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SPORTS, PHYSICAL ACTIVITY AND PELVIC FLOOR MUSCLE DISORDERS

BOROȘ-BALINT IULIANA[1*], CIOCOI-POP D. RAREȘ[1], SIMON-UGRON AGNES[1] & VĂDAN ANCA LUCIA[1]

ABSTRACT. Introduction: Physical activity is essential to leading a healthy lifestyle; however, in some cases (when not adequate to one's individual needs, both quantitatively and qualitatively), it might lead to unforeseen outcomes. One such consequence is pelvic floor muscle dysfunction, nowadays a major public health problem, mainly because of its impact on the quality of life of the general population and the associated high health costs, respectively. **Material and Methods:** The articles used for the study were available via online databases. Our research is based solely on studies written in English, out of which 65 represent the main frame of this paper. **Results:** Participating in high-intensity physical activities (competitive sports, challenging manual labour) can increase the load on pelvic floor muscles. What is more, overloading the pelvic floor muscles might lead to disorders such as incontinence or pelvic organs prolapse. Some studies showed a 41% prevalence of urinary incontinence in elite athletes. This prompted us to review the circumstances leading to the pelvic floor disorders, more specifically, the relationship between physical activity and pelvic floor muscle dysfunctions. The analysis was based on the available published literature. Physical activity (PA) refers not only to recreational and regular physical training, but also to household tasks and other work-related and transport-related undertakings. Women engaged in hard manual labour can be 9.6 times more likely to have stage 2-4 grade uterine prolapse. **Conclusions:** Women suffering from urinary stress incontinence should be encouraged to participate in regular leisure and fitness activities and women engaged in vigorous physical activity have to be forewarned. Specific perinea muscle reinforcement may be needed in order to maximize the pelvic floor muscle strength.

Keywords: *physical activity, sport, manual labour, pelvic floor muscle dysfunction.*

REZUMAT. *Sportul, activitatea fizică și disfuncțiile musculaturii planșeului pelvian*. Introducere: Activitatea fizică este esențială pentru a avea un stil de viață sănătos; cu toate acestea, atunci când nu este adaptată nevoilor individuale, atât din punct de vedere calitativ, cât și din punct de vedere cantitativ, ea poate

[1] *Babeș-Bolyai University, Faculty of Physical Education and Sport, Cluj-Napoca, Romania*
[*] *Corresponding author:* iuliana.borosbalint@ubbcluj.ro

avea urmări nedorite. Una dintre aceste consecințe nedorite este afectarea musculaturii planșeului pelvian, considerată în prezent o problemă majoră de sănătate publică, datorită atât impactului negativ asupra calității vieții, cât și costurilor mari pe care le generează. **Material și Metode**: Articolele introduse în acest studiu au fost selectate din bazele de date disponibile online. Au fost căutate doar articole în limba engleză, fiind selectate 65 dintre acestea. **Rezultate**: Practicarea activităților fizice de mare intensitate (sport, muncă fizică solicitantă) poate crește solicitarea musculaturii planșeului pelvian. Suprasolicitarea musculaturii planșeului pelvian poate duce la incontinență urinară sau la prolapsul organelor pelviene. Unele studii indică o prevalență de 41% a incontinenței urinare în rândul sportivelor de performanță. Drept urmare, am decis să investigăm condițiile în care apare afectarea musculaturii planșeului pelvian, precum și legătura dintre activitatea fizică și afectarea musculaturii planșeului pelvian, bazându-ne pe literatura de specialitate disponibilă online. Prin activitate fizică se înțelege nu doar activitatea fizică practicată în mod regulat sau recreațional, ci și munca fizică sau căratul. Femeile care prestează muncă fizică grea au un risc de 9.6 ori mai mare de a prezenta prolaps uterin de gradul 2-4. **Concluzii**: Femeile care suferă de incontinență urinară de efort trebuie încurajate să practice în mod regulat activități fizice recreaționale, iar femeile care practică activități fizice de mare intensitate trebuie să fie prevenita asupra riscurilor. Exercițiile specifice pentru planșeul pelvian pot fi utile pentru a crește rezistența musculaturii de la acest nivel.

***Cuvinte cheie**: activitate fizică, sport, muncă fizică, disfuncțiile musculaturii planșeului pelvian.*

Introduction

Pelvic floor disorders (PFDs), for instance urinary incontinence and pelvic organ prolapse (POP) disregard age, having damaging effects on the quality of life and self-image of all women experiencing these disorders.

Pelvic organ prolapse refers to the abnormal descent of the pelvic organs (bladder, uterus, vagina, small bowel and rectum), from their normal position into the pelvis. Urinary incontinence (UI) is defined as any involuntary leakage of urine (Sultan et al., 2017) and is the most prevalent type of PFM dysfunction among women (Islam et al., 2017). Pelvic floor muscle dysfunction (PFMD) is present in many other clinical conditions, such as fecal incontinence (Hock et al., 2019), pelvic pain syndrome and sexual dysfunction (Bortolini et al., 2010). Regarded as shameful, sexual dysfunction is oftentimes difficult to approach thus making it a rarely looked upon problem, though it would be easily measured using the Female Sexual Function Index (FSFI). (Rosen et al., 2000; Wiegel et al., 2005; Hock et al.,

2019). Advancing age, childbirth, obesity and race are associated with both pelvic organ prolapse and urinary incontinence. (Good et al., 2019) Other risk factors, such as hysterectomy, hormone therapy and family history, have been less well explored. Up to one in seven women undergoes surgery for pelvic organ prolapse and/or urinary incontinence in her lifetime, procedure that can also be accompanied by incontinence and deterioration in one's sexual life. (Hock et al., 2014; Hock et al., 2015).

Stress urinary incontinence (SUI) is defined by the International Urogynecological Association (IUGA)/International Continence Society (ICS) as 'a complaint of involuntary loss of urine on effort or physical exertion (e. g. such as sporting activities), or on sneezing or coughing'. SUI lowers the quality of life and well-being (Monz et al., 2005; Krause et al., 2003; Papanicolaou et al., 2005) of affected women and reduces their participation in sports and fitness activities (Bo et al., 2004; Nygaard et al.,1990) as well. A higher prevalence of UI has been found in female athletes (Eliasson et al., 2002) as they appear to have a 2.5 times greater risk of having UI than physically inactive women (Da Roza et al., 2015). SUI is a non-negligible problem in nulliparous female athletes, with the prevalence varying from 12.5% to as high as 80% (Almousa et al., 2015). SUI in young athletes often goes unreported for fear of embarrassment (Hägglund et al., 2007). Earlier studies have shown that treating women with incontinence or prolapse can positively influence their quality of life and sexual satisfaction. But women may delay care or not seek help because these conditions may lead to stigmatization. It is very important for the women to be forewarned, because different physiological conditions such as pregnancy, childbirth, or menopause can also alter further on pelvic floor muscle strength. (Hock et al., 2019, Hock et al., 2006)

One little known risk factor leading to pelvic floor muscle dysfunctions is choosing inadequate physical activities. Hence, this study is built as a survey meant to show the impact of physical activities on pelvic floor muscle conditions.

Methods

The articles required for the study were searched by means of the available online databases (www.sciencedirect.com / PubMed http://www.ncbi.nlm.nih.gov/pubmed), using keywords such as 'physical activity', 'leisure time physical activity', 'sports', 'physical work', 'incontinence', 'pelvic organ prolapse' and 'pelvic floor muscle strength'. Language was an equally important criterion in selecting the articles used in this survey; publications in other than English foreign languages were excluded. In this article, we mainly deal with the problems affecting women. Nonetheless, men also encounter pelvic floor muscle conditions and dysfunctions.

Pelvic floor exercises are commonly performed by women in order to strengthen their pelvic muscles, to improve continence and sexual function. Recent studies suggest that pelvic floor exercises can improve mens' sexual function as well. (Palancsa et al., 2018; Randolph et al., 2019). Based on the before mentioned criteria, 65 studies were selected. (We quoted 23 more articles in the explanation of the base definitions in the introduction and method section.)

Results

Recreational sports or leisure time physical activities and competitive sports

In a cross-sectional study of U.S. women, 28% of those who report UI find it to be at least a moderate barrier to exercising. 11.6% of women with UI did not exercise because of UI, 11.3% exercised less, 12.4% changed the type of exercise and 5% stopped exercising in a gym. For women with severe UI, about one-third did not exercise or exercised less because of UI. Women with other type of incontinence (overactive bladder, OAB) are less likely to undergo moderate or vigorous physical activities or to satisfy the recommended PA levels compared to those with no or minimal symptoms of OAB. (Nygaardet al., 2005; Coyne et al.,2013)

Habitual walking can decrease the odds of SUI by roughly one-half in older women from various ethnic backgrounds. Increased physical activity could, by increasing overall strength, regularly engaging pelvic floor musculature and decreasing weight, decrease UI or POP. Several studies have shown that current leisure activity is associated with lower odds of SUI while lack of exercise increases these odds (Hannestad et al., 2003; Zhu et al., 2008; Nygaard et al., 2015).

Knowledge of pelvic floor muscles (PFMs) in young female athletes is limited. There are two opposite hypotheses regarding their PFMs: (1) physical activity may strengthen the PFMs and (2) physical activity may overload and weaken the pelvic floor. The first theory is supported by findings of an increase in the cross-sectional area of PFMs in subjects whose activities included high-impact landing. (Kruger et al., 2005). Current data concerning the latter theory do not indicate that strenuous exercise prompts the development of SUI.

Even young nulliparous women often experience incontinence during exercise. Occurrence is greater during activities that require repetitive jumping (Fernandes et al., 2014), or is significantly more likely to occur in women who underwent basic parachute training than for those who did not (Larsen et al., 2007).

According to the "hammock hypothesis" theory, the levator ani muscle plays a crucial role in maintaining urinary continence (DeLancey et al., 1994). Whilst the intra-abdominal pressure increases, this pelvic floor muscle closes the uro-genital hiatus with a strong postero-anterior contraction in order to maintain continence and to resist the downward descent of the organs.

Assuming that high-intensity sport activity, sustained for a long period of time, can lead to an overload of the female musculoskeletal system, frequent exposure is expected to cause some degree of muscle damage or impairment and consequently alter the biomechanical response of the musculature in the long term (Bo et al., 2004; Dietz et al., 2008). Clinical observations have shown that levator ani injuries can result in reduced urethral support (urethral hypermobility) (DeLancey et al., 2002), which is often associated with stress incontinence.

However, there are significant differences in physiological conditions and environmental factors when comparing young female athletes with the general female population. (The contribution of these factors to the pathophysiology of stress incontinence remains unclear and requires further investigation.)

First, young female athletes are often exposed to significantly greater and sudden onset intra-abdominal pressure, especially during activities such as running and jumping (Goldstick et al., 2014). A pad test was used to test for loss of urine during jumping on a trampoline.80% of the participants reported urine leakage during training or competition and only 51.4% found it embarrassing. (There was no loss of urine during coughing, sneezing or laughing.) The mean urinary loss during the pad test was 28g (9-56g).

The examined athletes were less able to interrupt the flow of urine by voluntary contraction of the pelvic floor muscle than the control group. Incontinent trampoline athletes were significantly older (16 vs. 13 years old), trained longer and more frequently (Eliasson et al., 2002). Based on this, it seems that not only the type of exercise but also the frequency and intensity should be differentiated as a view of urine incontinence. In another study of nulliparous women, the largest negative effect of urine loss was reported during the most intensive part of the preparation period. (They were 2.5 times more likely to have urinary incontinence.) (Da Roza et al., 2015a; Da Roza et al., 2015b).

Another study also confirms the high incidence of urinary incontinence, particularly during high-intensity sport activities, in Q9 nulliparous athletes, and also points out that training duration can be a significant predictor of urinary incontinence. Athletes who considered themselves as not having continence dysfunctions showed urine loss during a one-hour training session. The severity and magnitude of urinary loss in the pad test was significantly related to the number of hours spent exercising daily (dos Santos et al., 2018).

The aim of a study was to assess the prevalence of urinary incontinence in fitness instructors and how people respond to incorporating PFM exercises into classes. The survey was completed by 106 participants, of whom 73.6% were female and 52.8% were in the 35–54 years age group. Prevalence of UI was 28.2%, and severity based on ICIQ-UI scores was 'slight' 65.2%, or 'moderate' in 26.1%. Leakage of urine was associated with physical activity in 36%, of whom 31.8% had not taken actions to reduce the impact and 86.4% had not sought professional advice or treatment. There was widespread willingness to incorporate pelvic floor muscle exercise into classes if given appropriate training 86.1%, and 67.1% would be happy to recommend a PFME app (Stephen et al.,2019).

Those who exercise more than 8 hours a week have a statistically significantly higher incidence of anal (wind and stool) incontinence than all other subjects (14.8% vs. 4.9, p = 0.001).In case of anal incontinence, mainly flatus was reported (84%). (Vitton et al., 2011).

Young university athletes were asked if they had ever experienced unexpected loss of urine due to participating in sports, coughing, sneezing, lifting heavy objects, going to the bathroom, sleeping, and the sound of running water. 28% reported at least one episode of urinary leakage during sport / competition (gymnastics 67%; tennis 50%; basketball 44%; shinney 32%; volleyball = 9%; swimming = 6%; softball = 6%; golf = 0%).42% experienced a loss of urine during daily activities and 38% experienced a disturbing situation (Nygaard et al., 1994). It is very important that even small amounts of urine can cause confusion and that 84% of athletes have never talked to anyone about their condition (Caylet et al., 2006). In addition to the type and intensity of exercise, preliminary evidence suggests that eating disorders may increase the risk of urinary incontinence in athletes (Jiang et al., 2004; Bo et al., 2001).

Borin et al. (2013) compared the strength of pelvic floor muscle of 10 handball, 10 volleyball and 10 basketball players and a non-athletic control group and found lower muscle strength in volleyball and basketball players compared to participants of control group. It was also established that lower muscle strength relates with increased symptoms of urinary incontinence. Although the incidence of urinary incontinence is high, many athletes do not perceive urine loss during strenuous activities and a high increase in abdominal pressure.

However, based on the principles of functional anatomy and biomechanics, it is likely that lifting heavy weights and strenuous physical activity can cause these conditions in already vulnerable women. Physical activity can reveal and worsen their condition (Moore et al., 2013). The authors emphasize that further studies are needed to understand the effect of different physical loads on the pelvic floor muscles. Previously examined physically active, nulliparous girls with SUI were diagnosed on upright voiding cysto-urethrography (VCUG) and the researchers

came to the conclusion that they should be considered for non-surgical therapy but will likely require bladder neck elevating surgery later. Non-surgical therapy works for those with minimal bladder descent on cystography (Bauer et al., 2018).

The results of muscle strength exercises have shown to increase muscle thickness, decrease muscle length, reduce the size of the levator hiatus, and raise the levator plate toward the abdominal cavity in pelvic organ prolapse-related diseases (Brækken et al., 2010). If the pelvic floor muscle has a certain "rigidity" (Ashton-Miller et al., 2001; Haderer et al., 2002), it is likely that the muscles can counteract the increased intra-abdominal pressure during exercise. There have also been studies on passive support options. There are tools that can be effective in preventing urine loss during physical activity. (A vaginal swab may be such a device). In a study by Glavind (1997), 6 women with stress incontinence used vaginal devices and they did not show urinary loss during 30 minutes of aerobic exercise. (The authors note that in the event of minor leaks, pads can be used during training and competition.)

However, little is known about the difference in the structure or function of the pelvic floor muscles in athletes. The levator ani muscle of 10 high impact frequent intense training (HIFIT) athletes was evaluated by MRI and researchers found about 20% larger cross-section area in the PFM compared to the age-matched nulliparous control group. HIFIT athletes showed greater mean diameter (0.96 cm vs. 0.70 cm, $P < 0.01$) in the pubo-visceral muscle as well (examined by ultrasonography), but found greater bladder sinking (prolapse) and larger hiatus size during Valsalva maneuver. (There was no difference between the participants at rest or during maximum voluntary contraction.) However, the pelvic floor muscle strength was lower in the athlete group than in the non-athlete group (Kruger et al., 2005; Kruger et al., 2007; Borin et al., 2013).

The highest rate of stress incontinence was found in volleyball players. It was found that cumulative MET did not influence the incidence of stress incontinence, but the type of sport did. As part of the risk assessment for stress incontinence, volleyball players were found to have a 116% chance of stress incontinence. In fitness, basketball and handball, the risk of stress incontinence was lower.

Tennis players, skaters and floorball players had no urine leakage and no evidence of stress incontinence. Stress incontinence (ICIQ-UI SF) (International Consultation on Incontinence Questionnaire Urinary Incontinence Short Form) was rated by participants in fitness, athletics, basketball, volleyball and handball as having a negative impact on quality of life (Hagovska et al., 2018). (The first-line treatment of pelvic floor muscle dysfunction is provided by a set of pelvic floor muscle rehabilitation methods, which has also been used favorably in volleyball players (Ferreira, 2014). The amount of urine lost (45.5%) and frequency (14.3%) were significantly reduced.

Studies, now to date, have shown a 41% prevalence of urinary incontinence in elite female athletes. Body weights of 1.6 and 2.5 fold were measured during moderate speed running (11 km / h) and believed to affect the pelvic floor muscle. Pelvic floor muscles therefore require not only adequate muscle strength but also rapid contractions. So far, research on the pelvic floor muscle function has focused on voluntary and concentric contractions. However, many activities in everyday life that typically cause urinary incontinence, such as running, require involuntary and rapid reflex contraction in the pelvic floor muscles. However, data on the reflex activity and contraction characteristics of the pelvic floor muscles under impact loading are far from complete (Leitner et al., 2017). Knowledge of the eccentric and concentric function of the pelvic floor muscles under impact loads is still inadequate. Very little is known about the eccentric function and the displacement of the pelvic floor muscle during the functional collision load of everyday life (e.g. stair climbing, running) (Leitner et al, 2015). Muscle actions can be classified as isometric (no change in muscle length), concentric (shortening action) and eccentric (lengthening action) (Komi, 2003). The pure form of these types of muscle actions is seldom found. The concentric and isometric muscle actions lead to a lift (elevation) and squeeze (constriction) of the pelvic floor (Bo et al., 2001; LovegroveJones et al., 2009; Raizada et al., 2010). However, knowledge about this combination of eccentric and concentric actions in the PFM during impact load is still inadequate. Not much is known about the eccentric muscle action of the PFM and the displacement during functional impact load activities of daily life (e.g. stair-climbing, running) and several (unexpected) factors may influence the outcome of the tests, such as was not explicitly instructing contraction of the pelvic floor muscle when running on a treadmill, but many stress incontinent women have used preventive "hidden" contractions. It is likely that stress incontinent subjects have consciously activated their pelvic floor muscles to prevent the expected urinary leakage. If stress incontinent women are familiar with the function of the pelvic floor muscles, they might be presumed to have increased awareness and skill in the pre-urinary contraction timing.

A cross-sectional study (n = 397; mean age 22.8 years (14-51 years) 8.6% gave birth) of 8 national sports clubs in Denmark (including ballet dancers) found that 51.9% of participants experienced loss of urine during sport or everyday life.43% in sports (gymnastics 56%; ballet 43%; aerobics 40%; badminton 31%; volleyball 30%; athletics 25%; handball 21%; basketball 17%) (Thyssen et al., 2002). According to some studies, athletes are unfamiliar with the symptoms and the factors leading to urinary incontinence. It is necessary for health professionals participating in sports teams to provide information on pelvic floor muscle disorders (dos Santos et al., 2018).

Physical work/manual labor

Physical activity (PA) includes not only recreational and regular exercise training, but also PA during household tasks and other work-related and transport-related PA (Caspersen et al., 1985). These non-recreational types of physical activity are particularly relevant to women. For example, by including only recreational PA, 26% women met the Centers for Disease Control and Prevention guidelines for sufficient activity. However, this proportion increased to nearly 73% when activity from all domains was included (Schaal et al., 2016).

The link between hard manual work and pelvic floor disorders is evident. In a study about Chinese women, manual labour increased the odds of UI 7-fold compared with no manual labour. Similarly, among rural Thai women, labourers experienced incontinence at a higher degree than other workers (Liu et al., 2014; Manonai et al, 2006).

A study in rural Tanzania (1047 people, mainly women who work in farms - 73%) confirms the possibility of pelvic floor muscle problems on account of heavy physical activity (at least 2 hours a day). 64.6% of the participants had stage 2-4 uterus prolapse. (Researchers have found that with increasing age, multiple vaginal deliveries, unskilled delivery, and lifting and carrying heavy objects, women in Tanzania are at increased risk of uterine prolapse (Masenga, 2018).

In a cross-sectional study, in which all activities (physical activity, work, childcare, elderly care, housework and garden work) were surveyed, researchers found an increased risk of stress incontinence. (Those who did heavy manual labor were 9.6 times more likely to have stage 2- 4 uterus prolapse.)

Discussion and conclusion

Concerning the relationship between PA and UI, a recent review (Nygaard et al., 2016) indicated that current leisure time activity and mild to moderate PA both decreased the risk of having UI, whereas a lack of PA or strenuous exercise/ heavy workload may increase the risk. Computer modeling and simulation provide a potential solution to these challenges in testing. Recent advances in medical imaging allowed the reconstruction of computer models based on high-resolution MR images, maximally preserving anatomical integrity and correctness. Computer simulation provides a reliable tool for characterizing dynamic biological processes that are otherwise difficult to observe through traditional techniques. Several computer models have been developed to study SUI and pelvic organ prolapse, but limited efforts have been made to apply this approach to explore the pathophysiology of SUI in young female athletes (Dias et al., 2017).

The health benefits of physical activity are obvious and the promotion of physical activity is considered a public health priority. However, both elite and leisure athletes tend to reduce their participation in physical activity due

to possible embarrassing consequences of stress incontinence. Stress incontinent women should be encouraged to engage in regular recreational and fitness activities in addition to the pelvic floor muscle exercises (Leitner et al., 2017). Women with high levels of physical activity had a higher manual grip force and a better body composition than those who did not exercise, but their pelvic floor muscle strength was not significantly higher, suggesting targeted pelvic floor muscle exercises may be needed enhancement of pelvic floor muscle strength (Middlekauff et al, 2016).

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