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*Published in:*  
Diseases of the Colon and Rectum

*DOI:*  
[10.1097/DCR.0000000000001615](https://doi.org/10.1097/DCR.0000000000001615)

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*Document Version*  
Publisher's PDF, also known as Version of record

*Publication date:*  
2020

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

Jonker, J. E., Trzpis, M., & Broens, P. M. A. (2020). Fecal continence for solid and liquid stool: The function of the anal-external sphincter continence reflex and the puborectal continence reflex. *Diseases of the Colon and Rectum*, 63(10), 1419-1426. <https://doi.org/10.1097/DCR.0000000000001615>

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# Fecal Continence for Solid and Liquid Stool: The Function of the Anal–External Sphincter Continence Reflex and the Puborectal Continence Reflex

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**BACKGROUND:** The anal–external sphincter continence reflex and the puborectal continence reflex control fecal continence by involuntary contractions of the external anal sphincter and puborectal muscle. To date it is unknown what the effect of liquid stool is on these reflexes.

**OBJECTIVE:** The purpose of this study was to analyze the consequence of liquid stool on the presence and function of these fecal continence reflexes.

**DESIGN:** This was a prospective, observational study.

**SETTING:** The study was conducted at the Anorectal Physiology Laboratory, University Medical Center Groningen.

**PATIENTS:** Forty-two healthy subjects were included.

**MAIN OUTCOME MEASURES:** Pressure changes at the level of the external anal sphincter and the puborectal muscle during the anorectal pressure test used to measure voluntary contractions, the balloon retention test used to measure involuntary contractions mimicking solid stool, and the rectal infusion test used to investigate the effect of only water mimicking liquid stool were measured.

**RESULTS:** During the test mimicking solid stool, the pressure at the level of the external anal sphincter increased from the start to the end ( $132 \pm 54$  vs

$198 \pm 69$  mm Hg;  $p < 0.001$ ). The pressure at the level of the puborectal muscle increased simultaneously ( $30 \pm 9$  vs  $176 \pm 52$  mm Hg;  $p < 0.001$ ). After injecting water into the rectum, mimicking liquid stool, we observed immediate activation of the anal–external sphincter continence reflex ( $87 \pm 32$  vs  $145 \pm 36$  mm Hg;  $p < 0.001$ ); this was after a median 30 seconds, whereas no activation of the puborectal continence reflex appeared ( $26 \pm 9$  vs  $26 \pm 7$  mm Hg;  $p = 0.655$ ).

**LIMITATIONS:** We only performed anorectal function tests mimicking 2 types of stool consistencies, namely water and solid.

**CONCLUSIONS:** The anal–external sphincter continence reflex controls fecal continence of both solid and liquid stool. Contrarily, the puborectal continence reflex contributes to solid stool continence only. See **Video Abstract** at <http://links.lww.com/DCR/B286>.



## CONTINENCIA FECAL PARA HECEAS SÓLIDAS Y LÍQUIDAS: LA FUNCIÓN DEL REFLEJO DE CONTINENCIA DEL ESFÍNTER ANAL EXTERNO Y EL REFLEJO DE CONTINENCIA PUBORRECTAL

**ANTECEDENTES:** El reflejo de continencia del esfínter anal externo y el reflejo de continencia puborrectal controlan la continencia fecal mediante contracciones involuntarias del esfínter anal externo y el músculo puborrectal, respectivamente. Hasta la fecha, se desconoce cuál es el efecto de las heces líquidas en estos reflejos.

**OBJETIVO:** Analizar las consecuencias de las heces líquidas en la presencia y función de estos reflejos de continencia fecal.

**DISEÑO:** Estudio prospectivo observacional.

**AJUSTE:** Laboratorio de Fisiología Anorrectal, *University Medical Center Groningen*.

**Funding/Support:** None reported.

**Financial Disclosure:** None reported.

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Dis Colon Rectum 2020; 63: 1419–1426

DOI: 10.1097/DCR.0000000000001615

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DISEASES OF THE COLON & RECTUM VOLUME 63: 10 (2020)

1419

**PACIENTES:** Cuarenta y dos sujetos sanos.

**MEDIDA DE RESULTADO PRINCIPAL:** Los cambios de presión a nivel del esfínter anal externo y el músculo puborrectal durante la prueba de presión anorrectal utilizada para medir las contracciones voluntarias, la prueba de retención con balón utilizada para medir las contracciones involuntarias que imitan las heces sólidas, y la prueba de infusión rectal utilizada para investigar El efecto de solo agua imitando las heces líquidas.

**RESULTADOS:** Durante la prueba que imita las heces sólidas, la presión a nivel del esfínter anal externo aumentó desde el principio hasta el final ( $132 \pm 54$  mm Hg *versus*  $198 \pm 69$  mm Hg,  $p < 0.001$ ). La presión a nivel del músculo puborrectal aumentó simultáneamente ( $30 \pm 9$  mm Hg *versus*  $176 \pm 52$  mm Hg,  $p < 0.001$ ). Después de inyectar agua en el recto, imitando las heces líquidas, observamos la activación inmediata del AESCR ( $87 \pm 32$  mm Hg *versus*  $145 \pm 36$  mm Hg,  $p < 0.001$ ), esto fue después de una mediana de 30 segundos, mientras que no hubo activación de la continencia puborrectal apareció reflejo ( $26 \pm 9$  mm Hg *versus*  $26 \pm 7$  mm Hg,  $p = 0,655$ ).

**LIMITACIONES:** Solo realizamos pruebas de función anorrectal que imitan dos tipos de consistencia de heces, a saber, discriminando entre a agua y sólidos.

**CONCLUSIONES:** El reflejo de continencia del esfínter anal-externo controla la continencia fecal de las heces sólidas y líquidas. Por el contrario, el reflejo de continencia puborrectal contribuye solo a la continencia de heces sólidas. Consulte **Vídeo Resumen** en <http://links.lww.com/DCR/B286>. (*Traducción—Dr Adrian Ortega*)



**KEY WORDS:** Anal–external sphincter continence reflex; Anorectal manometry; Fecal continence; Liquid stool; Puborectal continence reflex; Solid stool.

Fecal incontinence is the uncontrolled loss of solid or liquid fecal material.<sup>1</sup> It is a debilitating condition that seriously impairs patient quality of life.<sup>2</sup> The prevalence of fecal incontinence worldwide is estimated to be  $\approx 8\%$ , varying between 2% and 21%.<sup>3–5</sup> The prevalence of the different forms of fecal incontinence is also described in the literature. It appears that more people experience liquid rather than solid stool incontinence.<sup>6–8</sup> Furthermore, it is known that diarrhea is a common risk factor for fecal incontinence.<sup>4</sup> Despite the attempts of researchers to explain these differences in prevalence and the underlying mechanisms, the differences between solid and liquid stool incontinence remain unclear.<sup>4,6,7</sup>

To increase our understanding of its pathophysiology, we need to thoroughly comprehend the physiologi-

cal mechanisms of fecal continence. Current knowledge about fecal continence describes the voluntary contractions of the external anal sphincter and puborectal muscle.<sup>9</sup> In addition to these voluntary contractions, 2 fecal continence reflexes play an important role in controlling fecal continence; the anal–external sphincter continence reflex (AESCR) and the puborectal continence reflex.<sup>10,11</sup> These fecal continence reflexes control fecal continence by regulating involuntary contractions of the external anal sphincter and puborectal muscle. They have been described in healthy subjects and in patients during the balloon retention test, which mimics solid stool.<sup>10,11</sup> The question remains whether these fecal continence reflexes are also activated by liquid stool. The aim of this study was therefore to describe and compare the functions of both the AESCR and the puborectal continence reflex for solid and liquid stool in healthy subjects.

## PATIENTS AND METHODS

### Participants

This was a prospective study conducted with healthy subjects. All of the subjects had completed The Groningen Defecation and Fecal Continence Questionnaire,<sup>12</sup> on the basis of which we selected those subjects who had no history of anorectal disorders, no reported anorectal problems, no trauma or surgery in the lower GI tract, and, in the case of women, no pregnancies or deliveries. A total of 53 healthy subjects were invited for the anorectal function tests. The study was approved by the University Medical Center Groningen Medical Ethical Committee, and all of the subjects gave their written informed consent.

The healthy subjects were medical students. We contacted them through an email containing details that they could address if they were interested in participating in the study. They received appropriate monetary compensation afterward, which was rated in accordance with the guidelines of the Medical Ethical Committee.

### Measuring Equipment

The anorectal function tests were administered in our Anorectal Physiology Laboratory at University Medical Center Groningen. We used solar, GI, high-resolution anorectal manometry, version 9.3 (Laborie/Medical Measurements Systems, Enschede, the Netherlands). Two catheters were used during the anorectal function tests. Catheter number 1 was a solid-state Laborie/Unisensor K12981 catheter (Boston type, width 12 F). It records pressure around the catheter every 8 mm at the level of the anal canal up to the distal part of the rectum. Catheter number 2 was a Laborie/Unisensor K14204 catheter (width 14 F) with 2 microtip sensors to measure pressure into the connected rectal balloon during inflation. Below, we describe the 3 anorectal function tests used in the present study. The tests

were performed consecutively on the same day with an interval of  $\approx 5$  minutes between the tests. The anorectal pressure test was performed as first, the balloon retention test as second, and the rectal infusion test as the last one.

### Anorectal Function Tests

#### Anorectal Pressure Test

We used Catheter 1 for the anorectal pressure test. During this test the subjects were lying down on their left side and were asked to squeeze. Change in pressure was measured at the level of the external anal sphincter and the puborectal muscle and reflects voluntary contractions.

#### Balloon Retention Test

We gave a full description of the balloon retention test accompanied by a clarifying figure in one of our previous articles.<sup>10</sup> This test is used to measure the involuntary contraction of the external anal sphincter and the puborectal muscle.<sup>10,11,13</sup> We performed the test with Catheters 1 and 2, inserting the 2 catheters at the same time while the subject was sitting upright on a commode. Water at body temperature at a speed of 1 mL/s was injected into the rectal balloon, thus the water remained in the balloon. The end of the balloon retention test was defined as the moment of maximal tolerable sensation or maximal retainable sensation. Because the water remains in the balloon while it is in the rectum, the balloon retention test mimics solid stool and therefore the Bristol stool score 3 to 5 is applicable.<sup>14</sup>

#### Rectal Infusion Test

We performed the rectal infusion test to investigate whether both reflexes are involved in controlling fecal continence for liquid stool. During this test, water at body temperature was injected directly into the rectum to mimic liquid stool, equivalent to the Bristol stool score 7.<sup>14</sup> For the rectal infusion test we only used Catheter 1. This test was also performed while the subject was sitting upright on a commode. Water was injected with a constant speed of 1 mL/s. The test was stopped when 1000 mL was inserted into the rectum, which was after 16.7 minutes. This moment was defined as the end of the test. We excluded the “healthy subject” if they could not retain the water until the end of the test, that is, those subjects who were not continent for liquid stool. We measured the time and volume at which the first increase of pressure was observed at the level of the external anal sphincter and the puborectal muscle. Because pressure at the level of the puborectal muscle did not increase, we used the moment when the first pressure increase at the level of the external anal sphincter was observed as the moment to register the pressure at the level of the puborectal muscle. In addition, we measured the pressure at the start and at the end of the test for both the external anal sphincter and puborectal muscle.

The standard procedure during the rectal infusion test is to inject 1500 mL of water into the rectum.<sup>15</sup> In the present study, we infused 1000 mL during all measurements. To determine, however, whether using 1500 mL changed the outcomes, we first infused 12 healthy subjects with 1500 mL. We found no significant differences between the outcomes obtained with 1000 and 1500 mL for either the external anal sphincter or the puborectal muscle. Thus, the results are based on only the 1000-mL infusions.

### Statistical Analysis

Data were analyzed with SPSS version 23.0 for Windows (IBM SPSS Statistics, IBM Corp, Armonk, NY). Values were presented as numbers (percentages), as means  $\pm$  SDs, or as medians (ranges). The independent samples *t* test and the paired-samples *t* test were performed for normally distributed data. The Mann–Whitney and Wilcoxon signed-rank tests were performed when data were not normally distributed. Pearson correlation was used to measure the association between 2 continuous parameters. The level of statistical significance was set at  $p < 0.05$ . Figures were generated using either GraphPad Prism, version 7.02 for Windows (GraphPad Software, La Jolla, CA) or Microsoft Office Publisher 2010 (Microsoft Corp, Redmond, WA).

## RESULTS

### Subject Selection and Characteristics

Of our total of 53 invited subjects, we excluded 11 subjects because the anorectal function tests were not administered according to protocol for the following reasons: pressure not recorded ( $n = 4$ ), not a good position of the catheter ( $n = 3$ ), test was finished too early ( $n = 3$ ), or the pump did not function ( $n = 1$ ). Consequently, the measurements of 42 healthy subjects were analyzed in this study. Of these, 24 (57%) were women and 18 (43%) were men ( $p = 0.44$ ). The median age of the subjects was 22 years (18–30 y). No subject dropped the balloon during the balloon retention test, thus the end of the test was maximal tolerable sensation. All of the subjects retained the water during the rectal infusion test. The start pressure for the balloon retention

**TABLE 1.** Comparison of the involuntary contractions of the external anal sphincter and puborectal muscle in the presence of solid and liquid stool in the rectum

Total ( $n = 42$ )	Pressure at start, mm Hg	Pressure at end, mm Hg	<i>p</i>
External anal sphincter			
BRT, mean $\pm$ SD	132 $\pm$ 54	198 $\pm$ 69	<0.001
RIT, mean $\pm$ SD	87 $\pm$ 32	108 $\pm$ 43	0.005
Puborectal muscle			
BRT, median (range)	30 (20 – 55)	185 (70 – 280)	<0.001
RIT, mean $\pm$ SD	26 $\pm$ 9	31 $\pm$ 13	0.04

BRT = balloon retention test (mimicking solid stool); RIT = rectal infusion test (mimicking liquid stool).

test differed significantly from the start pressure for the rectal infusion test ( $132 \pm 54$  mm Hg vs  $87 \pm 32$  mm Hg;  $p < 0.001$ ; Table 1).

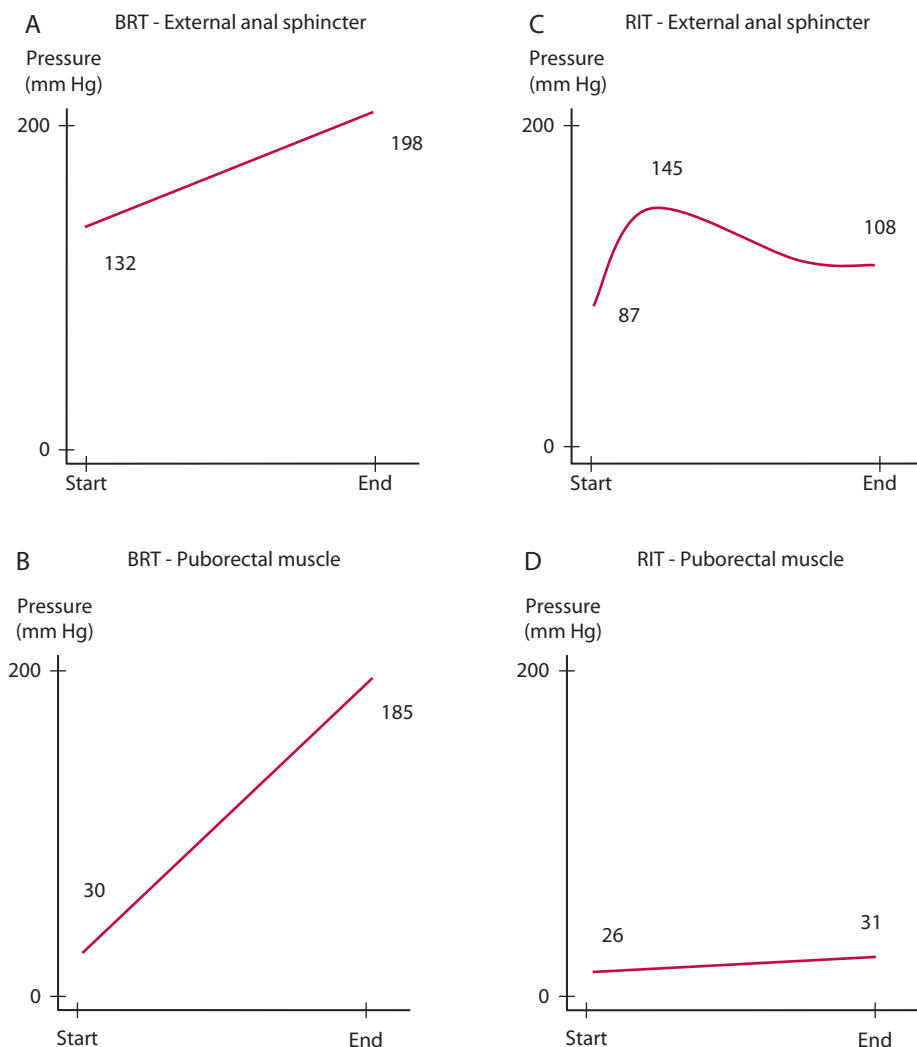
### Functioning of Fecal Continence Reflexes in the Presence of Solid Stool

The pressure at the level of the external anal sphincter during the balloon retention test, which mimics solid stool, was significantly increased from the start to the end of the test ( $132 \pm 54$  vs  $198 \pm 69$  mm Hg;  $p < 0.001$ ; Table 1 and Fig. 1A). At the same time, during the same test, the pressure at the level of the puborectal muscle also significantly increased from start to end (30 (20–55) vs 185 (70–280) mm Hg;  $p < 0.001$ ; Table 1 and Fig. 1B). The

mean time until the end of the test was  $6.5 \pm 1.9$  minutes. At the end of the test we found no association between the pressures of the external anal sphincter and the puborectal muscle, reflecting the AESCR and the puborectal continence reflex ( $r = -0.134$ ;  $p = 0.40$ ; Fig. 2). A representation of the results of high-resolution anorectal manometry of 1 subject during the balloon retention test is shown in Fig. 3A.

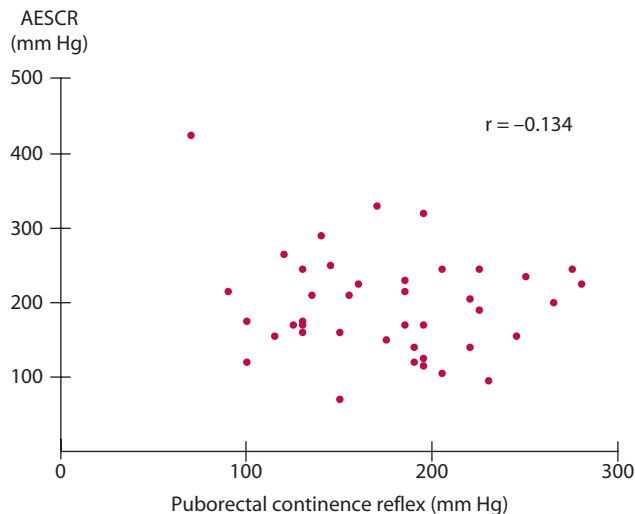
### Functioning of Fecal Continence Reflexes in the Presence of Liquid Stool

After injecting water into the rectum, we observed an immediate increase in pressure at the level of the external anal sphincter, up to  $145 \pm 36$  mm Hg, which was signif-



**FIGURE 1.** Graphical display of the mean and median values of the balloon retention test (BRT) and rectal infusion test (RIT) at the start and at the end of the test for both the external anal sphincter and the puborectal muscle. A, Increase in pressure at the level of the external anal sphincter during the BRT, which mimics solid stool, thus activation of the anal–external sphincter continence reflex (AESCR). B, Increase in pressure at the level of the puborectal muscle during the BRT, which mimics solid stool, thus activation of the puborectal continence reflex. C, First rapid increase in pressure at the level of the external anal sphincter after median 30 seconds and later stabilization of the increase in pressure when water is injected. D, No rapid increase in pressure, and only a small, clinically irrelevant increase in pressure at the level of the puborectal muscle during injection of water.





**FIGURE 2.** Comparison of the anal–external sphincter continence reflex (AESCR) and the puborectal continence reflex.

icantly higher compared with the pressure at the start of the test ( $87 \pm 32$  mm Hg;  $p < 0.001$ ; Table 2 and Fig. 1C). The median time of this increase in pressure was 30 seconds. During the same test, at that same time, we found no increase at the level of the puborectal muscle ( $26 \pm 9$  vs  $26 \pm 7$  mm Hg;  $p = 0.66$ ; Table 2).

After having injected 1000 mL of water, that is, the end of the test, we observed a significant increase in pressure at the level of the external anal sphincter, up to  $108 \pm 43$  mm Hg, which was also a significant increase from the start of the test ( $87 \pm 32$  mm Hg;  $p = 0.005$ ; Table 1 and Fig. 1C). We also found a significant increase in pressure at the start and end of the test at the level of the puborectal muscle. However, this was only a mean difference of 5 mm Hg ( $26 \pm 9$  vs  $31 \pm 13$  mm Hg;  $p = 0.04$ ; Table 1 and Fig. 1D). A representation of the results of high-resolution anorectal manometry of 1 subject during the rectal infusion test is shown in Fig. 3B.

### Sex Differences in Fecal Continence Mechanisms

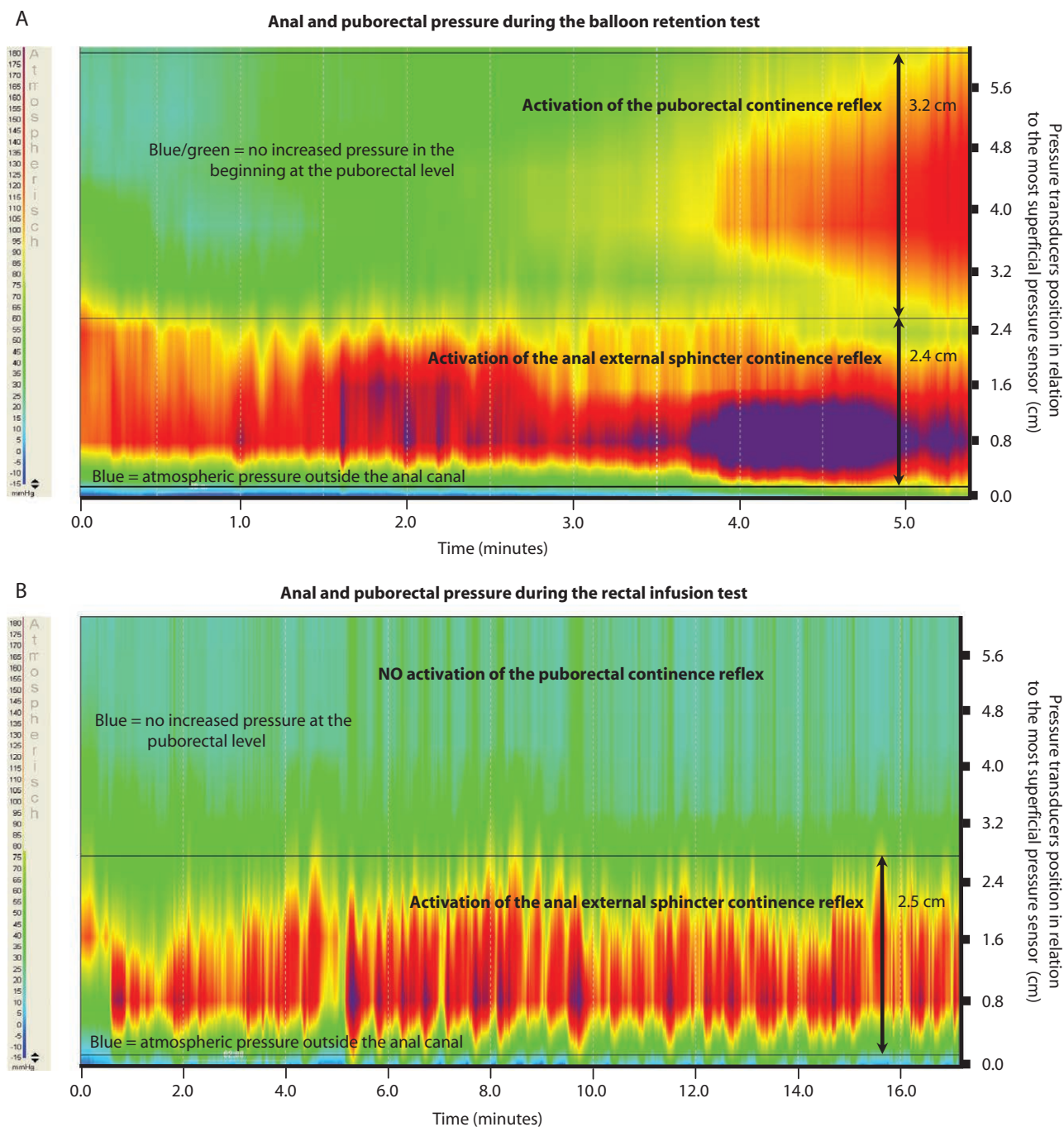
In Table 3, the differences between the sexes for both voluntary and involuntary contractions while mimicking solid and liquid stool are presented. Men generated a significantly higher voluntary contraction at both the level of the external anal sphincter and the puborectal muscle compared with women ( $p = 0.008$  and  $p = 0.003$ ). Contrarily, we observed no differences for involuntary contractions at the end of the test while mimicking solid stool and liquid stool between men and women for both the external anal sphincter and puborectal muscle ( $p = 0.68$  and  $p = 0.51$ ). However, the pressure at the start of the balloon retention test and the rectal infusion test at the level of the external anal sphincter were significant higher in men compared with women ( $p = 0.002$  and  $p = 0.001$ ).

## DISCUSSION

In this study we investigated the effect of mimicking solid and liquid stool (the balloon retention test and the rectal infusion test) on the AESCR and the puborectal continence reflex. Although we have described these 2 reflexes previously, to date they have not been compared in one study, nor do we know under which conditions they are normally activated.<sup>10,11</sup> In the present study we found that the AESCR was activated during tests mimicking both solid and liquid stool, while the puborectal muscle was only activated in case of the balloon retention test that was used to mimic solid stool. During the balloon retention test, which we performed to mimic solid stool, we found comparable activation of both fecal continence reflexes. Interestingly, we found that after injecting water into the rectum, the AESCR was activated rapidly. This rapid increase in pressure was already seen after, on average, 30 seconds. In contrast to the AESCR, the puborectal continence reflex was not activated rapidly on injecting water. Although we found a statistically significant increase of pressure when comparing the start and the end of the rectal infusion test, we do not consider this difference as being clinically relevant, because it was only an increase of, on average, 5 mm Hg.

We note that, during the rectal infusion test, water flows into the proximal part of the colon and, although it passes both the external anal sphincter and the puborectal muscle, it is still the AESCR that is activated rapidly, while the puborectal continence reflex stays inactive. This difference in activation of the fecal continence reflexes can help us describe their characteristics in more detail. Previous research showed that, after administering a topical local anesthesia, the involuntary contractions of the external anal sphincter diminished.<sup>11</sup> This led to the hypothesis that the receptor belonging to the AESCR pathway is located superficially in the anal canal. Our observation that the AESCR is activated rapidly even after injecting only a few milliliters of water into the rectum, thus barely building up pressure in the anorectal area, indicates that the receptor has features resembling a contact receptor. In contrast to the AESCR, the puborectal continence reflex showed no activation after a small amount of water and only a slight, clinically irrelevant increase after 1000 mL were injected directly into the rectum. This supports our hypothesis that the receptor belonging to the puborectal continence reflex pathway might be a stretch receptor that activates its reflex only on increasing rectal pressure.

One could raise the objection that the pressure at the level of the external anal sphincter at the start of the balloon retention test was higher than at the start of the rectal infusion test and that these differences bear influence on our outcomes. During the balloon retention test, however, there are 2 catheters, one with a balloon inserted and one without, whereas during the rectal in-



**FIGURE 3.** A, High-resolution pressure during the balloon retention test, in which a rectal balloon is gradually filled with water. This figure shows a female healthy subject. Color changes represent change in pressure, in which blue represents no pressure change, thus atmospheric pressure, and red represents increasing pressure. On the right axis the pressure transducers are shown, which indicate the distance from outside the anal canal to more proximal in the anal canal. The pressure zones at the level of the external anal sphincter and the puborectal muscle are indicated. With this test, involuntary contractions of the external anal sphincter and puborectal muscle are measured, which are regulated by the anal–external sphincter continence reflex and the puborectal continence reflex, which are indicated. B, High pressure profile during the rectal infusion test, in which water is injected into the rectum. The test was performed in the same female subject as shown in A. Notice that the anal–external sphincter continence reflex is activated, resulting in a high pressure zone, but that there is no activation of the puborectal continence reflex.

fusion test only one catheter without a balloon is inserted. The difference of the pressures observed at the level of the external anal sphincter, and not at the level of the puborectal muscle, reinforces our hypothesis that

the AESCR is a contact receptor while the puborectal continence reflex is not. Naturally, the effect of 2 catheters and a balloon is a stronger incentive than 1 catheter only.

**TABLE 2.** Comparison of the pressures measured at the level of the external anal sphincter and the puborectal muscle during the rectal infusion test

Muscle	Pressure at start, mean $\pm$ SD, mm Hg	First increase of pressure, mean $\pm$ SD, mm Hg <sup>a</sup>	Mean	95% CI	p
External anal sphincter	87 $\pm$ 32	145 $\pm$ 36	58	46 to 71	<0.001
Puborectal muscle	26 $\pm$ 9	26 $\pm$ 7	0.6	-3.2 to 2.1	0.66

<sup>a</sup>First increase of pressure was median 30 seconds (30 mL).

### Difference in Prevalence of Solid and Liquid Stool Incontinence

It is known that people suffer more from incontinence for liquid stool than from solid stool.<sup>6–8</sup> In addition, diarrhea is known to be a common risk factor for fecal incontinence.<sup>4</sup> Although many researchers have attempted to explain the phenomenon, the issue remains unclear. On the one hand, our finding that continence for solid stool is controlled by both fecal continence reflexes, while continence for liquid stool seems to be controlled by only the AESCR, might explain the higher prevalence of incontinence for liquid stool. Consequently, in case of a nonfunctioning AESCR, fecal continence for liquid stool can no longer be controlled. On the other hand, continence for solid stool is still possible in this case, because the puborectal continence reflex is still functioning. In other words, continence for solid stool is controlled by at least 2 involuntary mechanisms, while liquid stool is controlled by only one. Fortunately, stool is solid most of the time, with an average Bristol Stool Chart in the normal population of types 3, 4 and 5, with 1 being hard lumps and 7 completely liquid stool.<sup>14,16</sup> Thus, in healthy people, the 2 fecal continence reflexes probably function simultaneously, and only in case of solely liquid stool does the AESCR control fecal continence.

### Influence of Sex on Voluntary and Involuntary Contractions

Our findings that voluntary contractions of the external anal sphincter and the puborectal muscle are stronger in men than in women corroborate previous research.<sup>17,18</sup> Interestingly, the involuntary contractions for both the external anal sphincter and the puborectal muscle did not differ for the sexes. Nevertheless, we found that the pressure at the start of the test, at the level of the external anal sphincter, was higher in men than in women. It is well-known in the literature that the resting pressure is higher in men compared with women.<sup>19,20</sup> Furthermore, it may possibly be explained by the fact that the anorectal function tests were performed by a young woman. We noticed that during the measurements the behavior of male subjects was more awkward and they were more nervous than the female subjects. The fact that the male subjects were more nervous and thus probably less able to relax their pelvic floor muscles could explain the higher pressure at the start of the test in the male subjects compared with the female subjects.

### Limitations

One could criticize that we performed the rectal infusion test with only water as a substitution for liquid stool rather

**TABLE 3.** Sex differences in relation to fecal continence mechanisms

Anorectal manometry measurements	Total group (n = 42)	Women (n = 24)	Men (n = 18)	p
Maximal voluntary contraction, mm Hg				
External anal sphincter, median (range)	325 (160–585)	298 (180–445)	365 (160–585)	0.008
Puborectal muscle, median (range)	75 (25–245)	63 (25–150)	113 (35–245)	0.003
Involuntary contraction during BRT				
External anal sphincter, mm Hg				
Pressure at start, mean $\pm$ SD	132 $\pm$ 54	109 $\pm$ 37	163 $\pm$ 57	0.002
Pressure at end, mean $\pm$ SD	198 $\pm$ 69	201 $\pm$ 76	193 $\pm$ 61	0.68
Puborectal muscle, mm Hg				
Pressure at start, median (range)	30 (20–55)	30 (20–45)	25 (20–55)	0.15
Pressure at end, mean $\pm$ SD	176 $\pm$ 52	180 $\pm$ 58	170 $\pm$ 42	0.51
Time to end test, mean $\pm$ SD, min	6.5 $\pm$ 1.9	6.5 $\pm$ 2.0	6.5 $\pm$ 1.7	0.90
Involuntary contraction during RIT				
External anal sphincter, mm Hg				
Pressure at start, mean $\pm$ SD	87 $\pm$ 32	74 $\pm$ 23	105 $\pm$ 33	0.001
Pressure at end, mean $\pm$ SD	108 $\pm$ 43	106 $\pm$ 36	110 $\pm$ 52	0.74
Puborectal muscle, mm Hg				
Pressure at start, mean $\pm$ SD	26 $\pm$ 9	26 $\pm$ 10	26 $\pm$ 9	0.83
Pressure at end, mean $\pm$ SD	31 $\pm$ 13	29 $\pm$ 8	33 $\pm$ 18	0.35
Time to end test, min	16.7	16.7	16.7	NA

NA = not applicable; BRT = balloon retention test (mimicking solid stool); RIT = rectal infusion test (mimicking liquid stool).



than adding a thickening solution as is sometimes the case with other experiments. We did so purposely to closely mimic the most extreme form of liquid stool. We acknowledge that such an extreme form of diarrhea does not occur often. Nevertheless, with this study design we also covered the severest form of diarrhea. With the present study we also showed that the puborectal muscle appears to have a stretch receptor that reacts to pressure. We postulate that the activation might depend on stool thickness. In other words, if stool is watery, but still more or less solid, the puborectal continence reflex might still be activated. Additional research on different stool consistencies is needed to confirm this hypothesis.

We could have minimized the apparent discomfort of the male subjects by providing a male experimenter to perform the tests. Nevertheless, we aimed to avoid interindividual differences between the measurements.

## CONCLUSION

The AESCR controls fecal continence of both solid and liquid stool. Contrarily, the puborectal continence reflex contributes to solid stool continence only.

## ACKNOWLEDGMENTS

The authors thank Mss T. de Groot, S. Gerritsen, and B. Brongers-Posthuma for their priceless service in the Anorectal Physiology Laboratory and appreciate the help of T. van Wulfften Palthe, Ph.D., in correcting the English manuscript.

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