

Regression Model for the Prediction of Risk of Pelvic Floor Muscle Weakness among Older Adults

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Research article

Keywords: Parity, Pelvic floor dysfunction, Pelvic floor muscle weakness, Perineometer, Institutionalised older adult, Regression model

Posted Date: April 24th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-24224/v1>

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Version of Record: A version of this preprint was published at Topics in Geriatric Rehabilitation on April 1st, 2021. See the published version at <https://doi.org/10.1097/TGR.0000000000000311>.

Abstract

Background Pelvic floor muscle (PFM) weakness is a major cause of pelvic floor dysfunction (PFD) among women. Though PFD is a major disabling condition among institutionalized older women, PFM strength (PFMS) evaluation is not included in regular geriatric assessment because of privacy issues, availability of perineometer, and lack of trained therapists. Hence there is a need to develop an alternative method that can address the issues related to present PFMS evaluation. Methods After obtaining ethical clearance, the institutionalized older women were screened for inclusion criteria and informed consent was taken in this case-control study. PFM strength as a dependent variable was assessed by using the peritron perineometer. Independent variables assessed were age, parity, BMI, menopausal period, abdominal surgical history, core, and peripheral muscle strength, functional comorbidity index consisting of 18 comorbidities and functional mobility. Results One hundred and two institutionalised older women were included in this study. Among the variables considered, age ($p = 0.005$), years post menopause ($p = 0.040$), pelvic surgery ($p = 0.050$), disc disorders ($p = 0.047$), right hip adductor strength ($p = 0.039$), left hip adductor strength ($p = 0.016$), left hip external rotator strength ($p = 0.045$) and left hip extensor strength ($p = 0.017$) showed a statistically significant odds ratio ($r^2 = 0.484$; $p \leq 0.05$) and hence they were considered for developing the model. Conclusion A regression model for determining PFM weakness among institutionalized older women has been developed, which may be used as a simple and easy to administer method.

Introduction

Pelvic floor muscle (PFM) weakness is one of the prominent yet underreported problems among older adults. [1] The PFM weakness precipitates pelvic floor dysfunction (PFD) which includes urinary incontinence (UI), anal incontinence, pelvic organ prolapse, and defecatory dysfunction. Older women have a higher risk of developing PFD than older males. The global prevalence of PFD reported in older women is 51.9% [2, 3] and among Indian women, it is 34% among which 20.74% of women are over 60 years. [4] PFM weakens with age, obesity, chronic obstructive diseases, menopause, hormonal status, weak peripheral and core muscles, pelvic surgery, mode of delivery and parity. [5] The consequences of PFM weakness which include hygiene issues, embarrassment, depression, sleep disturbances, and a decrease in quality of life. [6] These consequences are noted more among institutionalized older women when compared to community-dwelling older women. The penalties being more on institutionalised older women could be due to poor nutritional status, depression, lack of communication, embarrassment, fear and trust issues with the caretakers and reduced physical and leisure activities. [7,8]

Hence, pelvic floor muscle strength (PFMS) is an important determinant of geriatric women's health, the evaluation of the pelvic floor muscles plays a significant role in the management of its dysfunction. Perineometry is the standard and most reliable technique to evaluate PFMS and endurance. [9] Nevertheless, it might not be possible to use perineometer in the community settings because of the cost factor, lack of availability, [10] need for trained personnel, medico-legal issues and privacy concerns so, there is a need to develop a substitute method to check the pelvic floor muscle strength.

Methods

This case-control study was carried out between March 2016 and February 2017. The study protocol was approved by the institutional ethics committee, Kasturba hospital, Manipal (IEC 111/2016). Participants aged above 60 years were recruited from institutions for older adults with similar sociodemographic background located in Udupi and Mangalore taluk, India. Residents were screened and excluded if they had stoma in situ, congenital anorectal malformations, pelvic inflammatory disease, neurological dysfunction, MMSE < 24 and current low back pain. All the participants were explained about the study procedure and signed written informed consent.

The dependent variable was the maximum voluntary contraction of PFM, assessed using digital Peritron™ 9300 Perineometer with a vaginal probe (molded 23x17.5x5cm) covered with latex sleeves. Participants were instructed not to hold their breath during the contractions, to avoid any influence from the abdominal muscles. Each contraction was held for 5-10 seconds with a rest period of 5 seconds in between the two consecutive contractions. The average reading in cm of H₂O of the first three contractions was recorded. [11] The participants who had PFMS \leq 18 cm of H₂O with urinary incontinence were considered as cases and more than 18 with no urinary leakage were categorized as controls. This cut-off was decided based on the research by Gamerio et al. (2011) [12] and Chevalier, Fernandez and Cuesta (2014), [13] and also by expert opinion.

The independent variables assessed were age, parity (number of births), number of miscarriage, history of pelvic surgery, years post menopause, body mass index (BMI), core muscle strength, peripheral muscle strength (six muscles), functional comorbidity index (18 comorbidities), and functional mobility. Weight and height were measured using a calibrated weighing scale and an inch tape respectively and BMI (kg/m²) was calculated. Core muscle strength was assessed as the maximum time that a prone plank position could be sustained (duration in seconds).

Muscle strength of hip adductors, hip external rotators, and hip extensors were assessed using a hand-held isometric dynamometer. [14, 15] For the assessment of hip adductors, the subject was positioned in the side lying on the lower limb to be assessed. The leg to be evaluated was placed with the knee extended and the hip in neutral rotation, the contralateral limb was stabilized by the examiner at 90 degrees of hip and knee flexion supported by pillows. The participant had to perform a maximum isometric contraction of adductors, with resistance to movement applied just superior to the medial malleolus.

Evaluation of lateral hip rotators was carried out with the participant in high sitting with hip and knee flexed to 90 degrees. The participant held their arms against the body. With the hip in slight lateral rotation and the medial malleolus aligned with the midline of the body, the participant performed a maximal isometric contraction of external rotators, with resistance to movement applied just superior to the medial malleolus. The strength of hip extensors was evaluated in prone lying with the knee flexed to

90° in hip slight lateral rotation. The participant had to perform an isometric contraction of hip extensors, with resistance to movement applied to the distal thigh posteriorly.

Functional comorbidity index is a diagnosis based index which will rule out the age-related comorbidities of the participants. [16] It consists of assessment of 18 comorbidities like arthritis, osteoporosis, asthma, COPD, angina, heart failure, myocardial infarction, neurological disease, stroke, peripheral vascular disease, diabetes, gastrointestinal disease, depression, anxiety, visual impairment, hearing impairment, disc disease and obesity. Each item scores one for each diagnosis and the sum of all the 18 items is the final score. Functional mobility was assessed using the Timed up and go test.¹⁷ It calculates the time in seconds and milliseconds that participant takes to rise from a chair, walk three meters, turn around, walk back to the chair and sit down. During this test, participants were made to wear their daily footwear, were allowed to use their walking aid and were instructed to walk at their normal walking speed.

All statistical analysis was performed with SPSS version 15.0. Descriptive statistics were used to summarize demographic data. Binary logistic regression with stepwise backward technique was used to determine if the independent variables were associated with pelvic floor weakness, to determine the odds ratio and to develop the prediction model. The level of significance was set at $p \leq 0.05$.

Results

One hundred and seventy-three institutionalized older women were screened and 71 were excluded, of which 24 did not give written informed consent, 22 had low backache at the time of the study, 14 had a score of <24 in MMSE and 11 had undergone abdominal surgery within the last 6 months (Figure 1). So 102 participants (46 cases and 56 controls) were included in the study and completed the assessment. Table.1 depicts the demographic characteristics of participants among cases and controls. The mean age and mean years post menopause showed a statistically significant difference between cases and controls, where the mean age was 3.60 ± 1.19 years and mean years post menopause was 3.54 ± 1.12 years more among cases when compared to controls.

Table 1 represents the muscle strength profile of participants in lbs. The mean isometric peripheral muscle strength was less among cases when compared to controls. The mean PFMS (in cm of H₂O) was shown to have a difference of 10.46 ± 1.14 between cases and controls, whereas mean prone plank time was 1.23 ± 0.88 seconds less among cases when compared to controls. Only 17 participants among the controls and 10 among the cases could perform prone planks and were scored more than 0. A statistically significant difference was observed in right and left hip adductors, left hip external rotators, left hip extensors and PFMS between cases and controls.

Table 2 represents the percentage of comorbidities among participants in cases and controls. Only 2.2% of the participants among cases and 3.6% among controls did not report any diagnosed comorbidity. Around 63.9% of the participants in cases and 66.0 % among controls had multi-morbidities. Diagnosed diabetes mellitus was reported by the maximum number of participants with 67.5% and 62.5%

respectively among cases and controls. Arthritis was the next common problem among cases and controls with 65.2 % and 62.5% respectively.

The adjusted and unadjusted odds ratio with the exposed factors is represented in table 3. The variables which showed statistically significant odds ratio were age, years post menopause, pelvic surgery, degenerative disc disorders and strengths of right and left hip adductors, left hip external rotators and left hip extensor muscles, hence those were taken for developing the model.

The regression model developed using those variables was: PFM weakness = - 1.652 + [0.017 (age) + 0.106 (years post menopause) + 1.388 (history of pelvic surgery) + 0.149 (right hip adductor strength) - 0.163 (left hip adductor strength) - 0.023 (left hip external rotator strength) - 0.124 (left hip extensor strength) - 2.95 (disc disorders)] with an r^2 value of 0.484. History of pelvic surgery and disc disorders are categorical and rest all are continuous variables in the model. Factors like heart disease and anxiety were not reported by any of the participants among cases and hence odds ratio could not be calculated. So 48% variance of PFM weakness in this study is explained by age, years post menopause, history of pelvic surgery, right and left hip adductor strength, left hip external rotator and extensor strength and disc disorders.

Discussion

The present study aimed to develop a regression model to determine pelvic floor muscle strength among institutionalized older women. Pelvic floor muscle strength of 18 cm of H₂O was kept as the cut-off for categorizing the participants into cases and controls. This cut-off was decided based on the research by Gamerio et al. (2011) [12] and Chevalier, Fernandez and Cuesta (2014), [13] who reported the mean PFMS among older adults would range between 15 to 20 cm of H₂O and also on the basis of expert opinion. The mean pelvic floor muscle strength observed in this study was 12.89 ± 3.16 cm of H₂O for cases and 23.35 ± 4.30 cm of H₂O for controls. A study on pelvic floor muscle strength among women aged above 40 years reported PFMS to be 36.0 (25.8 to 46.3) cmH₂O. [18] Despite using similar equipment; the digital Peritron Perineometer, the PFMS was two times more than that of the institutionalized older adults in this study. Possible reasons for this could be the diverse ethnicity, where that study was conducted in Australia; the age group variation, where the mean age was 34 ± 8.6 compared to 74.65 ± 6.73 in this study and also it was conducted among community-dwelling individuals.

Twenty-seven independent variables were considered for developing the regression model. A backward stepwise regression revealed only eight variables to have an influence, hence were taken for developing the model. The regression model thus developed had an r^2 value of 0.484. The independent variables included were age, years post menopause, pelvic surgery, right and left hip adductor strength, left hip external rotator strength, left hip extensor strength and disc disorders.

Previous studies have reported that with advancing age the pelvic floor muscle strength reduces persistently. [3,7,18] This age-related decline could be hormonal, neural or the architectural changes in the

muscles. Estrogen deficiency accounts to be the major contributing factor for the decline in PFM strength. [19] As one ages, the actin-myosin sliding mechanism is disturbed during muscle contraction due to the deficiency of beta-estrogen receptors in type 1 muscle fibers. Additionally, it corresponds to a vicious cycle in which the symptom (subdued pelvic floor muscle strength) and the consequences of pelvic floor dysfunction like immobility, embarrassment and social anxiety [20] occur collectively. Other causes like age-related neuropathic changes, sarcopenia of the muscle fibers and neuromuscular changes with age could also be attributed to reduced muscle strength.

In the studies done by Marianna et al. (2016) [5] and Heidi et al. (2014) [21] it is distinct that pelvic floor muscle strength is associated with peripheral (hip adductors, hip extensors, hip external rotators) and core muscle strength. It has been reported that these muscles are in close proximity to the PFM, thereby causing a synergic contraction with strenuous activities. [22] The current study also reports a positive correlation between peripheral muscle strength and pelvic floor muscle strength.

A positive relationship was seen between PFM and degenerative disc disorders. Several studies acknowledge the association between lower lumbar and sacroiliac joint dysfunction with PFM weakness and urinary incontinence. [23] Nicholas, Jason & Kelly (2017) [24] quoted that in older women denervation of pelvic sphincter muscles takes place due to the degeneration of the lumbosacral canal; age-related decline in the bone and muscle architecture also add to the problem which influences PFMS. [25]

The study has potential significance in clinical scenarios where there are high chances of violation of patient confidentiality. The model developed contributes towards addressing the issues related to pelvic floor muscle strength assessment like high cost, lack of availability of equipment, need for trained personnel, medico-legal issues, and privacy concerns. In a typical clinical scenario, a clinician can use the equation and estimate PFM weakness by putting the values of four continuous variables (age, hip adductor, external rotator, and extensor muscle strength) and two categorical variables (pelvic surgery and disc disorders; value1 for present and 0 for absent). Hence it may be used as a simple and easy to administer method for determining PFM weakness.

The majority of the participants complained of shoulder discomfort during the prone plank test and thus could not complete the test procedures. A few factors that might influence PFMS namely duration of labor, history of incontinence after childbirth, physical activity levels of the participants and pelvic floor muscle tone were not evaluated are some of the limitations of this study. Another limitation could be the recall bias, as information of many of the independent variables were collected from older individuals themselves and the researcher bias as all the assessments were carried out only by one investigator. Future research may focus on validating the model, the development of a similar regression model for community-dwelling elderly and address the limitations of this study by incorporating other independent variables.

Conclusion

A regression model for determining PFM weakness among institutionalized older women has been developed, which may be used as a simple and easy to administer method. The variables in the model are age, years post menopause, pelvic surgery, disc disorders, and hip muscle strength.

Declarations

Ethics approval and consent to participate: Ethics approval was taken from the institutional ethics committee, Kasturba hospital, Manipal (IEC 111/2016). Written informed consent was taken from all the participants of this study

Consent for publication: "Not applicable"

Availability of data: The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests: "The authors declare that they have no competing interests"

Funding: None

Authors' contributions:

	Ms. Prajakta Karkare	Ms. Sidhiprada Mohapatra	Dr. Girish N
Conceptualisation	☐		☐
Literature review	☐		
Research gap identification		☐	☐
Designing methods		☐	☐
Seeking ethical approval	☐		
Data collection	☐		
Data analysis			☐
Journal submission			☐

Acknowledgements: "Not applicable"

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Tables

Table 1. Demographic characteristics and muscle strength profile of the participants (n=102)

Variables	Cases (n=46)	Controls (n=56)	p value
	Mean ± SD		
Age (in years)	76.63 ± 7.15	73.03 ± 5.96	0.007
Years post menopause	23.89 ± 5.49	20.25 ± 6.61	0.004
Height (in cm)	149.50 ± 5.61	150.97 ± 7.70	0.282
Weight (in kg)	54.93 ± 11.59	54.92 ± 10.90	0.998
BMI (in kg/m ²)	24.54 ± 4.81	24.13 ± 4.79	0.669
Right hip adductors (in lbs)	11.26 ± 4.98	13.57 ± 4.94	0.021
Left hip adductors (in lbs)	11.21 ± 4.10	13.76 ± 5.11	0.007
Right hip external rotators (in lbs)	12.48 ± 4.25	13.99 ± 5.27	0.122
Left hip external rotators (in lbs)	11.55 ± 5.34	13.99 ± 5.09	0.021
Right hip extensors (in lbs)	13.56 ± 13.91	14.50 ± 5.22	0.643
Left hip extensors (in lbs)	11.57 ± 4.47	14.24 ± 5.08	0.007
PFMS (in cm of H ₂ O)	12.89 ± 3.16	23.35 ± 4.30	0.000
Prone plank (in seconds)	1.93 ± 0.67	3.16 ± 1.55	0.103

Table 2. Percentage of comorbidities in cases and controls (n=102)

Variable	Cases (n=46)	Controls (n=56)	p value
	Number (%)		
Arthritis	30 (65.2)	35 (62.5)	0.470
Osteoporosis	2 (4.3)	1 (1.8)	0.426
Asthma	12 (26.1)	11(19.6)	0.295
COPD	1(2.2)	1(1.8)	0.701
Angina	1 (2.2)	2 (3.6)	0.574
Heart disease	0	1(1.8)	0.549
Heart attack	7 (15.2)	3 (5.4)	0.092
Neurological disorders	4 (8.7)	5 (8.9)	0.451
Stroke	0	1(1.8)	0.473
Diabetes Mellitus	31 (67.5)	35 (62.5)	0.381
Vascular disorders	1 (2.2)	1 (1.8)	0.701
Gastrointestinal disorders	4 (8.7)	2 (3.6)	0.251
Depression	1 (2.2)	2 (3.6)	0.574
Anxiety	0	2 (3.6)	0.229
Visual impairment	20 (43.5)	9 (16.1)	0.002
Hearing impairment	7 (15.2)	9 (16.1)	0.564
Degenerative disc disorders	2 (4.3)	6 (10.7)	0.208
BMI > 30	0	2 (3.6)	0.299

Table 3. Adjusted and unadjusted odds ratio with the exposed factors (n=102)

Variables	Unadjusted odds ratio		Adjusted add ratio	
	Odds ratio	p value	Odds ratio	p value
	(95% CI)		(95% CI)	
Age	1.09 (1.02, 1.16)	0.010	1.23 (1.03, 1.18)	0.005
Height	0.96 (0.91, 1.02)	0.280	0.99 (0.99, 1.07)	0.833
Weight	1.00 (0.96, 1.03)	0.998	1.02 (0.96, 1.08)	0.410
Parity	0.88 (0.72, 1.07)	0.224	1.11 (0.78, 1.58)	0.557
Miscarriage	0.60 (0.05, 6.83)	0.681	22.64 (0.18, 2714.21)	0.201
Years post menopause	1.10 (1.03, 1.18)	0.005	1.11 (1.27, 1.97)	0.040
Pelvic surgery	3.75 (1.37, 10.25)	0.010	4.00 (1.99, 16.07)	0.050
TUG	1.04 (1.00, 1.08)	0.033	1.02 (0.95, 1.09)	0.538
Arthritis	0.88 (0.39, 2.00)	0.779	1.13 (0.24, 5.34)	0.869
Osteoporosis	0.40 (0.03, 4.55)	0.460	0.49 (0.01, 21.23)	0.713
Asthma	0.69 (0.27, 1.75)	0.440	0.63 (0.11, 3.59)	0.607
COPD	0.81 (0.05, 13.45)	0.888	0.72 (0.88, 1.07)	0.821
Angina	0.60 (0.05, 6.83)	0.600	0.74 (0.12, 2.04)	0.712
Heart attack	3.17 (0.77, 13.04)	0.110	2.31 (0.59, 12.41)	0.236
Diabetes Mellitus	1.24 (0.54, 2.81)	0.607	0.58 (0.13, 2.47)	0.464
Vascular disorders	1.22 (0.07, 20.09)	0.888	0.81 (0.00, 76.20)	0.931
Gastrointestinal disorders	2.57 (0.44, 14.71)	0.289	17.47 (.52, 586.41)	0.110

Depression	0.60 (0.053, 6.83)	0.681	0.605 (0.01, 20.08)	0.778
Visual impairment	4.01 (1.59, 10.09)	0.003	1.13 (0.91, 11.02)	0.112
Hearing impairment	0.93 (0.32, 2.74)	0.906	0.86 (0.67, 1.91)	0.562
Degenerative disc disorders	1.37 (0.07, 1.97)	0.249	1.05 (0.00, 0.96)	0.047
Hip external rotators(L)	1.91 (0.84, 0.98)	0.024	2.97 (0.77, 0.89)	0.045
Hip external rotators(R)	0.93 (0.86, 1.01)	0.122	0.99 (0.80, 1.21)	0.925
Hip adductors (L)	0.88 (0.81, 0.97)	0.010	1.85 (0.67, 0.84)	0.016
Hip adductors (R)	0.90 (0.83, 0.98)	0.024	1.16 (0.93, 0.99)	0.039
Hip extensors (L)	0.89 (0.81, 0.97)	0.009	1.88 (0.73, 0.93)	0.017
Hip extensors (R)	0.99 (0.94, 1.03)	0.646	1.02 (0.94, 1.11)	0.492

Figures

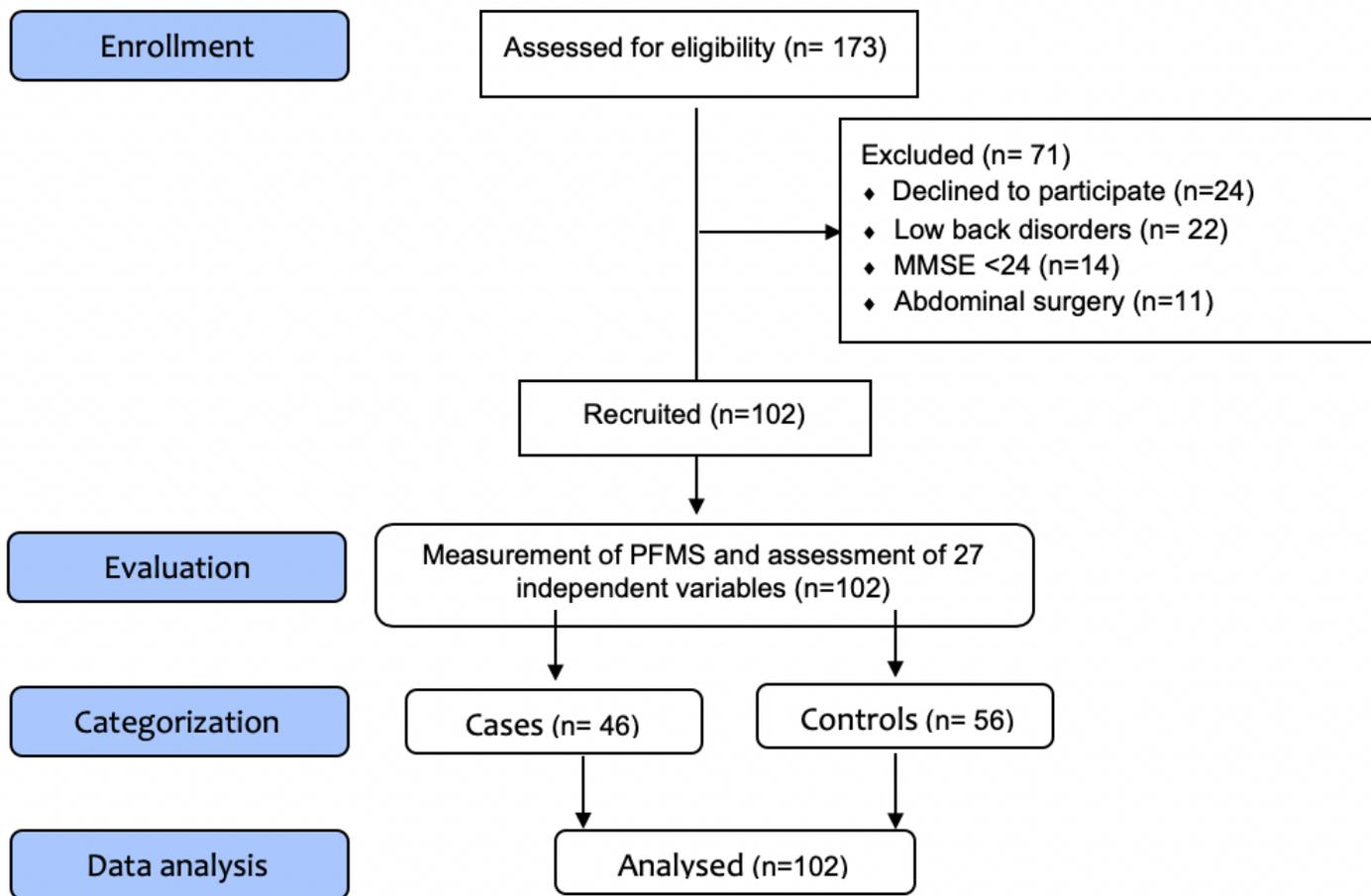


Figure 1

Flow of participants in the study