Comparison of pelvic floor muscle strength in competition-level athletes and untrained women

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SUMMARY

Introduction: Exercise can stress the pelvic floor muscles. Numerous women experience urinary incontinence while exercising or competing in sports. This study investigated pelvic floor muscle strength, urinary incontinence, and knowledge in contracting pelvic floor muscles among female athletes and untrained women.

Materials and methods: This was a prospective case-control study measuring pelvic floor muscle strength using vaginal pressure measurement. Participants answered questions regarding general health, urinary incontinence, and knowledge on pelvic floor muscles. Participants were healthy nulliparous women aged 18-30 years, athletes and untrained women. The athletes had competed in their sport for at least three years; including handball, soccer, gymnastics, badminton, BootCamp and CrossFit.

Results: The women were comparable in age and height. The athletes (n=18) had a body mass index (BMI) of 22.8 kg/m² vs. 25 kg/m² for the untrained (n=16); $p<0.05$. The athletes trained on average 11.4 hours/week while the untrained women participated in some activity on average for 1.3 hours/week; $p<0.05$. Mean pelvic floor strength was 45±2 hPa in the athletes vs. 43±4 hPa in the untrained; $p=0.36$ for whether the athletes were stronger. Of the athletes, 61.1% experienced urinary incontinence (n=11) compared with 12.5% of the untrained women (n=2); $p<0.05$. Incontinence usually occurred during high intensity exercise. The athletes were more knowledgeable about the pelvic floor muscles; $p<0.05$.

Conclusion: There was not a significant difference in the strength of pelvic floor muscles of athletes and untrained women. This suggests that pelvic floor muscles are not strengthened during general training but require specific exercises. This holds especially for football, handball and sports with high physical intensity. Coaches need to pay special attention to training and strengthening women's pelvic floor muscles to reduce the occurrence of urinary incontinence.

Introduction

The benefits of regular exercise are well known but there are also signs that strenuous exercises can cause too much stress on the pelvic floor muscles.[1] Numerous women experience pelvic floor dysfunction, including urinary and/or anal incontinence, pelvic organ prolapse, pain or sexual dysfunction.[2] Common risk factors for pelvic floor dysfunction such as urinary incontinence, are aging, female sex, number of births, smoking, history of repeated urinary tract infections, and obesity.[1,3] Previous studies have shown high rates of urinary incontinence among female athletes.[4–6] Furthermore, studies have shown that approximately half of all women do not know how to correctly contract the pelvic floor muscles without guidance.[7-9]

The incidence of urinary incontinence among nulliparous female athletes has been found from 0% for golf players and up to 80% for trampolinists.[4,10–11] The highest incidence is in high stress sports such as gymnastics, track and field, and various ball sports.[10]

Urinary incontinence has been defined as involuntary loss of urine which is a social or hygienic problem and is objectively demonstrable and stress urinary incontinence has been defined as loss of urine during physical exertion (like coughing, laughing and exercising)[12]. Urinary incontinence can hinder participation in social activities and sports. There are cases of women having given up their sport or other form of exercise due to difficulty with incontinence. Incontinence may also interfere with competition in their field.[13] This can reduce the quality of life of the affected women[14] and can lead to social isolation. Women who suffer from urinary incontinence often experience shame and are unable to discuss their problem with others unlike, neither friends nor health professionals, contrary to other sports-related problems such as a pulled muscle, which is discussed without hesitation.[15]

There are two opposing hypotheses about the effect of intense sports training on the pelvic floor muscles. One suggests that intense training strengthens the pelvic floor muscles along with training for the largest muscle groups of the body. The other hypothesis suggests that intense general training causes too much stress on the pelvic floor muscles leading to pelvic floor muscle weakness.[16] For example, the deadlift (a well-known power lifting exercise where a weighted barbell is lifted from the floor to hip-

doi.org/10.17992/lbl.2018.03.177

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Key words: *pelvic floor, exercise, training, urinary incontinence.*

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Table I: *Description of participating women.*

	Female athletes (n=18)				Untrained women (n=16)				
	Mean	St. Dev.	Max	Min	Mean	St. Dev.	Max	Min	p-value
Age (years)	24.2	3.2	30	19	24.1	2.9	30	20	0.92
Height (cm)	168	7.5	180	152	170.5	6.5	181	156	0.31
Weight (kg)	64.9	8.4	83	54	72.9	13.7	108	53	0.05
BMI	22.8	2.2	29.4	19	25	3.8	35.3	19.5	0.05
Exercise time (hours/week)	11.4	2.7	18	9	1.3	1.5	4	0	0.00

BMI (Body Mass Index) = weight (kg) / [height (m)]^2. The p-value shows the result of a t-test comparing the means of the two groups.

height) requires contracting the pelvic floor and abdominal muscles before the lift. If the pelvic floor muscles are not strong enough for the weight being lifted, it can lead to the pelvic floor muscles losing tension and resulting in urinary incontinence. Although co-activation of the pelvic floor muscles with some muscle groups in the trunk and pelvis in healthy nulliparous women is known[17] it is not presently known if the pelvic floor muscles strengthen along with other muscle groups when women participate in general exercise programs or if they require special training. Research has found that female athletes have larger pelvic floor muscles than untrained women[18] but it is not known if the pelvic floor muscles of female athletes are in fact stronger compared with untrained women.

To answer these questions, this study measured and compared the pelvic floor muscle strength of competition-level female athletes and untrained women and evaluated the women's ability of contracting the pelvic floor muscles correctly. This study also explored the frequency of stress urinary incontinence among these groups and assessed the women's knowledge and awareness of pelvic floor muscles.

Material and Methods

This was a prospective case-control study of the strength of pelvic floor muscles in competitive athletes and untrained women. The study was performed on participants from the capital area of Iceland in 2012. The participants (n=34) were nulliparous women aged 18-30 years old (Table I). The women were recruited and divided into two groups, athletes (n=18) and untrained women (n=16). In a study, researchers constructed a model for childbirth where they found 45% increase in peak force during labor among elite athletes[18]. Given that it was necessary to have at minimum 16 women in each group to find a statistically significant difference, assuming a 5% type I error and 90% statistical power.

An interview verified that the untrained women did not participate in any form of regular exercise and engaged in little physical activity. The athletes were all at competition level; they had participated and competed in their sport for at least three years. The athletes participated in different sports, including: handball, football (soccer), gymnastics, badminton, weightlifting, BootCamp or CrossFit. The athletes trained for at least nine hours per week. The women in both groups had to be healthy and free from diseases that could influence the measurements (for example, muscular dystrophy diseases, inheritable diseases affecting connective tissue, no history of frequent urinary infections, and had not had an operation for urinary incontinence).

To recruit athletes, trainers in different sports were approached who introduced the study to their athletes and invited them to participate. Through snowball sampling the athletes helped the researchers to seek women for the untrained group. Since each woman knows a large number of other women, this method is likely to identify a randomized sample with respect to the research questions. Potential participants were approached and sent information about the study in advance and gave informed consent for the study.

The women attended once at a physical therapist clinic (Táp physical therapy, Kopavogur, Iceland) where measurements took place and the women answered a questionnaire about their height, weight, age, frequency and duration of exercise training, knowledge about the pelvic floor muscles, and a standardized questionnaire about urinary incontinence (ICIQ-UI-SF)[12].

The pelvic floor muscle strength was measured with a Myomed 932 pressure sensor from Enraf-Nonius. The device had been reliability tested.[19] The women were tested in a supine position. A physical therapist first tested if the women could contract the pelvic floor muscles correctly with vaginal palpation and observation of inward movement of the perineum. Subsequently the pressure sensor was inserted into the vagina and the strength of the pelvic floor muscles measured in hectoPascal (hPa). The women were asked to contract the muscles for practice and then three times while the strength was measured. Each measurement took 5 seconds, followed by at least 10 seconds of rest. The greatest pressure each woman could generate was used as the observed strength.

Based on a prior study of pelvic floor muscles, it was expected that the untrained women would on average be measured as producing a pressure of 42 hPa.[19]

The statistical significance of the difference between averages in the two groups was calculated using a t-test for the comparison of two independent samples with estimated standard deviations. Odds-ratio analysis was used to judge the statistical significance of differences in percentage shares between the groups. A binary logistic regression was used to simultaneously estimate the significance of the impact of observable characteristics on whether the women had urinary incontinence events or not.

Table II: *The number of women and hours per week of training cross-classified by sport.*

	Female athletes (n=18)					Untrained women (n=16)				
	Freq.	%	Mean hours per week	Max	Min	Freq.	%	Mean hours per week	Max	Min
Walking	0	0	0	0	0	6	37.5	1.2	2	1
Running and joggingk	7	38.9	2.9	6	1	2	12.5	1	1	1
CrossFit/BootCamp	11	61.1	8.5	18	1	2	12.5	1.5	2	1
Weightlifting and gym machines	8	44.4	2.5	5	1	4	25	1.3	2	1
Dance. swimming. biking	2	11.1	0.7	1	1	1	6.3	1	1	1
Football. handball	6	33.3	8.8	10	6	0	0	0	0	0
Gymnastics	1	5.6	15	15	15	0	0	0	0	0
Badminton	1	5.6	1	1	1	0	0	0	0	0
Yoga	0	0	0	0	0	1	6.3	1	1	1

Results

The women were comparable in age and height (Table I). The untrained had significantly higher BMI (body mass index) than the athletes (25 vs. 22.8 kg/m², $p<0.05$). The self-reported exercise training of the athletes was significantly more than the untrained women (11.4 hours/week vs. 1.3 hours/week, respectively, $p<0.05$, see Table II). The athletes participated in various and often multiple sports: 38.9% running or jogging; 61% trained in CrossFit or BootCamp combined; 44.4% in weightlifting; 11.1% in dancing, swimming, or bicycling; 33.3% were in ball sports (handball, football). Only one woman was in gymnastics and one in badminton. The untrained women who did some physical activity or exercise reported it was little and irregular: 37.5% walked and two, 12.5%, jogged irregularly. Two, 12.5%, stated to irregularly attend BootCamp and 25% irregularly used gym exercise machines. The untrained woman who exercised the most, reported exercising on average two hours per week.

The measurement results for the pelvic floor muscle strength found that the mean pressure generated by the athletes was 45±2 hPa and the untrained women generated on average 43±4 hPa in pressure (Table III), which is not a statistically significant difference ($p=0.36$ in a *t*-test of whether the athletes were stronger on average).

The odds ratio analysis on the differences in shares of women reporting urinary incontinence shows that statistically significantly more athletes had urinary incontinence than the untrained (<0.05). Results from the questionnaire showed that 61.1% (n=11) of the athletes experienced urinary incontinence and 12.5% (n=2) of the untrained (Table IV). All the athletes who had urinary incontinence experienced it while they were under high exercise intensity and hence had stress urinary incontinence. Twenty-two percent of the female athletes also experienced stress urinary incontinence under other circumstances than during physical exercise, for example, when coughing or sneezing. Based on the questionnaire, the athletes had more knowledge about the pelvic floor muscles and they were also more likely to perform pelvic floor exercises (such as Kegel exercises[20]) compared with the untrained.

Two women in each group (11.1% and 12.5%) were not able to contract the pelvic floor muscles correctly at the start of the study.

Table III: *Results of pelvic floor muscle strength measurements.*

Female athletes	Strength (hPa)	Untrained women	Strength (hPa)
A1	25	U1	30
A2	61	U2	42
A3	47	U3	36
A4	54	U4	25
A5	38	U5	51
A6	43	U6	15
A7	40	U7	41
A8	38	U8	56
A9	50	U9	56
A10	45	U10	57
A11	50	U11	17
A12	31	U12	56
A13	43	U13	31
A14	56	U14	86
A15	54	U15	48
A16	35	U16	36
A17	44		
A18	47		
Mean	44.5	Mean	42.7
St. dev.	9.1	St. dev.	18
St. error	2.2	St. error	4.5
95% interval	40-64	95% interval	33-52

A1-A18 represent the female athletes, U1-U16 represent the untrained women. hPa is the pressure unit hectoPascal, used to measure muscle strength. The p-value for the t-test of whether the athletes were stronger on average is 0.36, which is not statistically significant.

This was discovered with internal examination by the physical therapist. There was therefore not a significant difference between the groups in the knowledge how to contract the pelvic muscles ($p>0.05$). However, there was a statistically significant difference between the groups in reporting knowledge about the pelvic floor muscles, with only four athletes claiming to think and know lit-

tle about them whereas 9 untrained women answered like that ($p<0.05$) (Table IV).

There was not a significant difference in incontinence symptoms among the athletes of different sports. There were not enough observations to measure those differences and since the same woman could be in more than one sport (the responses for each sport are not mutually exclusive a woman can belong to more than one sport) the responses to those questions were not independent. About half (54.5%) of the female athletes in CrossFit or BootCamp experienced urinary incontinence and about two-thirds (66.7%) of the women in handball or football (Table V).

Table IV: *The women's responses on urinary incontinence and knowledge of the pelvic floor muscles.*

	Female athletes (n=18)		Untrained women (n=16)	
	Freq.	%	Freq.	%
Experienced urinary incontinence	11	61.1	2	12.5
Did not experience urinary incontinence	7	38.9	14	87.5
Knowledge of pelvic floor muscles (PFM)				
Think little of PFM. know little about them	4	22.2	9	56.2
Think occasionally about PFM; exercise them ≤ x2 per month	7	38.9	4	25
Think regularly about PFM; exercise them > x2 per month	6	33.3	3	18.8
Very aware of PFM; exercise them every week	1	5.6	0	0
Occurrence of urinary incontinence				
Do not recall	0	0	0	0
During light daily activities	1	5.6	0	0
On the way to the restroom	0	0	2	12.5
By coughing or sneezing	4	22.2	0	0
During medium training intensity	0	0	0	0
During high training intensity	11	61.1	0	0
Frequency of urinary incontinence				
About once a week or less	11	61.1	1	6.3
Two to three times a week	0	0	1	6.3
About once per day	0	0	0	0
Always	0	0	0	0
Quantity. urinary incontinence				
Little quantity	11	61.1	2	12.5
Medium quantity	0	0	0	0
Large quantity	0	0	0	0
How much does urinary incontinence disturb your daily life on a scale of 1-10				
0	4	22.2	0	0
1	3	16.7	2	12.5
2	0	0	0	0
3	2	11.1	0	0
4	0	0	0	0
5	2	11.1	0	0
6+	0	0	0	0

Table V: *Number of women with urinary incontinence, cross-classified by sport.*

Sport	Frequency with urinary incontinence	Frequency without urinary incontinence
Endurance	3 (43.0)	4 (57.0)
CrossFit/Bootcamp	6 (54.5)	5 (45.5)
Weightlifting. gym machines	4 (50.0)	4 (50.0)
Handball. football	4 (66.7)	2 (33.3)

Two logistic regressions were run. The first where all athletes were grouped together using an "athlete" binary indicator variable that is 1 for athletes and 0 for the non-athletes (Table VI). In the second logistic regression, the athletes were classified by sport (Table VII). It was found (Table VII) that running and jogging (highest effect), followed by handball and football (second largest), and then CrossFit/BootCamp (smallest effect) had statistically significant relationships with increased probability of urinary incontinence. Weightlifting and gym machines were not significant and the other sports could not be included due to too few participants.

Discussion

The result for the average strength of the pelvic floor muscles of the untrained women, 43±4 hPa, fit the expectation of 42 hPa, which was based on other research[19]. There has been little research on this topic for female athletes and that is one of the important contributions of this research. It was surprising that there was not a significant difference in the average pressure measurements for the pelvic floor muscles of the athletes and the untrained women. However, there was a much smaller standard deviation in the strength of the pelvic floor muscles of the athletes than for the untrained women.

It is a weakness of this research that the sample of women was small. However, recall that the size of the sample was determined based on the objective of being able to measure a 45% difference in strength with statistical significance as is described in the methods section. Since the difference in strength turned out to be small it was not found statistically significant in this research. With a larger sample, it is possible that a small difference in strength could be estimated with statistical significance A future study with a greater number of participants is needed to explore the impact of various pelvic floor exercise programs on the pelvic floor muscle strength and urinary incontinence in female athletes.

Other research has shown, using magnetic resonance imaging, that female athletes have larger pelvic floor muscles than untrained women.[18] However, it is not known if larger pelvic floor muscles are stronger and that research did not measure the pelvic floor muscle strength. It is generally known that strength training enlarges (hypertrophy) and strengthens skeletal muscles.[21] Research has however not shown that female athletes have stronger pelvic floor muscles than other women[22,23]. The results of the present study show that the athletic training done by the competition-

Table VI: *Logistic regression results for probability of urinary incontinence as a function of observed characteristics.*

Variable	Coefficient	Standard Error	t-statistic	p-value
Athlete	4.163	1.453	2.87	0.002*
Pelvic floor muscle strength	-0.051	0.047	-1.10	0.137
Body mass index	0.386	0.186	2.08	0.019*
Age	0.231	0.172	1.34	0.091
Constant	-15.664	7.406	-2.11	0.017*

* Statistically significant, p-value<0.05. The P-value is for a one-tailed test. Number of observations = 34. LR test $\chi^2(4) = 16.72$, $P > \chi^2 = 0.0022$. Log-likelihood = -14.26. Pseudo $r^2 = 0.37$.

Table VII: *Logistic regression results for probability of urinary incontinence as a function of observed characteristics with athletes classified by sport.*

Variable	Coefficient	Standard Error	t-statistic	p-value
Pelvic floor muscle strength	-0.033	0.042	-0.80	0.213
Body mass index	0.334	0.186	1.80	0.036*
Age	0.454	0.229	1.98	0.024*
Running and jogging	0.912	0.455	2.00	0.023*
CrossFit/BootCamp	0.184	0.103	1.80	0.036*
Weightlifting. gym machines	0.426	0.474	0.90	0.185
Handball. football	0.368	0.180	2.04	0.021*
Constant	-19.80	9.29	-2.15	0.016*

*Statistically significant. P-value<0.05. The P-value is for a one-tailed test. Number of observations = 34. LR test $\chi^2(4) = 14.28$. $P > \chi^2 = 0.0463$. Log-likelihood = -15.47. Pseudo $R^2 = 0.32$.

level athletes in this study does not lead to a significant increase in the strength of the pelvic floor muscles. This suggests the pelvic floor muscles need special exercises and training, which is presently lacking in athlete training.

Since a large share of the female athletes had urinary incontinence, it can be asked if the strength of the pelvic floor muscles of female athletes is enough to support the pelvic organs during high intensity training. It has been showed that the pelvic floor muscles of female athletes need to be much stronger than in untrained women to be able to avoid urinary incontinence.[1]

Based on the questionnaire results, the female athletes with symptoms all had in common that the symptoms appeared almost only when they were under intense physical stress during sport or training. Since there was not a significant difference in strength between the athletes and the untrained it cannot be ruled out that the untrained women would also experience stress urinary incontinence if they were to exercise intensively. The untrained women, who noted urinary incontinence, mostly had this occur when they were on their way to the restroom and the bladder was full, hence it is unclear if those were stress urinary symptoms.

The frequency of urinary incontinence between female athletes and untrained women has previously been compared using electromyography (EMG).[24] There it was found that urinary incontinence was more prevalent among the athletes, 63.6% vs. 28.2% for the untrained. However, no difference was found in muscle activation or work. Our research gives a weak suggestion (not statistically significant, =0.137, Table VI) that there is a lower probability of urinary incontinence with increasing pelvic floor muscle strength. A larger study could possibly shed more light on this relationship.

Reduced estrogen levels, such as during menopause, have been linked with increased probability of urinary incontinence.[1] It is also known that women who are training intensively or even overtraining, have reduced estrogen levels.[25] It is therefore an interesting future research question to find if reduced estrogen level in female athletes is a contributing factor for their urinary incontinence, beyond just pelvic floor muscle activation and strength effects.

The questionnaire showed that the female athletes were more conscious about their pelvic floor muscles than the untrained, and they were more likely than the untrained to report doing pelvic floor muscle exercises. This was not surprising since a large share of the athletes was dealing with urinary incontinence symptoms and therefore motivated to try to reduce the problem.

The results show that share of women with urinary incontinence was statistically significantly greater among the athletes than the untrained. Running, handball, football, BootCamp, and CrossFit were all sports where a large share of the female athletes reported urinary incontinence. The small sample size does not allow broad conclusions to be drawn about these results for particular sports within the groups. Taken together, however, these are all sports that involve running and jumping, often under high intensity. This fits prior research that has shown a higher frequency of urinary incontinence among female athletes in high intensity sports involving running and jumping.[13] The highest frequency of urinary incontinence in this research was in the ball sports, which supports the results of other research.[1]

Conclusions

Based on the results it is concluded that pelvic floor muscles are not strengthened enough with general athletic training. We therefore recommend that specific pelvic floor muscle exercises be a part of all female athlete training programs. Even though the emphasis of this research is on female athletes, all women should perform pelvic floor muscle exercises as a part of their general physical exercise. Pelvic floor exercises are generally considered the first treatment against urinary incontinence.[14] It has been shown that pelvic floor muscle exercises increase strength and lead to improved pelvic stability.[26]

These findings render further support for the importance of pelvic floor exercises for all women, irrespective of age and parity, but especially for female athletes. Sport coaches should be aware of this problem. We recommend that coaches include special training of their female athletes' pelvic floor muscles beyond what is needed in men. We also recommend including pelvic floor muscle training in trainers' and sport science curricula.

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