syndrome and is also a major contributor to the physical frailty syndrome, defined as age-related loss of muscle mass and strength. Frail's phenotype can be broadly divided into five types. That is, malnutrition (weight loss), subjective decreased vitality (easy fatigue), decreased activity, decreased mobility (decreased walking speed), and decreased muscle strength (decreased grip strength). Of these, weakness and weakness are called physical frailty and are elements of sarcopenia. Sarcopenia has been attracting attention in recent years as a cause of bedridden and fall risk in the elderly. The prevalence of sarcopenia is estimated to be approximately 9% in young women and approximately 18% in older men [33]. The causes of sarcopenia are qualitative changes accompanied by functional decline such as fast muscle fiber-specific atrophy, decreased fiber count, and connective tissue hyperplasia due to changes in nutritional status, decreased physical activity, and production of inflammatory cytokines.

Eddy currents caused by magnetic stimulation induce contraction of skeletal muscle by causing depolarization of cell membranes of peripheral nerves and skeletal muscle. Electrical stimulation has been widely used in the clinical setting of conventional rehabilitation, but rehabilitation by painless magnetic stimulation is expected in the future. In addition, a study examining the relationship between sarcopenia and ADL in patients with early-stage Alzheimer's suggests that disorientation and sarcopenia may interact to induce functional urinary incontinence. In addition, another study examining the correlation between dysuria and the overall functioning of the elderly found a significant correlation between urinary storage symptoms and the Barthel Index, suggesting that improvement in dysuria leads to improvement in symptoms, including sarcopenia. From these reports, magnetic therapy is expected to improve muscle mass and dysuria in sarcopenia patients, and may be a breakthrough non-invasive therapy in our aging society.

8. Current status of magnetic therapy in Japan and our efforts

In Japan, insurance is applied to female patients with intractable overactive bladder who do not improve their symptoms even after taking a urinary incontinence drug

Figure 1.
A device of magnetic stimulation therapy (Starformer by Fotona).

for 12 weeks or more, or who cannot use the drug due to the side effects of the drug. Insurance can be calculated up to 2 courses per year, with 6 weeks as 1 course, up to 25 minutes each time, up to 2 times a week. Considering reports from other countries, the usefulness of magnetic therapy is considered to span multiple diseases, and the therapeutic indication in Japan is still narrow. Therefore, our related facilities are providing treatment to patients with a wide range of diseases by introducing overseas magnetic stimulators (**Figure 1**). Although the number of cases is still small, magnetic therapy is performed for 20 to 30 minutes at a time, 1 to 2 times a week, for a total of 8 times as one course. Comparing the questionnaires before and after the treatment, both men and women showed improvement in nocturia, urinary incontinence, and sexual dysfunction in men, and felt the effectiveness of magnetic treatment. In fact, patients said "the number of nighttime urinations did not improve with drug therapy or physical therapy but decreased from 3 to 1 since I started magnetic therapy", "the intervals between urination has increased and it has become easier during the day and night", "urine leakage has improved and pad replacement has decreased", "erectile power has improved", and "I have improved my back pain after magnetic therapy." If the effect is poor in one cool, a second cool is recommended, and might improve the effects. I feel that it is necessary to increase the number of cases in future in order to expand the scope of application of magnetic therapy in Japan.

9. Conclusions

Magnetic therapy is a safe, non-invasive treatment that could be potentially used to treat pollakiuria, incontinence, men's health, and sarcopenia. With further research evidence in the future, it may become the gold standard for the initial treatment of pelvic dysfunction.

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Conflict of interest

The authors have no conflict of interest.

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