

Original Article

The Pelvic Proprioceptive Test (PP-Test): A Novel Pelvic Floor Evaluation in Female Athletes – A Reliability and Observational Study

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Abstract

Objectives: Force sense (FS) is a proprioceptive component related with functionality, but no specific tests have been developed for pelvic floor (PF). We aimed to evaluate the test-retest reliability of a novel pelvic proprioceptive test (PPT) to explore FS and its relationship with maximal voluntary contraction (MVC) in female athletes. **Methods:** A total of 42 female athletes (from 18 to 45 years old) were evaluated with digital intravaginal palpation and graded according to modified Oxford grading scale (MOGS) to ensure they had at least a grade 2 in MOGS and a correct PF contraction. All participants completed the PPT twice, 10 minutes apart, to obtain FS proprioceptive error (cmH₂O). MVC was also obtained with manometry during the PPT. A perineometer-manometer was used for evaluations. **Results:** The test-retest reliability was excellent for force sense (ICC = 0.94, $p < 0.001$), with an average of 6.2 ± 4.6 cmH₂O of proprioceptive error. A strong correlation was found between FS error and MVC ($r = 0.82$, $p < 0.001$). **Conclusions:** The novel PPT shows excellent test-retest reliability for assessing FS in terms of absolute proprioceptive error in female athletes and correlates with MVC: increased MVC strength is associated with reduced FS accuracy.

Keywords: Females, Force Perception, Pelvic Floor Musculature, Sport

Introduction

In sport, women often demonstrate high pelvic floor muscle (PFM) force-generating capacity¹. However, greater maximal force alone does not ensure optimal pelvic floor (PF) function. Although female athletes produce stronger PFM contractions than non-athletes^{1,2}, they report pelvic floor dysfunction (PFD) more frequently than sedentary women^{3,4}. Rather than peak strength, the timing of activation appears critical: earlier, feedforward PFM activation is

associated with better PF function⁵.

In proprioceptive research, force sense is recognized as a distinct component of proprioception, alongside joint position sense and kinaesthesia. Force sense refers to the ability to reproduce a required force level in a given muscle group, and it arises from the integration of peripheral afferent signals and central motor commands⁶. Specifically, force sense arises from the combined input of muscle spindles and Golgi tendon organs, proprioceptors that detect changes in muscle length and tension, along with the centrally generated sense of effort. This dual-source integration allows the nervous system to estimate and regulate force production accurately, even in the absence of visual feedback⁷. For measurement, a target contraction is typically established (commonly at 50% of maximal voluntary contraction - MVC) and the force reproduction error is calculated, either in Newtons or through the computation of the reproduced error⁸.

As a key proprioceptive component, force sense has been shown to be relevant to exploring the correct function

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of the muscular structures in other anatomical locations⁹. As described by Proske and Gandevia, proprioception encompasses not only the spatial awareness of body segments but also the perception of tension and effort, both of which are essential for motor control and functional stability⁶. Therefore, assessing FS provides insight into neuromuscular control mechanisms that extend beyond strength, offering a more comprehensive understanding of functional integrity in musculoskeletal structures such as the PF. However, to date no studies have developed a specific force sense test for PF structures.

The current evaluation tools remain limited to strength-based assessments, such as MVC, obtained through electromyography, dynamometry, or manometry¹⁰. However, these measures may not fully capture the functional integrity of the PF musculature. In contrast, feedforward responses are proprioceptive mechanisms essential for maintaining spinal stability and continence during sudden increases in intra-abdominal pressure and ground reaction forces¹¹. Moreover, motor learning not only modifies feedforward control but also alters the sensitivity of reflexive feedback responses to mechanical perturbations^{12,13}. There is a recognized clinical need for tools that assess proprioceptive components on the PF, which are crucial for anticipatory activation and neuromuscular control¹⁴. A new test could address this gap by providing a novel method to identify potential proprioceptive deficits in PF musculature.

The design of this novel test for the sport population requires exploring the viability and consistency of the measurements over time in female athletes, as a population with a typically increased capacity to force development compared to sedentary women^{1,2}. Furthermore, it would be useful to establish potential relationships with traditional maximal strength measurements and reference data in healthy sports population to have a comparison point for other populations like female athletes with PFD.

This study aimed to evaluate the test-retest reliability of the proprioceptive test focused on force sense of pelvic floor (PPT, proprioceptive pelvic test) in female athletes, apart from exploring the relationship of this novel test with the strength of PF musculature, assessed through MVC.

Methods

Design

A test-retest reliability and observational study was designed. From December 2024 to January 2025, female athletes were invited to participate in the study through mailing from their regional sport federations, sport teams, and social media. The evaluation sessions were carried out in the Physiotherapy laboratory of the University of the Balearic Islands.

Participants

To calculate sample size, we considered a finite population because there were 1.061.489 sport licences from female

athletes in Spain at the time of the study, according to the National Statistics report from the National High Sport. Based on recommendations for reliability studies using intra-class correlation coefficients (ICC), we assumed an expected variability of 12%, a margin of error of 10%, a confidence level of 95% (CI95%) ($\alpha = 0.05$), and a statistical power of 80%. Under these conditions, a minimum of 41 healthy female athletes was required to ensure sufficient precision in ICC estimation¹⁵.

As eligibility criteria, participants should be between 18 and 45 years old, nulliparous, and actively training and competing in any sport, with a minimum of two years of sports experience. As exclusion criteria, female athletes should not be pregnant, have pelvic floor disorders, history of pelvic surgery or neurogenic lower urinary tract dysfunction, or physiotherapy treatment focused on PFD in the previous 6 months. Also, women should have at least grade 2 on the modified Oxford grading scale (MOGS) in the digital intravaginal palpation to ensure the test feasibility and the correct PF contraction.

Procedures

In a single session, all participants were evaluated to obtain height and weight using a digital scale with ± 100 g precision (Tefal, France) and a t201-t4 adult height scale (Asimed, Spain), respectively, and completed an anonymous online questionnaire to collect information about sports characteristics. The MOGS was assessed in all participants through digital vaginal palpation to confirm eligibility and ensure correct PF contraction. All eligible participants completed the PPT test twice, separated by a 10-minute interval.

Anonymous online questionnaire: It was created on the JotForm platform[®], to collect information regarding age and sport (sport modality and years of sport experience). They also informed about PFD symptomatology by completing the ICIQ-SF (International Consultation on Incontinence Questionnaire)¹⁶, Wexner scale for bowel incontinence¹⁷, and FSDI (Female Sexual Function Index)¹⁸. The existence of prolapses was discarded during the digital palpation of MOGS. To maintain the anonymity of data, participants were asked to generate a personal code, only retrievable by themselves.

Modified Oxford grading scale (MOGS): Apart from ensuring the eligibility of participants, this assessment was used to familiarize participants with correct pelvic floor muscle contraction. The participants were asked to empty their bladder before the test. They were in crook lying position, undressed from the abdomen downward. The evaluator inserted the first two phalanges of the second and third fingers smeared in lubricant gel with a gloved hand into the anterior third of the vaginal opening and requested a maximal voluntary contraction (MVC) by giving the command "*contract the anus, do as if you wanted to hold a strong desire to void*", as recommended¹⁹. The PF muscle strength was graded on the Modified Oxford Grading

Scale (MOGS) as 0 (nil), 1 (flicker), 2 (weak), 3 (moderate), 4 (good) to 5 (strong)²⁰.

Pelvic proprioceptive test (PPT): A perineometer-manometer Phénix™ Liberty G3 (Vivaltis, Paris, France), equipped with a high precision pressure transducer and a vaginal pressure manometry probe, was used. Participants were positioned identically to the MOGS evaluation. The probe was covered with a lubricated condom and inserted approximately 3.5 cm proximal to the vaginal introitus, without pain or discomfort. Prior to testing, the probe was calibrated by manually inflating it to 50 cmH₂O and zeroing the pressure which facilitated probe insertion and ensured that all participants experienced the same baseline intravaginal pressure. The test began with two 5-second MVC trials, with the same command used for MOGS, separated by 10 seconds of rest. The 50% of the highest MVC was considered the Target (in cmH₂O). After 30 seconds, force sense was evaluated through two 5-second contractions at the target level, also separated by 10 seconds. To standardize instructions across participants, a voice-recorded audio was used to guide the entire test. Both PPT and MOGS assessments were conducted and supervised by the same examiner, who ensured correct pelvic floor contraction and that the probe remained properly positioned throughout the procedure. The examiner remained present during the entire test, including rest periods, as the probe was not removed between measurements. To minimize bias, the pressure values were recorded wirelessly by a second researcher who remained blinded to the examiner and did not disclose the results.

Although three trials are typically recommended in standard protocols for force sense assessment in other superficial muscle groups, two trials were used because a noticeable decline in performance was observed when using three trials during a previous pilot session. In that session, a consistent decline in performance was observed in the third repetition, with values deviating more from the target. Additionally, some participants reported subjective fatigue. This high fatigability of the PF muscles is due to their postural function and anatomical constraints²¹. The PF muscles are composed of slow-twitch fibers, responsible for postural tone because they can contract slowly but maintain the contraction for a long time; and fast-twitch fibers, that activate during sudden increases in intra-abdominal pressure²². These fast-twitch fibers are less resistant to fatigue and can sustain only a few contractions for short periods. Therefore, the protocol was adapted to include only two trials ensuring measurement reliability without compromising muscle performance.

After 10 minutes of resting period, all participants repeated the PPT. For each repetition, proprioceptive error in force sense (cmH₂O) was calculated as follows:
FS error = (|Target-Trial 1|+|Target-Trial 2|) / 2

Statistical Analysis

Descriptive characteristics of values from tests were given as mean and standard deviations for quantitative variables and frequencies for categorical variables. Normality of data was assessed using the Kolmogorov-Smirnov test. The test-retest reliability of the PPT was assessed using the ICC, specifically the two-way random-effects model for absolute agreement, single measurement - ICC (2,1). Reliability was reported with the ICC value, its 95 % confidence interval (CI), and the standard error of measurement (SEM), given the continuous nature of the force sense data. ICC was interpreted as follows: poor, ICC < 0.5; moderate, 0.5 ≤ ICC < 0.75; good, 0.75 ≤ ICC < 0.9; and excellent, ICC ≤ 0.9. The SEM was calculated using the pooled standard deviation (SD) of force sense errors across both sessions and the ICC value, following the formula: SEM=SDpooled × √(1-ICC). MDC (smallest detectable change) was calculated as 1.96×SEM×√2 to indicate the change needed to exceed measurement error²³. Additionally, the standard error of estimate (SEE) was reported to complement the reliability analysis. The relationship between force sense and MVC was explored with Pearson correlation and 95%CI, interpreted as follows: negligible, r < 0.10; weak, 0.10 ≤ r < 0.40; moderate, 0.40 ≤ r < 0.69; strong, 0.69 ≤ r < 0.90; very strong, r ≥ 0.90 (24). The SPSS statistical package version 24 was used for statistical analysis, with significance established at p < 0.05.

Results

Descriptive data

A total of 42 female athletes (30.0 ± 9.2 years old; 58.6 ± 8.5 kg; 1.66 ± 0.05 m; 21.2 ± 2.6 kg·m⁻²) participated in the study. Data from PPT are shown in Table 1. The values from repetition1 and repetition2 were similar for absolute proprioceptive error in force sense and MVC. Regarding MOGS, the average was 3.4 ± 0.8 grades, distributed as: 2.4% of participants in grade 2, 59.5% in grade 3, 26.2% in grade 4, and 11.9% in grade 5. Consistently, these female athletes had a MVC of 7.5, 24.6, 25.2, and 34.4 cmH₂O, respectively, as an average of the two repetitions.

Force sense test-retest reliability

For the absolute proprioceptive error in force sense during the PPT, the ICC for the test-retest reliability was excellent, with 0.94 (95%CI = 0.88 – 0.97, p < 0.001), SEE was 2.2, SEM was 1.09, and MDC was 3.0 cmH₂O (Figure 1).

Relationships between force sense and maximal voluntary contraction

A strong significant correlation was observed between absolute proprioceptive error in force sense and MVC (r: 0.82; 95%CI: 0.73 – 0.89, p < 0.001).

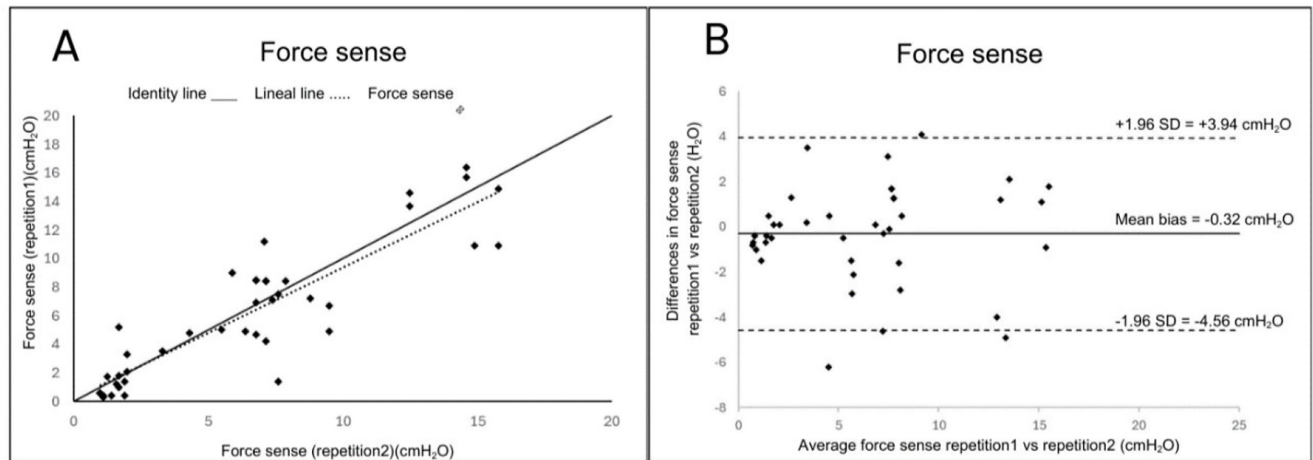


Figure 1. Test-retest reliability for proprioceptive pelvic test measurements; A: Identity line for force sense; B: Bland–Altman plot for the force sense test-retest reliability. The mean bias was -0.32 cmH_2O , with 95% limits of agreement ranging from -4.56 to $+3.94$ cmH_2O . SD, standard deviation.

Table 1. Mean and standard deviation values for force sense error and maximal voluntary contraction during two repetitions of the proprioceptive pelvic test in female athletes.

	Repetition1 Mean (SD)		Repetition2 Mean (SD)	
FS error (cmH_2O)	6.5	(4.6)	6.0	(4.6)
MVC (cmH_2O)	26.3	(14.1)	24.7	(14.9)

FS, Force sense error represents the absolute difference between target and reproduced intra-vaginal pressure, indicating proprioceptive accuracy; MVC, maximal voluntary contraction reflects the maximal intra-vaginal pressure generated during voluntary pelvic floor muscle contraction; SD, standard deviation.

Discussion

The main findings of this study indicate that the novel proprioceptive pelvic test demonstrates excellent test-retest reliability for exploring force sense in female athletes, in terms of absolute proprioceptive error (magnitude of proprioceptive error). These values are related with traditional measurements of maximal strength like MVC, showing that greater PF muscle strength was linked to larger force sense error.

Closely related to the excellent reliability, the smallest detectable change (MDC) was 3.03 cmH_2O , which clinicians can use to judge whether change exceeds measurement error. This is an important issue for clinical practice because it makes possible to use this novel proprioceptive test at different moments. Health professionals could monitor force sense among female athletes to detect “real” differences, instead of random variations derived from the

measurement, if they are higher than this value²³.

In our study, the average absolute proprioceptive error was ~ 6 cmH_2O , with higher errors observed in participants with higher MVC values. These results indicate that, in female athletes, increased PF MVC strength is inversely associated with force sense accuracy. Because no previous studies have explored PF proprioception throughout force sense, there is no possibility to compare data. Previous studies observed similar correlations in the knee joint, with more force sensitive errors for those participants with higher maximal isometric voluntary contraction^{25–27}. Their results, consistent with ours, suggest that participants with greater muscle strength is linked to reduced force sense acuity. The most plausible physiological explanation is that athletes with stronger PF muscles may rely more on motor output than on sensory feedback, potentially leading to less precise force modulation. This phenomenon has been described in other musculoskeletal systems, where

adaptations to strength training may alter neuromuscular control strategies and reduce proprioceptive acuity⁶. Such adaptations may involve changes in muscle fiber composition, recruitment patterns, and fatigue resistance, which are typical in athletic populations. Future studies are warranted to confirm these mechanisms.

Previous studies have shown that greater strength does not necessarily imply appropriate PF function, particularly in athletic population². Arbiato et al., compared PF and abdominal muscle strength, as well as PF function, between female professional athletes and non-athletes. These authors observed that athletes exhibited stronger PF and abdominal muscle, but the urinary incontinence in athletes and non-athletes was 54% and 35%, respectively². Thus, although stronger PF musculature is common in sports populations¹, these groups often present with a higher prevalence of PFD². Since our study focused on healthy female athletes, we cannot extend these findings to women with PFD. Once ensured the viability and consistency of the novel PPT in the present study, it should be explored in other populations to evaluate its sensitivity and responsiveness to those and other disorders.

Regarding MVC pressure measured with the manometer, we observed 25.5 ± 14.4 cmH₂O as average of all the repetitions performed by the athletes. Previous studies in sportswomen of a similar age range reported values ranging from 21 to 131 cmH₂O²⁸. In our study, the probe was emptied before being introduced into the vagina and thus, the air of the probe was progressively increase up to 50 cmH₂O. Once this pressure was reached, the values were zeroed. This procedure ensured that all participants experienced the same proprioceptive stimulus, which was a crucial factor for exploring proprioception. In previous studies, the intra-vaginal pressure prior to the MVC was not zeroed, being the potential explanation of the differences in MVC pressure compared to our results^{29,30}. In line, the study by Hilde et al., where the probe was set to 0 cmH₂O prior to be introduced into the vagina and zeroed before asking MVC, values ranged from 8 to 15 cmH₂O. Considering that participants of that study were non-sport first-time mothers 6 weeks after vaginal delivery, these values would be coherent with our study³¹.

When comparing MVC assessed by digital palpation and manometer, our results were consistent with previous studies³⁰ because women with lower MOGS grades generally showed lower MVC values. Perhaps, some differences may arise because manometry, when performed controlling the effect of the intraabdominal pressure to ensure a correct PF contraction (as in our study), measures exclusively vaginal squeeze pressure (occlusion component)³², whereas MOGS only considers the perineal lift in addition to occlusion³³. For this reason, the use of combined techniques has been recommended to evaluate pelvic floor muscle strength³⁴. Furthermore, the distribution of participants among MOGS grades was also comparable to previous studies³⁰, with most participants (61.9%) classified in grades 2 or 3.

In our study, MVC and force sense were evaluated by

using manometry. Although this tool measures the intra-vaginal pressure, this evaluation, as digital intravaginal palpation, is based on methodology already used and validated in previous studies^{28-30,35}. As observed, MVC values obtained by manometry were consistent with MOGS grades, with lower manometric pressures corresponding to lower palpation scores. In our study, although MOGS data confirmed results observed in MVC and force sense with manometry, it was mainly used to ensure the correct PF contraction³⁶.

In this study, force sense was assessed through intra-vaginal pressure using a manometer, expressed in cmH₂O. Although this unit does not represent muscular force in Newtons, it provides a clinically accepted proxy for PF muscle output. Pressure-based evaluations are among the most used methods by physiotherapists to assess PF function³⁴, often preferred over direct force measurements due to their practicality, reliability, and correlation with digital palpation^{34,37}. However, it should be emphasized that cmH₂O reflects pressure rather than absolute force, which may limit direct comparisons with proprioceptive research in other anatomical regions where force is typically reported in Newtons.

Our study has limitations. Firstly, participants were healthy female athletes, which limits the generalizability of the findings to other population. However, this constitutes an initial step to develop a new proprioceptive test that should be continued in future studies. Second, MVC was assessed using manometry, which provides pressure values (cmH₂O) rather than absolute force in Newtons. Third, reliability of the test was assessed within a single session, reflecting only within-session consistency. This design does not capture potential between-day influences such as diurnal variation, hormonal fluctuations, or menstrual cycle phase. Future studies should consider these factors to better determine the responsiveness of the test to training-induced changes.

The novel pelvic proprioceptive test demonstrated high reliability and consistency for assessing force sense in terms of absolute proprioceptive errors of pelvic floor in healthy female athletes. Health professionals may use this novel test as the only tool to the moment to specifically explore proprioception of PF musculature. It introduces the evaluation of an aspect of PF function that allows to quantify the proprioceptive acuity of this musculature. The implementation of this evaluation may hold substantial potential for optimizing the PF functional status in female athletes. Future studies should explore its responsiveness in detecting PFD, modifications in sports practice or other factors related to PF function, such as postpartum or incontinent women.

We concluded that the novel PPT demonstrates excellent test-retest reliability for assessing force sense through absolute proprioceptive error in female athletes. Moreover, PPT outcomes were associated with traditional maximal strength measurements of the PF, as athletes with greater PF strength tended to show higher proprioceptive error, reflecting lower force sense acuity.

Ethics approval

This study was approved by the Ethics Committee of the University of the Balearic Islands (Ref. O59CER24) and conducted in accordance with the Declaration of Helsinki (1964) and its later amendments.

Consent to participate

Before being enrolled in this investigation, all athletes were informed about the study and signed the written consent.

Authors' contributions

Elena Vico-Moreno: Data Curation, Investigation, Resources, Writing – original draft; Juan Carlos Fernández-Domínguez: Conceptualization, Methodology, Writing – review & editing; Elisa Bosch-Donate: Investigation, Resources, Writing – original draft; Andreu Sastre Munar: Resources, Software, Writing – original draft; María de la Paz Martínez-Bueso: Methodology, Supervision, Writing – review & editing; Natalia Romero-Franco: Conceptualization, Project administration, Methodology, Supervision, Writing – review & editing. All authors read and approved the final version of the manuscript.

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References

1. Acevedo-Gómez MB, Rodríguez-López ES, Oliva-Pascual-Vaca Á, Fernández-Rodríguez T, Basas-García Á, Ojedo-Martín C. Is the Elite Female Athlete's Pelvic Floor Stronger? *J Clin Med*. 2024;13(3):908.
2. Arbieto ERM, dos Santos KM, da Luz SCT, Da Roza T. Comparison of urinary incontinence, based on pelvic floor and abdominal muscle strength, between nulliparous female athletes and non-athletes: A secondary analysis. *Neurourol Urodyn*. 2021;40(5):1140–6.
3. Almeida MBA, Barra AA, Saltiel F, Silva-Filho AL, Fonseca AMRM, Figueiredo EM. Urinary incontinence and other pelvic floor dysfunctions in female athletes in Brazil: A cross-sectional study. *Scand J Med Sci Sports*. 2016;26(9):1109–16.
4. Carvalhais A, Natal Jorge R, Bo K. Performing high-level sport is strongly associated with urinary incontinence in elite athletes: a comparative study of 372 elite female athletes and 372 controls. *Br J Sports Med*. 2018;52(24):1586–90.
5. Koenig I, Eichelberger P, Luginbuehl H, Kuhn A, Lehmann C, Taeymans J, et al. Activation patterns of pelvic floor muscles in women with incontinence while running: a randomized controlled trial. *Int Urogynecol J*. 2021;32(2):335–43.
6. Proske U, Gandevia SC. The Proprioceptive Senses: Their Roles in Signaling Body Shape, Body Position and Movement, and Muscle Force. *Physiol Rev*. 2012;92:1651–97.
7. Niespodziński B, Kochanowicz A, Mieszkowski J, Piskorska E, Żychowska M. Relationship between Joint Position Sense, Force Sense, and Muscle Strength and the Impact of Gymnastic Training on Proprioception. *Biomed Res Int*. 2018; 5353242.
8. Hillier S, Immink M, Thewlis D. Assessing Proprioception: A Systematic Review of Possibilities. *Neurorehabil Neural Repair*. 2015;29(10):933–49.
9. Xue X, Chen Z, Xuan W, Tao W, Jin Z, Hua Y. Force sense deficits in chronic ankle instability: A systematic review and meta-analysis. *PM R*. 2023;15(6):780–9.
10. Navarro Brazález B, Torres M, Pt L, De La Villa P, Sánchez B, Pt S, et al. The evaluation of pelvic floor muscle strength in women with pelvic floor dysfunction: A reliability and correlation study. *Neurourol Urodyn*. 2018;37:269–77.
11. Moser H, Leitner M, Baeyens JP, Radlinger L. Pelvic floor muscle activity during impact activities in continent and incontinent women: a systematic review. *Int Urogynecol J*. 2018;29(2):179–96.
12. Maeda RS, Gribble PL, Pruszynski JA. Learning New Feedforward Motor Commands Based on Feedback Responses. *Current Biology*. 2020;30(10):1941–1948.
13. Küng UM, Horlings CGC, Honegger F, Allum JHJ. Incorporating voluntary unilateral knee flexion into balance corrections elicited by multi-directional perturbations to stance. *Neuroscience*. 2009;163(1):466–81.
14. Vieira GF, Saltiel F, Miranda-Gazzola APG, Kirkwood RN, Figueiredo EM. Pelvic floor muscle function in women with and without urinary incontinence: are strength and endurance the only relevant functions? a cross-sectional study. *Physiotherapy*. 2020;109:85–93.
15. Mokkink LB, de Vet H, Diemeer S, Eekhout I. Sample size recommendations for studies on reliability and measurement error: an online application based on simulation studies. *Health Serv Outcomes Res Methodol*. 2023;23(3):241–65.
16. Espuña Pons M, Rebollo Álvarez P, Puig Clota M. Validación de la versión española del International Consultation on Incontinence Questionnaire-Short Form. Un cuestionario para evaluar la incontinencia urinaria. *Med Clin*. 2004;122(8):288–92.
17. Minguez M. Cuestionario de gravedad de la incontinencia fecal de Wexner. *Dis Colon Rectum*. 2006;49(4):490–9.
18. Sánchez-Sánchez B, Navarro-Brazález B, Arranz-Martín B, Sánchez-Méndez Ó, de la Rosa-Díaz I, Torres-Lacomba M. The female sexual function index: Transculturally adaptation and psychometric validation in Spanish women. *Int J Environ Res Public Health*.

- 2020;17(3):994.
19. Charlanes A, Chesnel C, Jousse M, Le Breton F, Sheikh Ismael S, Amarenco G, et al. Verbal instruction to obtain voluntary pelvic floor muscle contraction: Acceptability, and understanding. *Progrès en Urologie*. 2021;31(4):231–7.
 20. Angelo PH, Varella LRD, De Oliveira MCE, Matias MGL, De Azevedo MAR, De Almeida LM, et al. A manometry classification to assess pelvic floor muscle function in women. *PLoS One*. 2017;12(10):e0187045.
 21. Muro S, Akita K. Pelvic floor and perineal muscles: a dynamic coordination between skeletal and smooth muscles on pelvic floor stabilization. *Anat Sci Int*. 2023;98(3):407.
 22. Wyndaele JJ. Study on the influence of the type of current and the frequency of impulses used for electrical stimulation on the contraction of pelvic muscles with different fibre content. *Scand J Urol*. 2016;50(3):228–33.
 23. Beckerman H, Roebroek ME, Lankhorst GJ, Becher JG, Bezemer PD, Verbeek ALM. Smallest real difference, a link between reproducibility and responsiveness. *Qual Life Res*. 2001;10(7):571–8.
 24. Schober P, Schwarte LA. Correlation coefficients: Appropriate use and interpretation. *Anesth Analg*. 2018;126(5):1763–8.
 25. Altun M, Balcan E, Batir S, Gökmen MH, Özgüneş Ş, Öztel Z. Acute responses of strength-related gene expressions to maximum strength and force sense acuity. *Turk J Med Sci*. 2024;54(1):148–56.
 26. Kaynak H, Altun M, Tok S. Effect of Force Sense to Active Joint Position Sense and Relationships between Active Joint Position Sense, Force Sense, Jumping and Muscle Strength. *J Mot Behav*. 2020;52(3):342–51.
 27. Altun M. Effects of 2 different external loads on joint position sense and the relationship between muscle strength and force sense. *J Sport Rehabil*. 2020;29(8):1115–20.
 28. Da Roza T, Mascarenhas T, Araujo M, Trindade V, Jorge RN. Oxford Grading Scale vs manometer for assessment of pelvic floor strength in nulliparous sports students. *Physiotherapy*. 2013;99(3):207–11.
 29. Pires T, Pires P, Moreira H, Gabriel R, Reis A, Viana S, et al. Leg stiffness and muscle power vs manometer in sportswomen with symptoms of stress urinary incontinence. *Clin Biomech*. 2021;90:105471.
 30. Silva JB da, Sato TO, Rocha APR, Driusso P. “Comparative intra- and inter-rater reliability of maximal voluntary contraction with unidigital and bidigital vaginal palpation and construct validity with Peritron manometer.” *Neurourol Urodyn*. 2020;39(2):721–31.
 31. Hilde G, Stær-Jensen J, Siafarikas F, Gjestland K, Ellström Engh M, Bø K. How well can pelvic floor muscles with major defects contract? A cross-sectional comparative study 6 weeks after delivery using transperineal 3D/4D ultrasound and manometer. *BJOG*. 2013;120(11):1423–9.
 32. Tennfjord MK, Engh ME, Bø K. An intra- and interrater reliability and agreement study of vaginal resting pressure, pelvic floor muscle strength, and muscular endurance using a manometer. *Int Urogynecol J*. 2017;28(10):1507–14.
 33. Laycock J, Jerwood D. Pelvic floor muscle assessment: The PERFECT scheme. *Physiotherapy*. 2001;87(12):631–42.
 34. Rai A, Sharma N, Jain SK, Lalwani A, Sharma S. Accuracy and Reliability of Different Approaches for the Assessment of Pelvic Floor Muscle Strength: A Systematic Review. *J Pharm Bioallied Sci*. 2023;15:S856-S861.
 35. Tennfjord MK, Engh ME, Bø K. An intra- and interrater reliability and agreement study of vaginal resting pressure, pelvic floor muscle strength, and muscular endurance using a manometer. *Int Urogynecol J*. 2017;28(10):1507–14.
 36. Ferreira CHJ, Barbosa PB, Souza F de O, Antônio FI, Franco MM, Bø K. Inter-rater reliability study of the modified Oxford Grading Scale and the Peritron manometer. *Physiotherapy*. 2011;97(2):132–8.
 37. Frawley HC, Galea MP, Phillips BA, Sherburn M, Bø K. Reliability of pelvic floor muscle strength assessment using different test positions and tools. *Neurourol Urodyn*. 2006;25(3):236–42.