Original article

# Effects on urethral maximum closing pressure during voluntary contraction of pelvic floor muscles in women

# Efectos sobre la presión máxima de cierre uretral durante la contracción voluntaria de los músculos del suelo pélvico en mujeres

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## Abstract

**Introduction:** Pelvic floor muscle exercises represent voluntary contractions and relaxations of the levator ani muscles. This muscle group gives support to the vagina, bladder, and urethra.

Urethral profilometry is a study that assesses the closing function of the urethral sphincter. There is limited scientific evidence regarding the changes in pressure values of the Maximum Urethral Closing Pressure (MUCP) during a voluntary contraction of the pelvic floor muscles (C-MUCP).

**Objective:** During a urodynamic test, evaluate the change in MUCP at rest and during voluntary contraction after verbal command, in patients from two tertiary referral hospitals.

**Material and methods:** Retrospective and cross-sectional study of two tertiary referral hospitals in Mexico. This study focused on reviewing hospital records of adult patients who underwent a urodynamic study from January 2016 to February 2022. Obstetric clinical history data and MUCP results at rest and in C-MUCP during urodynamics were taken. IBM SPSS Statistics version 22 statistical program was used.

**Results:** 928 patients with a mean age of 58 years were evaluated. Eighty three percent were postmenopausal women. An inverse relationship was observed between age and MUCP both at rest (p=<0.001) and in C-MUCP (p=0.009). Neurogenic disease and postmenopausal status had no significant relationship with the ability to increase MUCP. Sixty five percent of the population achieved a clinically significant increase of the MUCP.

**Conclusion:** There is a direct negative relationship between age, resting MUCP and C-MUCP. In patients with both neurogenic and non-neurogenic pathology, the rate of clinically significant increase in MUCP was low.

**Keywords:**
Pelvic floor muscle exercises, Kegel exercises, pelvic floor, maximum urethral closure pressure, urodynamic study

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## Resumen

**Objetivo:** Evaluar el cambio de la PMCU en reposo y durante contracción voluntaria de músculos de piso pélvico posterior a comando verbal durante urodinamia en pacientes de dos centros de referencia de tercer nivel.

**Material y métodos:** Estudio retrospectivo y transversal, de dos centros de referencia nacional de tercer nivel, en México. Revisión de expedientes de pacientes adultas a las que se realizó estudio urodinámico desde enero 2016 a febrero 2022. Se tomaron datos de historia clínica obstétrica y resultados de PMCU en reposo y en contracción voluntaria durante urodinamia. Se utilizó programa estadístico IBM SPSS Statistics versión 22.

**Resultados:** Se evaluaron 928 pacientes con una edad media de 58 años, de estas el 83% eran mujeres posmenopáusicas. Se observó una relación inversa entre la edad y PMCU tanto en reposo (p=<0.001) como en contracción voluntaria (p=0.009). La enfermedad neurogénica y estado postmenopáusico no tuvieron relación significativa con la capacidad del incremento clínicamente significativo de PMCU. Solo el 65% de la población total logró un aumento clínicamente significativo.

**Originalidad y valor:** Es un estudio original, con un grupo muy amplio de pacientes de dos centros de referencia de tercer nivel

**Limitaciones:** Estudio observacional donde se evaluó la presión Máxima de Cierre uretral sin hacer comparación de contracción voluntaria mediante exploración física.

**Conclusión:** Existe relación negativa directa entre edad y PMCU reposo y contracción voluntaria. Tanto en pacientes neurogénicas como no neurogénicas la proporción de incremento clínicamente significativo de la PMCU fue baja.


**Palabras clave:** Ejercicios de piso pélvico, ejercicios de Kegel, Piso pélvico, presión máxima de cierre uretral, estudio urodinámico

## Introduction

Pelvic floor dysfunction (PFD) is a group of conditions that affect voiding, anorectal, pelvic organ support, and sexual dysfunction.[1]

Multiple factors predispose to PFD such as multiple vaginal deliveries, previous abdominopelvic surgeries, generalized weakness of connective tissue, hormonal deficiency, among others.

The pubovisceral muscle (PVM), the most ventral of the pelvic floor muscles, acts on either side of the urethra and helps stabilize it during increases in intra-abdominal pressure by preventing its caudal movement.

There is scientific evidence which shows that to prevent leakage, an intentional increase in urethral closure pressure can be achieved by

voluntarily contracting the pelvic muscles before and during the increase in intra-abdominal pressure.[2]

The pelvic floor is made up of a group of muscles and connective tissue that runs like a sling along the bottom of the pelvis. This structure comprises two layers, the superficial perineal muscles, and the deep pelvic diaphragm. They all provide support to the pelvic organs, the bladder, and elements of the column.

Pelvic floor dysfunction and secondary stress incontinence negatively affect many women. As this population ages, more and more women will be affected, and the cost of treating these medical issues will also increase. The origins of PFD are multifactorial, consequence of human evolution.[3]

Pelvic floor muscle exercises involve the voluntary contraction and relaxation of the levator ani muscle (mainly the pubovisceral and puborectalis portions), which support the vagina, bladder, and urethra. They also contribute to the skeletal muscle component of the urethral sphincter mechanism. The main goal of pelvic floor muscle exercises in the treatment of urinary incontinence is to increase the strength and endurance of these muscles, thus improving the closing force of the urethra under certain conditions, such as a sudden increase in abdominal pressure. Implicit to our understanding of the physiological basis of the Kegel exercises is that a correctly performed contraction should increase the closure force of the urethra.

Some women seem unable to contract adequately when given verbal instructions on pelvic muscle contraction; they often perform the Valsalva maneuver or contract the gluteal and thigh muscles exclusively or in combination with the levator contraction. Dr. Arnold Kegel noted that many women are unaware of their pelvic muscle function and require some form of feedback to successfully contract the proper muscles.

Dr. Arnold Kegel, professor of gynecology and obstetrics in the United States in 1948, was the first to propose the exercise of the pelvic floor muscles as a series of repeated practices. In the context of Kegel study the levator ani is a striated muscle consisting of 67% slow fiber muscle and 33% fast fiber muscle; and its function is to tighten around the opening of the anus, vagina, and urethra.

The original article describes the first explanation given to the patients to perform the correct contraction of the pubovisceral muscle. The first step consists in recognizing anatomical structures, the second step in gentle digital examination to verify the tone contraction of the pubovisceral muscle and other structures, and the last step is to evaluate if this muscle contraction has been learned.

Learning how to perform the contraction correctly was not easy, and verbal or written instructions proved insufficient in up to 40% of these patients described by Kegel. In 50% of the cases, this contraction was performed using abdominal or gluteal accessory muscles, and in some cases, it worsened the symptoms.[4]

Conservative treatment of pelvic dysfunction includes pelvic floor exercises (PFE), recommended as the first line of treatment, strengthening pelvic floor muscles (PFM) through voluntary contractions, thus providing better support to the urethra.[5,6] Urethral profilometry is a study that assesses the urethral closure function,[7] however, the evidence is scarce regarding the influence of voluntary contractions of the pelvic floor muscles on

the changes observed in the MUCP during its performance.[8]

Bump *et al.* (1991) carried out a study on 47 women, all of them underwent a urodynamic study, and at 300 ml the maximum urethral closure pressure was measured at rest and were later asked to contract the muscles. An effective contraction was considered with a 20% increase over the baseline MUCP (100%), proving 60% of patients managed to perform it correctly.[9]

Van Loenen & Vierhout (1997) in their publication reported 72 patients with pelvic floor dysfunction who underwent an urodynamic study. MUCP was measured at half of the maximum cystometric capacity at rest and after the indication to contract the muscles, the patients were directed up until they understood the instruction. Patients who achieved 20% were considered effective contractions, with 39% obtaining an effective contraction without performing a Valsalva maneuver.[10]

The ICI (International Consultation on Incontinence) in its 2016 guidelines, recommended performing a multichannel urodynamic study (UDS) when a patient suffers signs and/or symptoms of a complicated UI or symptoms that are not confirmed by physical examination.[11] The multichannel urodynamic study could become a common clinical practice which lets us confirm the diagnosis of UI. We could indirectly evaluate the function of the pelvic floor muscles with the changes of maximum urethral closing pressure (MUCP) in a voluntary contraction.[12]

Dompeyre *et al.* evaluated MUCP at rest, functional urethral length, quality of life scores, and MUCP increase during exertion, finding a proportional relationship between pelvic floor muscle contraction and maximum urethral closure pressure during exercise.[13] Zubieta *et al.* found an average increase in MUCP during contraction of the pelvic floor muscles in healthy women that varied between 8 and 47.3 cm H2O. In women with incontinence this increase went from 6 to 23.5 cmH2O. This represented a 50% difference between these two groups. Abrahams et al. reported an increase in MUCP of up to 15% with respect to basal pressure.[7] The Fifth International Consultation on Incontinence in its Urodynamic Testing Committee observed a variation of ±10-15%.[11]

The main objective of this investigation is to evaluate the changes in the MUCP at rest and during the contraction of the pelvic floor muscles in women undergoing a urodynamic study and to assess factors that can modify the MUCP.

## Materials and methods

The current investigation was a retrospective, descriptive study, in which only the clinical records of the population which was going to be studied were analyzed. This population were recruited from two tertiary national reference centers in Mexico, they were only female and had to be adults (>18 years). They had all undergone a multichannel urodynamic study procedure in the timeframe between January 1, 2016, until February 28, 2022. Independent Pelvic Floor Dysfunction (PFD) were not considered to be included in the protocol. Excluded patients were those who were unable to follow orders and/or patients with loss of sensation and motor response in the lower limbs.

Evaluation procedure: Both medical centers local ethics and research committee authorized access to the files to do the present

investigation. Data concentration was carried out which included age, menopausal status, obstetric history and presence or absence of neurogenic disease, urodynamic results. The data obtained was worked on Excel 2007 data sheet, and with subsequent analysis in the SPSS version 22 program.

### *Statistical analysis*

Numerical variables were reported in mean and standard deviation, categorical variables in frequency and percentage. Based on what has been reported in the literature, we decided to designate an average in the value of a correct voluntary contraction of the pelvic floor muscles when an increase in MUCP was recorded at the moment of muscle contraction of 20% with respect to the initial basal measurement. The proportion of participants who managed to achieve that increase was registered. Comparison of MUCP measurements were made with student's t-test, correlating age and PMCU was determined by a linear regression and Pearson correlation, while comparisons with neurogenic diseases and postmenopausal status was analyzed with Chi-square. To carry out the analysis, the statistical package SPSS Statistics version 25 (Armonk; NY) was used.

## Results

### *Clinical and demographic characteristics*

Nine hundred twenty-eight participants with a mean age of 58 years (±13.76) were evaluated. Of these patients, the average number of pregnancies per patient was 3 (2-4), vaginal deliveries 2 (0-3). Two hundred sixteen patients had some underlying neurogenic pathology, and 778 were in a postmenopausal state. (Table 1).

**Table 1. Diagnostic demographic characteristics included in the study**

| Diagnosis | Number o patients |
|---|---|
| | (S) |
| Population | 928 (100%) |
| Age | 58.7 (13.76) |
| Pregnancies | 3 (2-4) |
| Vaginal deliveries | 2 (0-3) |
| Abortions | 0 (0-1) |
| Cesareans | 0 (0-1) |
| Post menopause | 778 (83%) |
| Neurological pathology | 216 (23%) |
| S: Standard deviation | |

### *Urodynamic evaluation*

Statistically significant differences were observed in MUCP at rest of the patients with the ability to perform effective C-MUCP compared to those who could not (67.59±26.32 cmH2O vs. 81.07±30.72 cmH2) (p=0.003). There were no significant differences when comparing these two groups with age, obstetric history, history of neurogenic disease, and menopausal status. (Table 2)

**Table 2. Characterization of urodynamic parameters before and after C-MUCP.**

| | Effective C-MUCP (n=604) | Non effective C-MUCP (n=324) | p |
|---|---|---|---|
| Age (Average±SD) | 58.79±13.76 | 57.22±13.48 | 0.299 |
| Pregnancies (median, RIC25-75%) | 3 (2-4) | 3 (2-4) | 0.645 |
| Vaginal delivery (median, RIC25-75%) | 2 (0-3) | 2 (0-3) | 0.727 |
| Miscarriage (median, RIC25-75%) | 0 (0-1) | 0 (0-1) | 0.775 |
| Cesareans (median, RIC25-75%) | 0 (0-1) | 0 (0-1) | 0.219 |
| MUCP (median±DE) | 67.59±26.32 | 81.07±30.72 | 0.003 |
| MUCP en C-MUCP (median±DE) | 93.58±32.58 | 58.88±26.86 | <0.001 |
| Neurological pathology (n,%) | 141 (23.3%) | 75 (23.1%) | 0.94 |
| Postmenopausal (n,%) | 512 (84.8%) | 266 (82.1%) | 0.292 |
| MUCP percentage elevation (median, RIC25-75%) | 28.90 (13.79-62.26) | -22.80 (-39.16--9.70) | <0.001 |

An inverse relationship was observed between age and MUCP. For each unit of age, the MUCP decreases -0.34. Age explains the variance of the MUCP in a poor way R2=0.028, although the model was statistically significant p=<0.001. An inverse relationship was also observed between age and C-MUCP, as for each unit of age, the C-MUCP decreased -0.21, age explains C-MUCP poorly R2=0.007, although statistically significant (p=0.009).

We observed that age did not predict MUCP, observing only borderline significance (p=0.056, B=0.009) (Figure 1) at rest, while there was a low positive correlation between age and effective C-MUCP, borderline statistical significance (k= 0.063, p=0.56). (Figure 2)

**Figure 1. Correlation between MCUP and AGE**

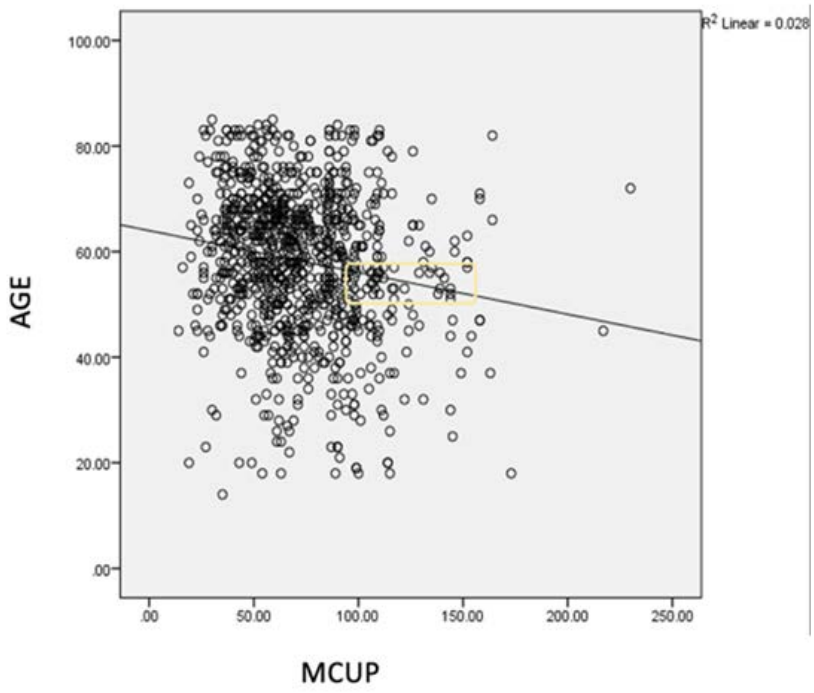
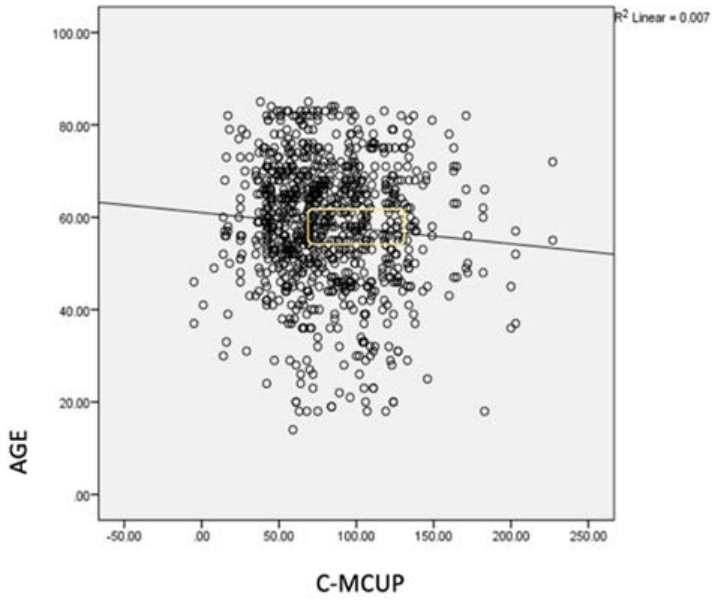



**Figure 2. Correlation between C-MCUP and AGE**



No relationship was observed between neurogenic disease and MUCP with effective contraction p=0.512, nor did we find differences between post menopause and C-MUCP during effective contraction p=0.206

## Discussion

To have been able to prove an inverse relationship between MCUP at rest and during voluntary contraction of the pelvic floor musculature was one of our main findings. Based on published literature, we decided to take a 20% increase in the baseline MCUP as effective contraction.

A published analysis of urodynamic studies refered that patients who were able to perform a C- MCUP adequately showed an increase in MCUP of 20% or more compared to their baseline value prior to performing it.[5]

A Cochrane systematic review published in 2011 included 6 RCTs and highlighted the benefit of PFME as a conservative treatment of prolapse compared to no intervention. They showed that PFME increased the likelihood of improvement in the stage of prolapse by 17% compared to no treatment.[6] There is currently no consensus in various meta-analyses and systematic reviews on the efficacy of PFME performed during Pelvic Floor Exercises in first-line management for SUI.[8] The hypothesis is that the improvement of the pelvic floor muscles in terms of strength, endurance, and coordination through PFME in women with PFD could provide better structural support for their pelvic organs.[6]

Currently, there is no standardized method for the objective evaluation of the effects produced by voluntary contraction of the pelvic floor muscles on urethral function. Reliable and validated methods are needed to measure the strength of the pelvic floor muscles in relation to the MCUP, where the degree of increase is positively associated with the contractility of the levator ani muscle.[13]

The measurement of the MCUP during urethral profilometry is an objective and highly reproducible tool that we can use in our clinical practice to assess proper recognition and function of the pelvic musculature.

One positive impact this study had was on helping standardize a cut-off point for MCUP increase, to consider it clinically significant. Different to other investigations, we included patients with different neurogenic diseases, proving that this special population had a statistically significant difference in the ability to perform the increase in the contraction of pelvic floor muscles.

An area of opportunity of this investigation was that we only evaluated the MCUP without making a clinical comparison during the examination of the contraction of the pelvic floor muscles. This investigation was a purely observational study, however, considering the results, there is an area of opportunity for future research where we can make the comparisons of profilometry with clinical contraction.

## Conclusions

This investigation gave proof that age has an inverse relationship with MCUP both at rest and during voluntary contraction of pelvic floor muscles. Even though there is a trend towards an increase in MCUP during voluntary contraction of the pelvic floor muscles, only 65% of patients can achieve this increase. A limitation to this analysis was that a comparison arm with

contraction during vaginal examination was not performed. Urethral profilometry stands to be an optimal study for the assessment of these parameters.

## CRediT taxonomy

1. Karen Michelle Loya Maldonado:
conceptualization, data curation, formal analysis, methodology, writing original draft, writing review, and editing.
2. Adrián Gutiérrez González:
conceptualization, project administration, methodology, supervision, validation
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## Conflict of interest

None of the authors have any conflicts of interest or financial ties to disclose.

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