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Influence of Gender and Age on Anorectal Function: Normal Values from Anorectal Manometry in a Large Caucasian Population

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Key Words
Ageing · Manometry, anorectal · Anorectal sensation · Gender · Neurogastroenterology

Abstract
Introduction: In the literature, data on the effects of gender and age on the pressure data of anorectal manometry differ. Possible reasons are investigation of only small numbers of healthy people and comparison of only 2 groups with large age differences. In addition, data about the influence of gender or age on anorectal sensation are sparse. Therefore, the aim of the present study was to determine the influence of gender and age on anorectal manometry in a large healthy female and male cohort spanning a great age range. ***Methods:*** Anorectal manometry was performed in 72 women and 74 men with a median age of 64 years in both groups (ranges: women 22–90 years; men 23–88 years). We determined mean anal resting and squeeze pressure as well as minimal rectal balloon volume for perception and for urge/desire to defecate. The Mann-Whitney U test was used to analyze for gender differences, regression analysis to search for age influences. ***Results:*** Squeeze pressure ($p = 0.007$) and perception threshold ($p < 0.001$) are significantly lower in females, while the mean resting pressure and urge threshold are similar in females and males. Mean resting pressure (women $p < 0.0001$; men $p = 0.03$) and mean squeeze pressure decrease (women $p < 0.0001$; men $p = 0.004$) with age. An age-related increase in sensory thresholds (= decreased rectal sensitivity) is only seen in females (perception threshold $p = 0.01$; urge threshold $p = 0.04$). ***Conclusion:*** Most of the parameters measured by anorectal manometry (anal canal pressure, sensory thresholds) are influenced by gender and age. Therefore, the results of anorectal manometry must be interpreted in relation to sex- and age-adapted normal values.

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Introduction

Defecation disorders affect 10–20% of the adult population [1–3]. Especially elderly patients suffer from these disorders such as fecal incontinence and constipation [4]. Several tests and techniques have been developed to evaluate anorectal disorders such as anorectal manometry,

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endoanal ultrasonography or defecography [5]. However, data on the influence of gender or age on these tests are either sparse or contradictory.

Anorectal manometry is widely used in patients with disorders of the anorectum to quantify motoric and sensoric data [5]. However, published normal values differ. This can be related, at least in part, to differences in methodology, in the small numbers of healthy people investigated, and to the comparison of (only) 2 groups with an large age difference [6, 7]. Yet, it might also be due to discrepancies in the study population (female:male ratio, age distribution) since Felt-Bersma et al. [8] observed a broad range of anal pressures when measuring normal individuals of different ages and gender. In addition, data about the influence of gender or age on anorectal sensory parameters are especially sparse [9–11].

If therapeutic decisions in patients with anorectal disorders are to be based on the results of anorectal manometry, reliable normative data are a prerequisite [8]. The current study represents an attempt to solve this issue by investigating a large healthy cohort of both sexes spanning a great age range.

Subjects and Methods

Seventy-two women and 74 men with a median age of 64 years in both groups (age range: women 22–90 years; men 23–88 years; all Caucasians) were consecutively recruited for this study. Women and men were not age-matched, but comparable numbers of patients were recruited for the decades <50, 51–60, 61–70, 71–80, and >80 years. All patients were admitted to our hospital for routine screening or surveillance colonoscopy. Anorectal manometry was performed before colonoscopy. The subjects received the usual bowel preparation at our endoscopy unit (macrogol based). No influence of bowel preparation on the results of anorectal manometry is reported in the literature [12]. Exclusion criteria were fecal incontinence, constipation, anorectal disorders or other gastrointestinal dysfunctions and a history of instrumental delivery (females with episiotomy or cesarean section included). None of the patients were taking any medication that had an influence on the GI tract, especially anorectal function, and no one had a history of previous abdominal surgery, neurological disease or diabetes. All subjects had a normal physical abdominal and anorectal (digital) examination. Of the 72 women, 58 had children (1–6, median 2) with 102 vaginal deliveries and 13 cesarean sections. The study protocol was approved by the local ethics committee and was in accordance with the updated Declaration of Helsinki. Informed consent was obtained from each subject.

Study Protocol

Anorectal Manometry

Anorectal manometry was performed according to the recommendations of the German Society for Neurogastroenterology and Motility [5]. In brief, anorectal manometry was performed with an 8-lumen water-perfused manometric probe (outer diameter 4.8 mm, perfusion rate 0.5 ml/min; MUI Scientific) which was connected via an analog-to-digital converter (Polygraph; Medtronic) to a computer. The pressure activity was displayed online on the computer screen (Lower GI software; Medtronic). A silicon rubber balloon 5 cm in length was tied to the end of the probe (balloon tied at both ends) and could be inflated via the central lumen of the manometric probe. With the patient lying in the left lateral position with knees flexed, the lubricated probe was introduced until all measuring ports were lying in the rectum. After a 10-min run-in period, the manometric probe was withdrawn at 1-cm increments until all ports were seen outside the anal canal. At each position during the withdrawal, the catheter remained until a stable pressure level was seen (at least 15 s). This maneuver was performed 3 times during rest with a >1-min pause between maneuvers. During the next 3 removals, the subjects were asked to squeeze the anus as tightly as possible at each station to register the maximum squeeze pressure. Rectal sensation was evaluated by rapidly inflating the rectal balloon with a handheld syringe in steps of 10 ml of air. The balloon was completely deflated between each inflation step. The patient was instructed to announce first perception and the occurrence of a constant sensation of urgency. The determination of rectal sensation was also performed 3 times, with a rest period of 2 min before re-inflating the balloon.

Analysis of Records

Mean Resting Pressure. At each level, i.e. 1, 2, 3 cm, and so on from the anal verge, we measured the difference between the baseline pressure (atmospheric pressure at the height of the anal verge) and the anal sphincter pressure at rest. The mean pressure at each level was calculated from the 8 radially oriented measuring ports and the highest mean resting pressure was noted for each of the 3 removal maneuvers. Of these 3 mean resting pressures, the lowest one was taken as the patient's mean resting pressure (MRP) because it represents the maximum resting pressure in the anal canal during the optimal state of relaxation of the patient (no voluntary contraction of the external sphincter muscle).

Maximum Squeeze Pressure. This was defined as the mean (of the 8 measuring ports) difference between the baseline pressure and the highest pressure that was recorded at any level within the anal canal during squeeze. By comparing the 3 attempts to squeeze, we selected for the patient's maximum squeeze pressure (MSP) the highest one because in this attempt the patient contracted his external sphincter muscle best.

Balloon Volume at First Perception. The lowest volume of air that reproducibly evoked a sensation in the 3 tests was taken as the balloon volume at first perception (BVP).

Balloon Volume Provoking Constant Urgency. The lowest volume of air that reproducibly evoked a constant sensation of the urge to defecate in the three tests was taken as the balloon volume provoking urgency (BVU).

Statistical Analysis

The manometric data from our patients are expressed as median and range. The Mann-Whitney U test was used to analyze for gender differences in anorectal function tests, regression analysis to search for age influences.

Table 1. Influence of gender and age on anorectal manometry

	MRP mm HG	MSP mm Hg	BVP ml	BVU ml
Median (range)				
Females (n = 72)	64 (17–126)	151 (64–418)	35 (10–100)	90 (45–200)
Males (n = 74)	67 (30–142)	201 (69–413)	40 (10–100)	120 (50–200)
<50 years				
Females	81	174	20	73
Males	85	265	30	85
51–60 years				
Females	79	157	15	80
Males	87	228	30	128
61–70 years				
Females	73	144	38	88
Males	72	217	30	120
71–80 years				
Females	52	131	30	83
Males	65	204	40	130
>80 years				
Females	46	136	30	100
Males	68	173	35	130

MRP = Mean resting pressure; MSP = mean squeeze pressure; BVP = balloon volume for perception; BVU = balloon volume for urge.

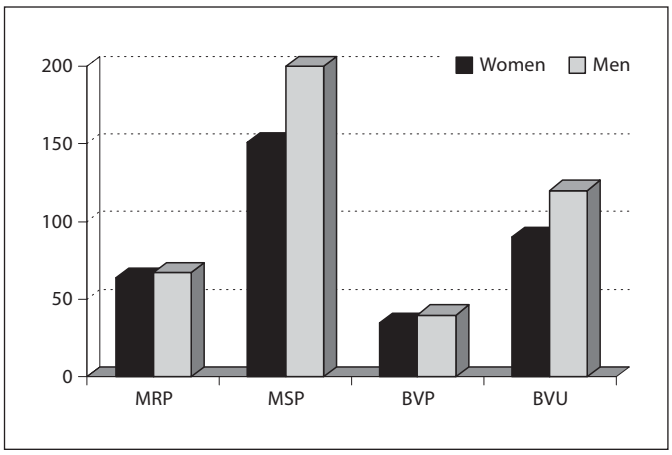

Fig. 1. Median values for the anal resting (MRP) and squeeze pressures (MSP) and balloon volume at first perception (BVP) and at constant urge for defecation (BVU) in women and men.

Results

Mean Resting Pressure

Only a very small insignificant difference in MRP was seen between females (median 64 mm Hg) and males (median 67 mm Hg; table 1; fig. 1). MRP decreased significantly with increasing age in both sexes (women $p < 0.0001$, men $p = 0.03$; fig. 2, 3). The median MRP decreased from 81 mm Hg in women aged <50 years to 46 mm Hg in women aged >80 years (table 1). The corresponding values in men are 85 mm Hg (<50 years) and 68 mm Hg (>80 years).

Maximum Squeeze Pressure

MSP (table 1; fig. 1) was significantly lower in females than in males ($p = 0.007$). MSP also decreased significantly with age in women and men (women $p < 0.0001$, men $p = 0.004$; fig. 2, 3). The values for the median MSP in the youngest and oldest age groups were 174 and 136 mm Hg in females and 265 and 173 mm Hg in males (table 1).

Balloon Volume at First Perception and at Constant Urgency

Perception threshold (table 1; fig. 1) was significantly lower in females (median BVP 20 ml in females and 30 ml in males; $p < 0.001$), while the difference in urge threshold between women (median 73 ml) and men (median 85 ml) was not significant. A small increase in sensory thresholds (= decreased rectal sensitivity) was seen with age, being significant only in females (perception threshold $p = 0.01$, urge threshold $p = 0.04$; fig. 4, 5).

Discussion

The present study was performed to investigate the influence of gender and age on anorectal pressure and sensation in a large healthy cohort spanning a great age range. The main results are: (i) no difference in mean resting pressure of the anal canal, while the maximum squeeze pressure is much lower in woman compared to men; (ii) a heightened perception for rectal distension in women (significant for balloon volume at first perception); (iii) ageing is accompanied by a decrease in anal (resting and squeeze) pressure and by a small deterioration of anorectal sensing (significant only in females).

Mean Resting Pressure

Several studies have investigated the effect of gender on resting pressure of the anal canal. However, the data are contradictory with about half of the studies stating a

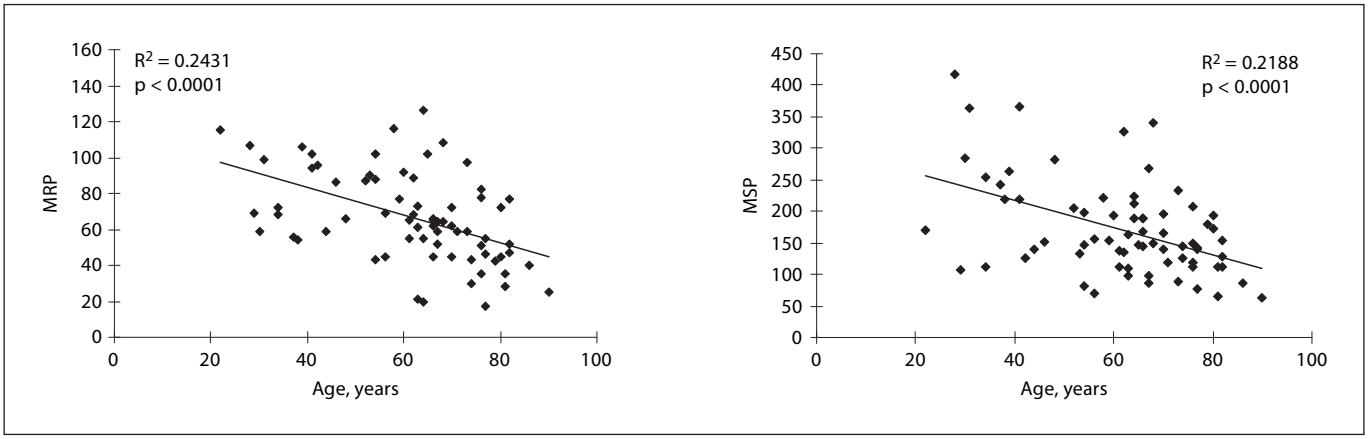

Fig. 2. Regression analysis on the influence of age on mean resting (MRP) and squeeze (MSP) pressure in women.

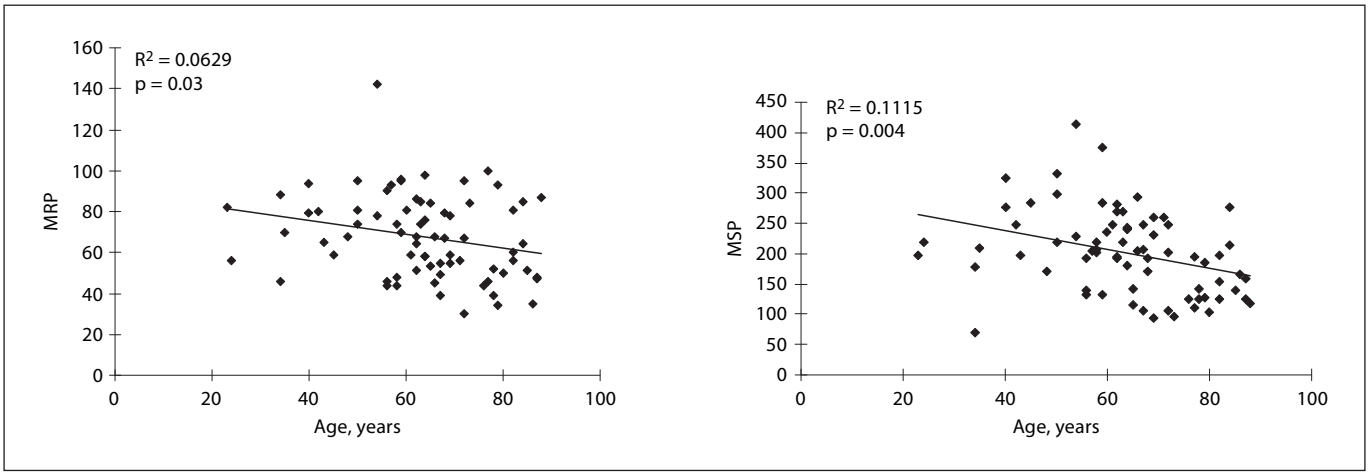

Fig. 3. Regression analysis on the influence of age on mean resting (MRP) and squeeze (MSP) pressure in men.

comparable resting pressure in females and males and a lower resting pressure in females [13–18]. In most of these studies, the number of investigated women and men was rather low (<25). Laurberg and Swash [14], who reported a greater number of subjects, observed a significantly lower resting pressure in females than in males. However, they investigated 102 women, but only 19 men. In contrast, Felt-Bersma et al. [8] did not observe a gender difference by comparing resting pressure in 40 women and men, each. This is in accordance with the result of our study in more than 70 people of both sexes.

The reported data about the effect of ageing on MRP are contradictory too. Some studies observed a significant lowering of MRP with age (more often in females than in males), some found only a small fall in MRP which did not reach statistical significance, while others did not see a decreased MRP in their older subjects [8, 11, 14]. Beside the above-mentioned problem of small sample size, it has to be kept in mind that in most studies different and rather low cutoff values between the younger subjects and the older ones were chosen (40, 50, 55, or 60 years). Poos et al. [19] were the only ones to compare 3 age groups (<40, 40–60, >60 years) and determined a significant fall in MRP in both sexes with increasing age. In the present study, we divided the subjects into 5 age groups (<50 and then by decades), and used regression analysis

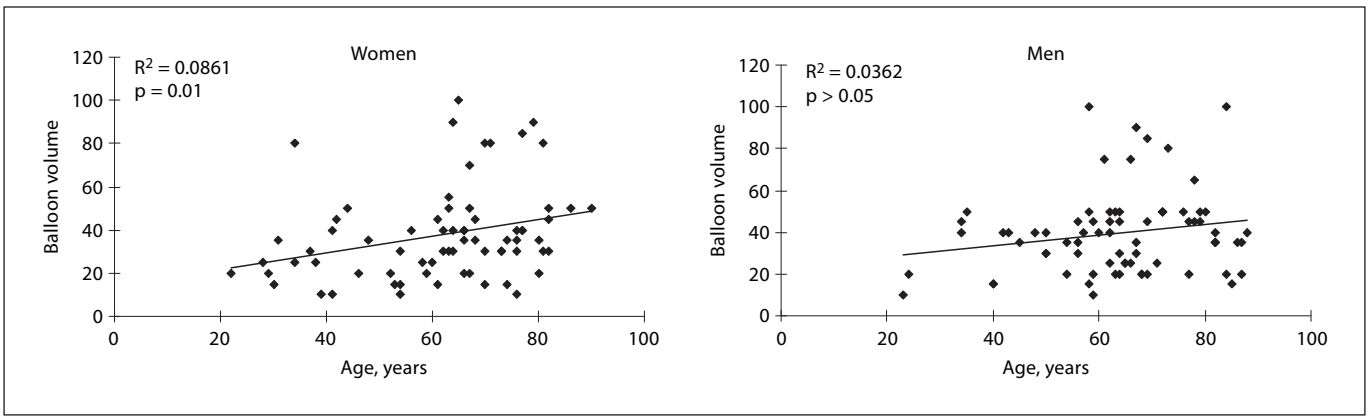

Fig. 4. Regression analysis on the influence of age on rectal balloon volume at first perception (BVP) in women and men.

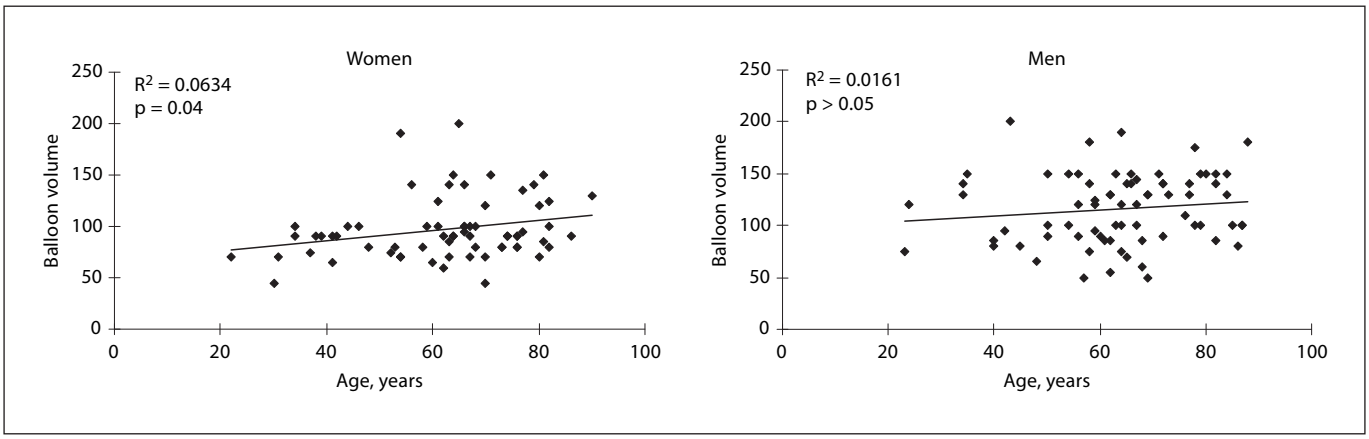

Fig. 5. Regression analysis on the influence of age on rectal balloon volume inducing the urge to defecate (BVU) in women and men.

to search for effects of age on MRP. Thus, it can be stated that MRP significantly decreases with age in females as well as in men. The age-dependent decrease in MRP might be due to fibrosis of the internal sphincter muscle in elderly patients [20].

Maximum Squeeze Pressure

All but one of the above-mentioned studies determined a higher MSP in men compared to women [8, 11, 14, 15, 17]. This result could be confirmed in the present study with its large cohort of healthy subjects. MSP represents the strength of the external sphincter muscle which is built by striated muscle [5]. Men have a greater striated muscle mass compared to women due to the well-known effect of testosterone on muscle growth [21]. For the external sphincter muscle, a shorter external sphincter muscle was seen anteriorly in females by MRI and 3D-EUS [22, 23], while no difference in muscle thickness was measured by conventional EUS [23–25].

Considering the influence of age on MSP, most of the studies [14, 17, 19, 33, 34] reported a decrease during ageing in females (significant in nearly all studies) and in males (significant in about 2/3 of the studies). The effect of age on MSP in females and males is confirmed by the results of regression analysis in the present study and in a study of Felt-Bersma et al. [8]. The main reason for the

age-related decrease in MSP might be the well-known decrease in skeletal muscle mass in elderly people [26]. Beside sarcopenia, a loss of neurogenic innervation of the external sphincter muscle seems to occur during ageing since a prolongation of the pudendal nerve terminal motor latency and an increase of the single fiber density of the external sphincter muscle was observed in elderly people [14]. In females, the pudendal nerve can additionally be damaged, subclinically or overt, during childbirth since nerves are vulnerable to traction [27, 28].

Anorectal Sensation

Data on the effect of gender on anorectal sensation are sparse. All reported data point to no difference in perception threshold between females and males [8, 29–32]. However, only the study of Bannister et al. [29] investigated more than 20 female and male people. In contrast to all these studies, we determined a significantly lower perception threshold in our 72 female subjects compared to our 74 male subjects. However, the difference in absolute level is rather low with a median difference of only 5 ml. Data about the effect of gender on rectal (balloon) volume which induces the urge to defecate are given by only two studies. Sun and Read [30] reported that males tolerated higher volumes until urgency occurred, while Rao et al. [11] did not find a significant difference between males and females. In the present study, a higher median balloon volume during urgency was calculated for men, but the difference was not significant as in the study of Rao et al. [11].

Data on the effect of age on anorectal sensation are even sparser. While 5 studies measured balloon volume at first perception of rectal distension [8, 30, 31, 33, 34], only 1 study gave data about rectal (balloon) volumes which induced the urge to defecate in younger (19–55 years) and older (66–87 years) people [29]. In the latter study, greater rectal volumes were tolerated in older people until urgency was provoked. Concerning perception threshold, 2 studies reported a normal and 3 studies a deteriorated sensation during ageing. In the present study investigating a greater number of subjects which enabled a regression analysis of the data, a significant increase in perception threshold and rectal volume provoking urgency was seen in females, while the small increase in males did not reach significance. All together, it seems that a deterioration in anorectal sensitivity parallels ageing. This assumption is in agreement with data on the effect of ageing on nerve cell density in the large bowel demonstrating fewer neurons in elderly subjects compared to younger ones [35]. However, it has to be kept in mind that the effect of ageing on anorectal sensation is small and its clinical importance remains unclear.

It has to be kept in mind that balloon distension, although the accepted standard, is not an ideal test of anorectal sensation as results are dependent on position and type of balloon as well as on rectal compliance and capacity [36–39]. Anorectal sensation can be more reliably measured with a Barostat device which also enables consideration of rectal compliance and capacity [37–40]. Sloots et al. [40] determined a greater rectal capacity and compliance in males which could account for the observed lower perception threshold in females. However, recent Barostat measurements confirm a heightened perception in females and the deterioration of sensitivity with age [41, 42].

Discussing the influence of gender on anorectal manometry, parity has to be considered. Vaginal delivery, even when uneventful, decreases resting and squeeze pressure [43]. However, the decrease in resting pressure is small and its relevance is debatable [9, 44]. Pudendal neuropathy and rupture of the sphincter musculature caused by vaginal delivery can contribute to the decrease in squeeze pressure after vaginal delivery [43]. Yet, a decrease in squeeze pressure after childbirth is also seen without damage to the nerve supply or the sphincter musculature [43]. A partial or even complete recovery of squeeze pressure is seen 6 months after delivery, while resting pressure also improves but to a lesser extent [45, 46]. Some, but not all studies observed a reduced electrical threshold for anal canal sensation after childbirth [9, 47, 48]. In addition, anal electrosensitivity normalized 6 months after uneventful delivery. Perception threshold and threshold for urgency measured by rectal balloon distension was not affected by childbirth [49].

In conclusion, gender and age influence most of the parameters of anorectal manometry. The observed gender differences and the effects of ageing may account for the higher rate of fecal incontinence in females and in elderly subjects. However, the observed differences between female and male subjects and between younger people and those in consecutive older decades make it necessary to interpret the results of anorectal manometry according to sex- and age-adapted normal values. These results obtained in Caucasians should be transferable to other ethnic populations such as Afro-Americans or Asians, but the normal range might be different. The normal range might also be slightly different with new recording equipment such as solid state sensors or high resolution manometry [50, 51]. However, it is very unlikely that the influence of gender and age would not be seen in these methods.

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