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NORMAL VALUES FOR HIGH-RESOLUTION ANORECTAL MANOMETRY IN HEALTHY WOMEN: EFFECTS OF AGE AND SIGNIFICANCE OF RECTOANAL GRADIENT

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Abstract

Background and Aims—High-resolution manometry (HRM) is used to measure anal pressures in clinical practice but normal values have not been available. While rectal evacuation is assessed by the rectoanal gradient during simulated evacuation, there is substantial overlap between healthy people and defecatory disorders, and the effects of age are unknown. We evaluated the effects of age on anorectal pressures and rectal balloon expulsion in healthy women.

Design—Anorectal pressures (HRM), rectal sensation, and balloon expulsion time (BET) were evaluated in 62 asymptomatic women ranging in age from 21 to 80 years (median age 44 years) without risk factors for anorectal trauma. Thirty women were aged less than 50 years.

Results—Age is associated with lower ($r = -0.47$, $p < 0.01$) anal resting [63[5] (50 y), 88[3] (<50 y)] but not squeeze pressures; higher rectal pressure and rectoanal gradient during simulated evacuation ($r = 0.3$, $p < 0.05$); and a shorter ($r = -0.4$, $p < 0.01$) rectal BET [17[9]s (50 y) vs 31[10]s (<50 y)]. Only 5 women had a prolonged (> 60 s) rectal BET but 52 had higher anal than rectal pressures (ie, negative gradient) during simulated evacuation. The gradient was more negative in younger (−41[6] mm Hg) than older (−12[6] mm Hg) women and negatively ($r = -0.51$, $p < 0.0001$) correlated with rectal BET but only explained 16% of the variation in rectal BET.

Conclusions—These observations provide normal values for anorectal pressures by HRM. Increasing age is associated with lower anal resting pressure, a more positive rectoanal gradient during simulated evacuation, and a shorter BET in asymptomatic women. While the rectoanal gradient is negatively correlated with rectal BET, this gradient is negative even in a majority of asymptomatic women, undermining the utility of a negative gradient for diagnosing defecatory disorders by HRM.

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Contributions

Drs Jessica Noelting, Shiva Ratuapli, and Karthik Ravi – data analysis and interpretation, critical revision of the manuscript
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Ms Doris Harvey – data acquisition, critically revising the manuscript

Dr Alan R. Zinsmeister - statistical analysis; critical revision of the manuscript

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BACKGROUND

Among patients with symptoms of chronic constipation, a prolonged rectal balloon expulsion time (BET) and a reduced rectoanal gradient (ie, lower rectal than anal pressures) during simulated evacuation are recommended and widely used to diagnose defecatory disorders (1). The latter criterion is based on the premise a normal gradient is necessary for normal evacuation while an abnormal gradient explains difficult defecation.

Contrary to these concepts, several observations suggest an imperfect correlation between the rectoanal gradient during simulated evacuation (or dyssynergia) and rectal BET. For example, up to 20% of asymptomatic people have paradoxical anal sphincter contraction during simulated evacuation. Moreover, paradoxical anal contraction by manometry (2, 3) or defecography (4) did not predict prolonged rectal BET in healthy people. Perhaps limited fidelity of traditional water-perfused or solid-state manometric catheters partly explains these observations. While their configuration of pressure sensors on these traditional systems is variable, no traditional catheter can simultaneously measure circumferential pressures throughout the anal canal and in the rectum. High-resolution manometry (HRM) catheters can do so and are increasingly used to evaluate anorectal functions in clinical practice. However, there is only 1 published study utilizing HRM in patients with constipation and fecal incontinence and normal values for anorectal HRM are not available (5). Since anal pressures are influenced not only by age and sex but also by techniques (6), this substantially limits the utility of HRM in clinical practice.

With traditional (ie, water perfused or solid state) manometry, anal resting and, more variably, squeeze pressures, are lower in older than younger asymptomatic people (7-11). However, the effects of age on anorectal pressures during simulated evacuation and rectal BE which are used to diagnose defecatory disorders (12) have not been characterized. Hence, the aims of this study were to assess (i) anal resting and squeeze pressures and the rectoanal gradient during simulated evacuation; (ii) the relationship of the rectoanal gradient during simulated evacuation to rectal BE; and (iii) the effects of age on these variables in asymptomatic women. While normal values for men are necessary, this study was limited to women because defecatory disorders and fecal incontinence are more common in women than men (1).

MATERIALS AND METHODS

Participants

Sixty-two asymptomatic women were recruited by public advertisement and participated in these studies which were approved by the Mayo Clinic Institutional Review Board. Of the 62 women, 20 were aged between 20 and 29 years, 5 were 30 to 39 years, 5 were 40 to 49 years, 22 were 50 to 59 years, 7 were 60 to 69 years, and 3 were 70 years or older. All participants had a clinical interview and physical examination. Exclusion criteria included significant cardiovascular, respiratory, psychiatric, neurological, or endocrine disease, functional bowel or anorectal disorders as assessed by a validated bowel disease questionnaire (13), inability to augment anal sphincter tone when asked to contract pelvic floor muscles during digital rectal exam, medications (with the exception of oral contraceptives or thyroid supplementation), and abdominal surgery (other than appendectomy, cholecystectomy or hysterectomy). Moreover, subjects who had any previous anorectal operations including hemorrhoid procedures, or had sustained anorectal trauma during delivery (*i.e.* grade 3 or 4 laceration, forceps-assisted delivery) as documented by obstetric records, were excluded.

Anorectal Manometry and Rectal Sensory Assessment

After 2 sodium phosphate enemas (Fleets®, C.B. Fleet; Lynchburg, VA), anal pressures were assessed by a HRM catheter (4.2-mm outer diameter; Sierra Scientific Instruments; Los Angeles, CA), which comprises 10 circumferential sensors, 8 sensors at 6-mm intervals along the anal canal and 2 sensors in the rectal balloon. At each level, 36 circumferentially-oriented pressure-sensing elements detect pressure using proprietary pressure transduction technology (TactArray) over a length of 2.5 mm; data are acquired at 35 Hz. The 36 sector pressures are then averaged to obtain a mean pressure measurement at each level. The response characteristics of each sensing element are such that they can record pressure transients in excess of 6,000 mm Hg/s and are accurate to within 1 mm Hg of atmospheric pressure for measurements obtained for at least the final 5 min of the study, immediately before thermal recalibration.

During each study, parameters were assessed in the following chronological order: anorectal pressures at rest (20 sec), during squeeze (3 attempts for a maximum duration of 20 sec each), and simulated evacuation before and after (50 mL) distending a rectal balloon. Thereafter the rectoanal inhibitory reflex and rectal sensation were simultaneously evaluated by progressively distending the rectal balloon in 20 mL increments from 0 to 200 mL and thereafter in 40 mL increments until a maximum volume of 400 mL; threshold volumes for first sensation, urgency, and maximum discomfort were recorded.

These parameters were analyzed using commercially-available software (Manoview AR v1.0, Sierra Scientific Instruments; Los Angeles, CA). Rectal pressure was measured by the orad sensor in the rectal balloon. While anal pressures are recorded by several, generally 9, sensors, which straddle the anal canal, the eSleeve option reduces the data to a single value at every point in time. However, the calculations for deriving this single value vary among maneuvers. At rest, during squeeze, and rectal distention the eSleeve identifies the highest of all pressures recorded by anal sensors at any point in time. This value is used to calculate the average anal resting and squeeze pressures over 20 seconds for each resting and all 3 squeeze maneuvers. The length of the high pressure zone (HPZ) was the length of the average pressure profile in the resting pressure frame defined as {Rectal Pressure + ([Anal Resting Pressure – Rectal Pressure] * 0.25)}. In contrast, during simulated evacuation, the eSleeve identifies the most positive (or least negative) difference between rectal and anal (Rectal – Anal) pressure over a 20-second epoch. During rectal distention, anal relaxation (%) was calculated as $[(1 - \text{residual anal pressure} / \text{anal resting pressure}) \times 100]$. The rectoanal inhibitory reflex was considered present if anal relaxation was greater than 25%.

Rectal Balloon Expulsion Test

The time required for subjects to expel a rectal balloon filled with 50 cc of warm water while seated in privacy on a commode was measured. The balloon was removed if the subject was not able to expel the balloon in 3 minutes.

Statistical Analysis

The associations between age and anorectal functions were evaluated by Spearman correlation coefficients. Since the distribution of BET was positively skewed, a rank transformation was first applied to these values. Linear regression models were then used to predict the extent to which the rectoanal gradient and other parameters could predict (the rank transformed) rectal BET.

RESULTS

Participant ages ranged from 21 to 80 years (44 ± 17 years, Mean $\pm$ SEM). The body mass index was 26 ± 4 kg/m²; 9 women had a body mass index greater than 30 kg/m². Twenty-nine women had no vaginal deliveries, 31 had 1, 1 had 2, and 1 had 6. Six women had a vaginal or abdominal hysterectomy.

Effect of Age on Anal Resting and Squeeze Pressures and Rectal Sensation

Anal resting pressure was inversely correlated ($r = -0.46$, $p < 0.01$) with age, ie, values were lower in older than in younger asymptomatic women (**Table 1, Figures 1 and 2**). The 10th to 90th percentile ranges for anal resting pressures were also higher in younger (68 - 112 mm Hg) than older women (33 - 91 mm Hg). Data are dichotomized by age 50 years, which was the median age of study participants. In contrast, anal squeeze pressures, anal squeeze duration, and rectal sensory thresholds were not related to age (**Table 1, Figures 1 and 2**). Anal sphincter fatigability was assessed by comparing squeeze duration for 3 consecutive maneuvers (12 ± 1 s for the first, 12 ± 1 s for the second, and 11 ± 1 s for the third maneuver). Fatigability and the anal squeeze increment (squeeze – resting pressure) were not correlated with age either (**Table 1**).

Effect of Age on Rectoanal Gradient During Simulated Evacuation and Rectal BE

Simulated evacuation was performed before and during rectal distention by 50 mL (**Figures 1 and 2**). Fifty-six women reported the desire to defecate during rectal distention. In women aged less than 50 years, rectal pressures (20 ± 3 mm Hg) were lower than anal pressures (63 ± 5 mm Hg) during simulated evacuation without rectal distention; hence the rectoanal gradient was negative (-41 ± 6 mm Hg). In comparison, rectal pressures and the rectoanal gradient during simulated evacuation were higher ($r = 0.3$, $p < 0.05$) and the rectal BET was shorter ($r = -0.4$, $p < 0.01$) in women aged 50 years or older (**Figures 1 and 2**).

During simulated evacuation after rectal distention, rectal pressure was 160 ± 5 mm Hg in women less than 50 years and 174 ± 6 mm Hg in women aged 50 years or older (**Table 1**). Using these values, the calculated rectoanal gradient was 98 ± 7 mm Hg for younger and 130 ± 8 mm Hg for older women. However, this relatively stiff rectal balloon inflated by 50 mL in atmosphere has a pressure of 137 mm Hg, which is probably substantially higher than intrarectal pressure when it is distended by 50 mL. Subtracting 137 mm Hg provides a rectoanal gradient of -39 ± 7 (-83 , -1 , [90% CI]) in younger and 7 ± 8 (-60 , 35 , [90% CI]) in older women. These values are similar to corresponding values without rectal distention.

The 90th percentile value for rectal BE was 75 seconds in younger but only 15 seconds in older women.

Relationship Between Rectoanal Gradient During Simulated Evacuation and Rectal BE

The correlation between rectoanal gradient during simulated evacuation and rectal BET was significant ($r = -0.51$, $p < 0.0001$ for before and during rectal distention) (**Figure 3**); the inverse correlation signifies that a lower (less positive or more negative) gradient was associated with a longer BET. In linear regression models, age and the rectoanal gradient significantly predicted BET during simulated evacuation before or after rectal distention (**Table 2**); together these and other variables explained 37% and 35% of the inter-patient variation in (rank transformed) rectal BET during simulated evacuation without and with balloon distention, respectively. The rectoanal gradient explained only 16% of the inter-patient variation in (rank transformed) rectal BET during simulated evacuation without and 13% with balloon distention, after adjusting for age, length of HPZ, mean resting pressure, and urge sensation threshold levels.

DISCUSSION

While HRM is increasingly used to evaluate anorectal functions in clinical practice, this is the first report using anorectal HRM in asymptomatic people. In addition to providing age-adjusted normal values for anorectal HRM, these observations shed light on the relationship between the rectoanal pressure gradient during simulated evacuation and rectal BE. Current guidelines, which are based on traditional manometry (ie, water-perfused or solid-state), suggest that a negative gradient, which may be due to inadequate propulsive forces or increased anal resistance to evacuation, is useful for identifying defecatory disorders (1, 14). The rectoanal gradient during evacuation measured by HRM was correlated with rectal BET which confirms the face validity of this index. However, this gradient was negative in all 30 asymptomatic women aged less than 50 years, of whom 25 had a normal rectal BE test. Since the rectal BE test is a very sensitive and specific index of rectal evacuation (15), these findings suggest that a negative rectoanal gradient by HRM does not reflect impaired rectal evacuation; indeed in women aged less than 50 years, the 90th percentile value was -74 mm Hg. While counterintuitive, these findings may be partly explained by differences between simulated and actual defecation, eg, during normal defecation, rectal pressures in the upright position in a rectum filled with stool are probably higher than during HRM. Indeed, rectal pressure is higher and anal pressure is lower during simulated evacuation in the seated than left lateral positions (3, 16). However, the same limitations also apply to traditional manometry, which is also performed in the left lateral position and where a negative gradient is regarded as abnormal, despite some evidence to the contrary. In 1 study, 36% of asymptomatic people had dyssynergia during traditional manometry in the left lateral position and, in contrast to the present study, the rectoanal gradient did not predict rectal BET (3). While the gradient is lower in patients with defecatory disorders and improves with pelvic floor retraining, there is considerable overlap in values among patients with defecatory disorders, chronic constipation not due to pelvic floor dysfunction, and asymptomatic women (14). Finally, the rectoanal gradient was also reduced in patients with pelvic pain without constipation (17). Taken together, these findings suggest that based on current techniques, a rectal balloon expulsion test is more useful than the anorectal gradient during simulated evacuation for diagnosing defecatory disorders.

Because the desire to defecate is necessary to initiate defecation, simulated evacuation was evaluated with and without rectal distention. The relationship between the gradient and rectal BET was similar for both maneuvers, suggesting that either should suffice. Moreover, there is concern that simulated evacuation with an inflated balloon may damage the pressure sensors (Tom Parks, Sierra Scientific Instruments, personal communication). Compared to younger women, the rectoanal gradient was more positive and the BET was shorter in women aged 50 years or older. Indeed, 11 women aged 50 years or older had a positive gradient during simulated evacuation before rectal distention. Moreover, the 90th percentile value for BET was much shorter in older (15 sec) than younger women (75 sec), perhaps because rectal pressure during simulated evacuation was higher in older than younger women. Since the current cut off for normal rectal BET is 60 s even in women aged 50 years or older, it is conceivable that some women with chronic constipation and a BET between 16 and 60 s have impaired rectal evacuation. Further studies are necessary to ascertain if a lower cut off (eg, 15 s instead of 60 s) improves the diagnostic precision of a rectal BE test in older women.

Since techniques for water-perfused or solid-state manometry are not standardized, normal values are variable and depend on the method used for measurement and analysis (18, 19). Allowing for differences among techniques, the average length of the high pressure zone in women by HRM (ie, 3.5-3.6 cm) was comparable to traditional manometry (ie, 3.7 cm) (10, 20, 21). However, comparisons with selected traditional manometry studies that provide

values for younger and older women, suggest there are differences in normal values for anal resting and squeeze pressures measured by HRM and traditional manometry. Allowing for differences in definitions (eg, for resting pressure), subject characteristics, and age cutoffs, the average mean anal resting pressure recorded by HRM in this study (88 mm Hg in younger and 63 mm Hg in older women) is higher than corresponding values recorded by traditional manometry (67 - 75 mm Hg in younger and 48 - 62 mm Hg in older women) (7, 10, 11). Similarly, the 90th percentile value for anal resting pressure (112 mm Hg in younger and 91 mm Hg in older women) is higher than the cutoff we used previously to define anismus (22). Perhaps these differences are partly explained by the e Sleeve option, which only considers the highest pressure at any level of the anal canal.

Confirming previous studies, the 10th percentile value for anal resting pressure, which is used to identify reduced anal resting pressure (eg, in fecal incontinence), was much lower in older (33 mm Hg) than younger women (68 mm Hg) (7-11). However the absolute anal squeeze pressure, squeeze increment, and squeeze duration were not related to age. Some previous studies observed lower anal squeeze pressures in older than younger asymptomatic women (7,9,11,23) and one did not (10). There are 3 possible explanations as to why anal squeeze pressures measured by HRM were not negatively correlated with age. First, it is conceivable that anal squeeze pressures decline at an older age than anal resting pressure; only 3 women in this study were aged 70 years or older. Second, we carefully excluded women with multiple deliveries and other risk factors for anorectal trauma; to speculate, women who have sustained injury to their external anal sphincter may be more susceptible to the age-associated reduction in anal squeeze pressure. Third, the e Sleeve option, may also underestimate the effect of age on anal pressures.

Squeeze duration is a useful but underutilized index of sphincter endurance. In this study, the squeeze duration was shorter than observed in previous studies (e.g., average of 14s versus 24s) (21), probably because the threshold pressure used to define sustained squeeze (i.e., 50% of maximum squeeze pressure) in this program is higher than previous studies, which typically used the longest duration between the onset of increase in sphincter pressure and return of pressure to baseline. This index reflects predominance of type 1 skeletal muscle fibers in the human anal sphincter, which are responsible for maintaining tone (23). While sphincter endurance was reduced in a subset of women with fecal incontinence (24), it was not related to age in asymptomatic women in this study.

Average rectal sensory thresholds for first sensation, urgency, and discomfort were 33, 56, and 86 mL, respectively. Allowing for differences among studies, normal values for corresponding thresholds with a latex balloon are typically higher (ie, up to 100 mL for first sensation, 200 mL for urgency, and 300 mL for maximum discomfort) (25), likely because this balloon is stiffer than a latex balloon. Also, in contrast to some (7, 26, 27) but not all (7, 10, 28-33) studies with a latex balloon, rectal sensory thresholds were not higher in asymptomatic older women. A type II error is unlikely because a sample size of 60 subjects provided 80% power to detect a correlation 0.35 between age and rectal sensation. One possible explanation for the absence of a significant association between age and rectal sensation is that this relationship depends on the type of rectal distention. Thus, similar to these observations, age did not significantly affect rectal perception during staircase distention with a barostat (11). In contrast, rectal perception of phasic distention was reduced in older asymptomatic women (11). Because balloon compliance is nonlinear and varies with repeated inflation, rectal compliance cannot be accurately measured with this balloon.

In addition to being limited to females, only 3 healthy subjects were older than 70 years of age. Hence, further studies are necessary to clarify normal values in women aged 70 years.

While no healthy subjects had symptom criteria for functional constipation or constipation-predominant IBS, it is conceivable that some asymptomatic women have pelvic floor dysfunction; indeed 5 women had a BET > 60 seconds. Inclusion of these women may have widened the normal (10-90th percentile values) range for anorectal parameters. Finally, a comparison of high resolution and traditional (i.e., water perfused or solid state) manometry in the same subjects will be useful, in particular, to clarify normal values for the rectoanal gradient with both techniques.

In summary, these findings establish normal values for anal pressures and rectal sensation measured by HRM in asymptomatic women. Increasing age is associated with lower anal resting pressure, a more positive rectoanal gradient during simulated evacuation, and a shorter BET in asymptomatic women. While the rectoanal gradient is negatively correlated with rectal BET, this gradient is negative even in a majority of asymptomatic women, undermining the utility of a negative gradient for diagnosing defecatory disorders by HRM.

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WHAT IS CURRENT KNOWLEDGE?

- Anorectal pressures, which can be recorded by traditional (water-perfused or solid-state) manometry or high-resolution manometry, are useful for diagnosing defecatory disorders and fecal incontinence.
- Age is associated with lower resting and, to a lesser extent, squeeze pressures, even in asymptomatic women.
- The rectoanal gradient during simulated evacuation and rectal balloon expulsion test are used to diagnose defecatory disorders.

WHAT IS NEW HERE?

- This study provides normal values for rectoanal pressures at rest, during squeeze, and simulated evacuation and rectal sensation using high-resolution manometry.
- Compared to younger women, women aged ≥ 50 years had higher rectal pressures, a higher rectoanal gradient during simulated evacuation, and a shorter balloon expulsion time.
- The rectoanal gradient during simulated evacuation explained only a small proportion of the inter-subject variation in rectal balloon expulsion time.
- Most asymptomatic women had a negative rectoanal pressure gradient during simulated evacuation, undermining the utility for this parameter for diagnosing defecatory disorders and fecal incontinence.

Figure 1.

Representative examples of HRM study in asymptomatic younger women with normal (upper panel, 23 s, 39 y) and abnormal rectal BET (lower panel, 360 s, 36 y). Compared to the upper panel, the lower panel reveals higher anal resting and squeeze pressures and also higher anal pressures during simulated evacuation before rectal distention. Rectal distention, which is accompanied by increased pressure in the rectal balloon, induced anal relaxation in both women. During simulated evacuation thereafter, anal pressures increased to a greater extent in the lower than upper panel. Rectal sensory thresholds for first sensation (1), urgency (2), and maximum discomfort (3) were recorded during rectal balloon distention up to 60 mL (upper panel) and 90 mL (lower panel).

Figure 2.

Representative example of HRM study in an asymptomatic older woman (80 y) with normal rectal balloon expulsion time (2 s). Compared to the younger women in Figure 1, anal resting pressure was lower and the HPZ was shorter. However, the squeeze response was preserved. Before rectal distention, simulated evacuation was accompanied by increased pressure in the rectal balloon and anal relaxation; the gradient was normal. Rectal sensory thresholds for first sensation (1), urgency (2), and maximum discomfort (3) were recorded during rectal balloon distention up to 90 mL.

Figure 3.

Relationship between rectoanal gradient during simulated evacuation and rank-transformed rectal BET in asymptomatic subjects. A more negative gradient was associated with longer rectal BET ($r = -0.51$, $p < 0.0001$).

Table 1

Anal Pressures, Rectal Compliance, Rectal Sensory Thresholds, and Pelvic Floor Motion in Patients

Variable	Women < 50 years (n=30)		Women ≥ 50 years (n=32)		Relationship with age *
	Mean ± SEM	10 th , 90 th percentile	Mean ± SEM	10 th , 90 th percentile	
Anal resting pressure	88 ± 3	68, 112	63 ± 5	33, 91	-0.47 [†]
Anal HPZ length (cm)	3.6 ± 0.1	2.8, 4.4	3.5 ± 0.2	2.4, 4.5	ns
Anal squeeze pressure ^a	167 ± 6	115, 209	162 ± 12	99, 248	ns
Anal squeeze increment ^{a, b}	73 ± 6	23, 113	96 ± 12	28, 171	ns
Anal squeeze duration (s) ^c	12 ± 1	3, 23	14 ± 3	3, 23	ns
First sensation (mL)	33 ± 2	20, 40	32 ± 2	20, 40	ns
Desire to defecate (mL)	56 ± 3	40, 75	59 ± 4	40, 90	ns
Urgency (mL)	86 ± 5	60, 120	96 ± 5	60, 120	ns
Balloon expulsion time	31 ± 10	4, 75	17 ± 9	3, 15	-0.4 [†]
Simulated evacuation without rectal distention					
Rectal pressure	20 ± 3	0.7, 47	32 ± 5	5, 72	0.29 ^{††}
Anal pressure	63 ± 5	35, 97	47 ± 6	3, 94	ns
Rectoanal gradient	-41 ± 6	-74, -1	-12 ± 6	-55, 32	0.33 [†]
% Anal relaxation	32 ± 5	7, 65	25 ± 10	-68, 91	ns
Simulated evacuation with rectal distention					
Rectal pressure	160 ± 5	129, 187	174 ± 6	147, 215	0.3 ^{††}
Anal pressure	63 ± 4	37, 100	46 ± 6	4, 97	ns
Rectoanal gradient	98 ± 7	54, 136	130 ± 8	77, 172	0.35 [†]

Values are mm Hg unless stated otherwise.

HPZ – high pressure zone. ns – not significant

* Spearman correlation coefficient

[†] p < 0.01^{††} p < 0.05^a These values are derived from the squeeze maneuver with the highest squeeze pressure^b Squeeze increment is (anal squeeze pressure – anal resting pressure).^c Average squeeze duration of 3 maneuvers.

Table 2

Relationship Between Rectoanal Gradient During Simulated Evacuation and Rectal Balloon Expulsion

Parameter	Simulated evacuation (SE)		Simulated evacuation with rectal distention (SERD)	
	R ²	Coefficient (SE)	R ²	Coefficient (SE)
Age	0.10 ^a	−0.51 (0.20)	0.13 ^a	−0.59 (0.20)
Anal resting pressure	0.004	−0.07 (0.14)	0.01	−0.12 (0.15)
Anal sphincter length	0.03	4.86 (3.84)	0.02	4.47 (3.93)
Rectoanal gradient during evacuation	0.16 ^b	−0.29 (0.09)	0.13 ^a	−0.23 (0.08)
Threshold for desire to defecate	0.02	−0.16 (0.15)	0.008	−0.10 (0.15)
Total	0.37		0.35	

^a
p 0.02^b
p 0.001