ORIGINAL ARTICLE

AG-2022-70
doi.org/10.1590/S0004-2803.202203000-76

The Fatigue Rate Index is higher in children with functional constipation and retentive fecal incontinence

Bruno **PAGANOTTI**, Marcio **MIASATO**, Mauro Batista de **MORAIS** and Soraia **TAHAN**

Received: 5 May 2022
Accepted: 22 June 2022

ABSTRACT – Background – The Fatigue Rate Index (FRI) is a parameter in anorectal manometry (ARM) to assess sustained voluntary contraction, considering the squeeze pressure and fatigability of the external anal sphincter. It is used in adults to detect fecal incontinence even in patients who present normal squeeze pressures. The FRI in adult patients with functional constipation is similar to controls. **Objective –** The aim of this study was to evaluate the feasibility and values of FRI in children in relation to the values previously established in adults and comparing children with functional constipation and retentive fecal incontinence to children without retentive fecal incontinence. **Methods –** This retrospective study evaluated 105 ARM performed from Jan 2014 to Apr 2015. 42 patients were selected (were able to perform a voluntary contraction and had no co-morbidities other than functional constipation). 14 (33.3%) of those collaborated in sustaining contraction for 40 seconds (s), allowing the evaluation of the FRI. Patients with retentive fecal incontinence secondary to functional constipation (n=7, aged 6 to 13 years, six boys) were our interest group. Patients with functional constipation without fecal incontinence (n=7, aged 6 to 13 years, four boys) were considered a reference group. The ARM were performed with a radial eight-channel perfusion catheter (Dynamed™, São Paulo, Brazil) and the FRI was calculated (Proctomaster 6.4) in the first 20 s and overall 40 s of sustained voluntary contraction. **Results –** 14 of the selected 42 collaborated in sustaining contraction for 40 s, allowing the evaluation of the FRI. In the first 20 s of contraction, the fecal incontinence group showed a significantly higher mean FRI (2.48±1.39 min) compared to the reference group (1.13±0.72 min, P=0.042), which was not observed in the 40 s interval due to less uniform contraction. The anal resting pressure was higher in the fecal incontinence group (76.83 mmHg) than in the reference group (54.13 mmHg), but the statistical study did not reach significance (P=0.051). **Conclusion –** The FRI is feasible in children. The mean FRI obtained in this study is lower than the reported in constipated adults. The mean FRI among children with functional constipation and retentive fecal incontinence is higher than among constipated children without retentive fecal incontinence.

Keywords – Manometry; constipation; child; anal canal; fecal incontinence.

INTRODUCTION

Functional constipation is a common clinical condition in the pediatric population[1]. One of the most important elements in the physiopathology of constipation in children is the fecal retention due to painful evacuation by volitional stool retention behavior in order to avoid defecation. The chronic retention of stool in the rectum leads to rectal dilation with loss of its sensory and motor function, resulting in overflow fecal incontinence, or retentive fecal incontinence[2]. The retentive fecal incontinence (RFI) due to functional constipation is the most common cause of fecal incontinence in children, being an important stress-related factor that affects quality of life[3].

The anorectal manometry is a useful test in the assessment of evacuatory disorders like constipation and fecal incontinence[2]. In children with chronic intestinal constipation, the anorectal manometry is important to evaluate the rectoanal Inhibitory reflex (RAIR), that if present suggests the exclusion of Hirschsprung's disease hypothesis. Besides the RAIR, the anorectal manometry evaluates other elements of the evacuatory dynamics, being useful as well to evaluate sphincter dysfunction in patients suffering from fecal incontinence[4]. The anal canal is composed of two sphincters: internal (IAS) and external (EAS), both different in its characteristics. The IAS is composed by smooth muscle (involuntary) and it maintains the muscular tonus when no voluntary contraction is performed, not presenting fatigue. On the other hand, the EAS is composed by striated muscle, whose control is voluntary and susceptible to fatigue[5]. The fecal incontinence can be associated with sphincter dysfunction of the IAE, EAS and recto-anal sensory dysfunction[6].

The anorectal manometry evaluates the IAS function utilizing the assessment of the anal resting pressure and the EAS function utilizing the voluntary contraction. The voluntary contraction is a volitional contraction of the EAS and puborectalis muscle, formed by striated muscle innervated by somatic fibers[4].

Incontinent patients with EAS impairment present low anal resting pressure and/or low voluntary contraction peak pressure, suggesting a weakness of the EAS or the IAS. For instance, patients with medullary lesions may present inability in the reflex contraction response of the EAS during the increase of the intra-abdominal pressure[7].

Declared conflict of interest of all authors: none
Disclosure of funding: no funding received
Universidade Federal de São Paulo, Departamento de Pediatria, Disciplina de Gastroenterologia Pediátrica, São Paulo, SP, Brasil.
Corresponding author: Bruno Paganotti. E-mail: brupaganotti@gmail.com

Patients with retentive fecal incontinence or non-retentive functional fecal incontinence may present normal EAS function[8].

The voluntary contraction can be assessed by the voluntary contraction and by the pressure maintenance during the contraction[9]. In adults, the voluntary contraction must be higher than 120 to 180 mmHg and be maintained by at least 20 seconds (s). A short contraction (maintenance for a short period) can suggest muscular fatigue. In adults, a voluntary contraction shorter than 10 s is associated with incontinence of liquid stool[10].

Therefore, it is debated that the analysis of the anal resting pressure and the voluntary contraction alone can lead to an incomplete evaluation of the patients and underestimate the diagnosis of fecal incontinence due to poor sensitivity[11]. Therefore, the ability to sustain the voluntary contraction of the anal canal would be considered the most adequate form of evaluating the fecal continence, when studying the sphincter function[12].

There are two parameters to evaluate the maintenance of the voluntary contraction. The Fatigue Rate (FR) expresses the rate in which the pressure decreases starting at the peak of the voluntary contraction. The Fatigue Rate Index (FRI) is a parameter proposed by Marcelo et al., that considers not only the squeeze pressure but also the fatigability of the EAS[13]. The FRI is calculated considering the FR and express the time it would take, if the contraction were to be sustained forever, in which the pressure would go from the peak of voluntary contraction to the anal resting pressure (EAS fatigue)[14]. In other words, the FRI is an estimative of the time that is necessary to the voluntary contraction reach the complete fatigue.

A simple analogy could be made with a car that is travelling at a regular speed, accelerates to top speed and then decelerates to regular speed again. In this example, the regular speed is the anal resting pressure, the top speed is the squeeze pressure, the deceleration is the fatigue rate, and the amount of time the car would take to go from the top speed to the regular speed is the FRI.

Studies show the role of the FRI in the diagnosis of abnormalities in the sphincter physiology of adults with fecal incontinence with normal squeeze pressure as well mean values in healthy patients with functional constipation[14].

Therefore, the FRI is an additional manometry parameter that allows the evaluation of the sustained voluntary contraction of the EAS, which can contribute to the assessment of cases of fecal incontinence (FI). Few studies have considered the FRI in adults, because specific software and more recent manometry equipment is required to calculate it[15].

Therefore, the objective of this study is to evaluate the feasibility of the FRI in children and adolescents with functional constipation and verify if its values are different in patients with and without retentive fecal incontinence.

METHODS

In this retrospective study, we evaluated anorectal manometries performed between January 2014 and April 2015, of children with severe functional constipation, followed in the ambulatory of the Pediatric Gastroenterology Discipline of the São Paulo Federal University.

A previous study showed that the cases followed in our service have a more severe clinic presentation, considering it is a referral center. This study demonstrated a longer duration of the clinical complaint of constipation as well a higher frequency of complications (such as abdominal pain e retentive incontinence) in all age groups amongst our patients[16].

Another recent published study shows the frequency of more severe clinical manifestations was higher in children our center[17].

The inclusion criteria were: age from 6 to 18 years old with the diagnosis of functional constipation, with no comorbidities, that presented the RAIR and complied to perform a voluntary contraction for at least 40 s (allowing the FRI evaluation with 20 a 40 s of sustained voluntary contraction), as depicted in FIGURE 1. The equipment used for the procedure was provided by Dynamed™ (São Paulo, Brazil), utilizing an eight-channel perfusion catheter with a latex balloon at the end of the catheter. The data obtained during the test was processed with the Proctmaster 6.4 software. The tests were performed in accordance with our service protocol, requiring the written consent. The preparation consisted of a phosphate enema to cleanse the rectum, 2 hours prior the manometry. A trained physician and a trained nurse executed the manometries, with the patient lying on his or hers left side and the presence of the legal guardian of the child.

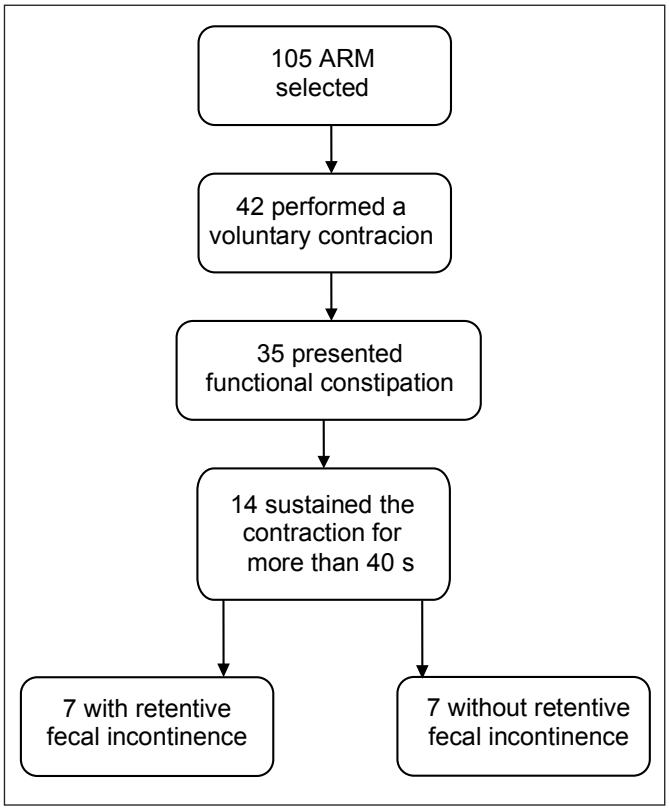

FIGURE 1. Patient selection.
ARM: anorectal manometry.

The routine of all of the procedures was to introduce the catheter, assess the anal resting pressure, determine the high-pressure zone and the functional anal canal length, evaluate the RAIR insufflating air in the balloon (located in the rectum) with progressive volumes, rectal sensitivity and evacuatory desire evaluation, five volitional attempts to evacuate and the request of the consecutive voluntary contractions after at least 30 s of stable anal resting pressure. The reference values for these parameters in children is in accordance with the study by Kumar et al. 2009[18].

The voluntary contraction is assessed by requesting the child to perform and sustain a voluntary contraction for the longest time possible. After 30 s of rest the request was made once or twice again.

In contrast to the anorectal manometry in adults, the protocols regarding the pediatric population aren't standardized. The BPSPGHAN published a recent consensus about the theme, in which it stated that the sequence of the studies in the pediatric anorectal manometry should base itself on the adult protocol, in which the evaluation of the squeeze pressure should be made prior to the RAIR evaluation[19]. On the other hand, the NASPGHAN consensus on pediatric anorectal manometry suggests the evaluation of the RAIR prior to the voluntary contraction evaluation[20].

Our protocol (FIGURE 2) initiates the study with the RAIR evaluation because the main goal in the pediatric anorectal manometry is ruling out Hirschsprung Disease.

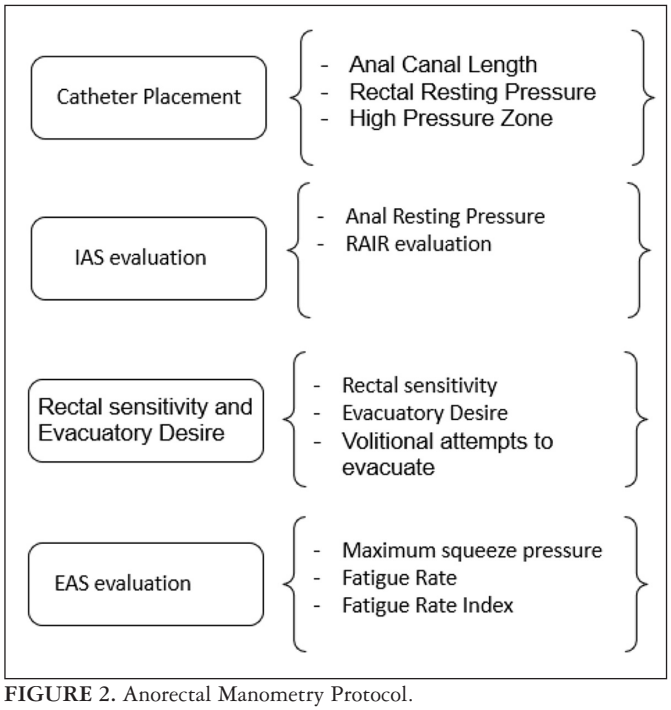

FIGURE 2. Anorectal Manometry Protocol.

This study focused on the evaluation of the voluntary contraction and calculation of the FRI. The Proctomaster 6.4 identified the anal resting pressure (ARP) right before the squeeze pressure and identified the peak of contraction (PC). Then, the examiner would delimitate the first 20 and 40 s of voluntary contraction and utilizing simple linear regression the software would calculate the FR. The FRI was the estimated by the formulae: FRI = (PC – ARP) / FR.

The FR was initially reported in the analysis of a 40 s period[14]. Nevertheless, children often present difficulties in sustaining the contraction for 40 s, but more recent studies considered the FRI in shorter periods (20 s)[21,22].

Therefore, the FRI was calculated utilizing the 40 s period of initial contraction and then again with the 20 s period of initial contraction (FIGURES 3 and 4).

As there are no reference values for children, we used the reference values established in the study in which Marcello et al first described the FRI[13], and the subsequent study by Tellford et al.[14], which included the 20 s interval analysis.

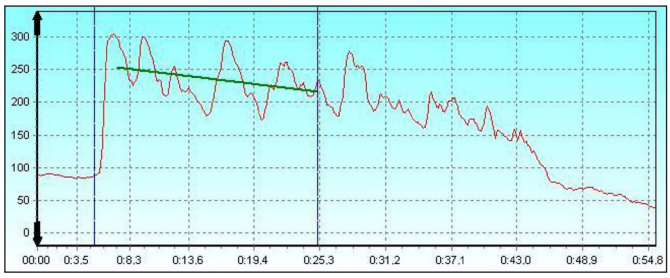

FIGURE 3. The Fatigue Rate Index in the 20 s interval.

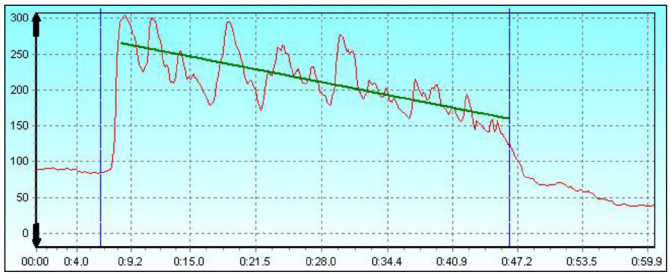

FIGURE 4. The Fatigue Rate Index in the 40 s interval.

For the statistical analysis, the *t* test was utilized for the normal variables, and the Mann-Whitney test was utilized for variables that failed the normality test.

The study was approved by the Ethics Committee of the University under the registration 48732915.9.0000.5505.

RESULTS

A total of 105 patients underwent an anorectal manometry between January 2014 and April 2015. 63 patients were excluded due to poor compliance to perform a sustained voluntary contraction. Seven patients were excluded due to comorbidities (cerebral palsy, epilepsy, chronic kidney disease) and 21 patients were excluded due to not maintaining the voluntary contraction for at least 40 s.

The demographics regarding gender, age and manometric data (Anal Resting Pressure and FRI in 20 s and 40 s) of the patients presenting functional constipation with or without retentive fecal incontinence are displayed, respectively, in TABLES 1 and 2.

TABLE 1. Study group demographics: age, gender, anal resting pressure, (FRI 20 s and 40 s).

Patient	FI	Gender	Age (yrs)	ARP (mmHg)	FRI20s (min)	FRI40s (min)
1	Yes	M	11	80.29	3.93	7.72
2	Yes	M	13	101.90	1.12	0.41
3	Yes	M	10	73.58	1.86	0.93
4	Yes	M	8	78.73	3.25	2.57
5	Yes	F	9	93.35	0.75	1.00
6	Yes	M	11	51.73	2.09	3.29
7	Yes	M	6	58.22	4.35	0.82
Mean				76.83	2.48 (1.39)	2.39 (2.57)

FI: fecal incontinence; ARP: anal resting pressure; FRI: Fatigue Rate Index; M: male; F: female.

TABLE 2. Control group demographics: age, gender, anal resting pressure (ARP), fatigue rate index (FRI 20 s and 40 s).

Patient	Gender	Age (yrs)	ARP (mmHg)	FRI 20 s (min)	FRI 40 s (min)
8	M	13	41.50	1.26	0.71
9	M	12	27.75	0.49	0.46
10	F	8	69.13	2.51	0.85
11	F	6	41.41	0.64	2.03
12	F	8	86.30	1.57	1.05
13	M	12	71.04	0.77	0.51
14	M	12	41.80	0.70	0.51
Mean			54.13	1.13 (0.72)	0.87 (0.55)

ARP: anal resting pressure; FRI: Fatigue Rate Index; M: male; F: female.

The comparative data between patients with and without retentive fecal incontinence considering demographics and manometric data (Anal Resting Pressure and FRI in 20 s and 40 s) is displayed in TABLE 3.

TABLE 3. Age, sex, anal resting pressure and Fatigue Rate Index (20 s and 40 s) comparison between the study group and the control group.

	Fecal retentive incontinence		*P*
	Yes (n=7)	No (n=7)	
Age (years)	9.7±2.3	10.1±2.7	0.756
Males/females	6/1	4/3	0.559
Anal resting pressure (mmHg)	76.8±17.8	54.1±21.2	0.051
Fatigue Rate Index (20 s)	2.48±1.39	1.13±0.72	0.042
Fatigue Rate Index (40 s)	1.00 (0.82; 3.29)	0.71 (0.51; 1.05)	0.209

Therefore, the 14 selected manometric studies were divided in two main groups (TABLES 1 and 2): Group 1 – functional constipation with retentive fecal incontinence (n=7, age from 6 to 13 years old, six boys) and Group 2: functional constipation without retentive fecal incontinence (n=7, age from 6 to 13 years old, four boys).

Considering all the patients (groups 1 and 2) there was no difference in the median value for the FRI when considering intervals of 20 s or 40 s. The median value considering the 20 s interval was 1.4 minutes, and 0.89 considering the 40 s interval (P=0.323, Mann-Whitney test).

In the first 20 s of contraction, the fecal incontinence group showed a significantly higher mean FRI (2.48±1.39 min) compared to the reference group (1.13±0.72 min, P=0.042, t test), which was not observed in the 40 s interval (possibly due to less uniform contraction).

The fatigue rate in the first 20 s and in the overall 40 s of contraction is depicted in FIGURES 3 and 4.

The anal resting pressure prior to the voluntary contraction was higher in the group presenting retentive fecal incontinence (76.83 mmHg) in comparison to the group without fecal retentive incontinence (54.13 mmHg), but the statistical study did not reach significance (P=0.051, t test).

The FRI mean value was higher among the children with high anal resting pressure (2.22±1.23) in comparison to children with low or normal anal resting pressure (0.77±0.34, P=0.049).

DISCUSSION

The fecal incontinence in children can be related to organic etiologies (secondary to neurological or sphincter lesions, for instance) or functional disorders[3]. The functional fecal incontinence includes the retentive fecal incontinence secondary to chronic constipation and the functional non retentive fecal incontinence[23]. The retentive fecal incontinence secondary to chronic constipation represents most cases of fecal incontinence during childhood.

The evaluation of the squeeze pressure and sustained voluntary contraction is routinely recommended when performing anorectal manometry in children[19,20].

A recent study that reviewed 227 studies regarding anorectal manometries in children found that the squeeze pressure was tested in 73, rarely describing how it was tested, and the maximum squeeze pressure was only assessed in four of the performed tests[24]. In this sense, the FRI is important because it considers the ability of the individual not only to perform a squeeze, but to sustain it, allowing a more accurate evaluation of the EAS function[13,14].

Although there are few studies performed regarding the FRI, a recent study included the FR and the FRI as manometric parameters in the evaluation of the fatigability of the EAS in adults with anorectal disorders[25].

This is a preliminary study that aims to assess the feasibility of the fatigue rate and the FRI in the assessment of the voluntary contraction of children who underwent an anorectal manometry and were followed at our center. Therefore, we chose to initiate this assessment with a group of children who presented functional chronic constipation, with or without retentive fecal incontinence.

We observed that 40% of the children in our study who can perform a voluntary contraction are capable of maintain the contraction plateau, which is essential to analyze the FRI. This might suggest the assessment of the FRI is feasible in the pediatric population.

The analysis of the first 20 s of contraction was more suitable in our sample to calculate the FRI than the overall 40 s. When considering compliant children, the 10 to 20 s time interval is suitable to analyze the voluntary contraction performed after a stable anal resting pressure[4].

Although considering the small sample size, the FRI mean value in this study (1.61 minutes) is lower than the reference values for adults (2.8 minutes)[13], suggesting a possible lower reference value to the pediatric population.

The FRI mean value was higher in the group of children that presented constipation and fecal incontinence when compared to the group of children that presented constipation without fecal incontinence. This is probably associated to a more severe retentive behavior among children in the fecal incontinence group. The higher FRI mean value among these patients suggests a very effective voluntary contraction, as opposed to what is observed among patients with organic fecal incontinence, in which the strength of the voluntary contraction of the external anal sphincter is impaired[26].

Also, in our study, both the group presenting retentive fecal incontinence and the group without fecal retentive incontinence presented high anal resting pressures[18] prior to the voluntary contraction. And although the fecal incontinence group anal resting

pressure was higher (76.83 mmHg in comparison to 54.13 mmHg, the statistical study did not reach significance (P=0.051, t test).

We also observed in our study that the mean FRI value was higher in children with high anal resting pressure in comparison to children with normal or low anal resting pressures. This might suggest that children presenting anal canal hypertrophy could also present a stronger voluntary contraction with slower fatigability.

Studies support the importance of the FRI in the diagnostic and prognostic assessment of adults fecal incontinence, but one study questioned its importance, considering that they did not find any difference regarding the FRI when comparing incontinent and continent constipated adults[15].

The FRI is an important tool in the evaluation of the fecal incontinence during the anorectal manometry, because it assesses not only the maximum squeeze pressure, but also its fatigability, which has an important role in the diagnostics and prognostics of fecal incontinence in adults[13,14,21,22].

A study performed in a academic center for anorectal physiology[12] enrolled 72 patients presenting different degrees of fecal incontinence showed that patients presenting mild to moderate fecal incontinence can perform a voluntary contraction with a satisfactory squeeze pressure when considering the maximum squeeze pressure (62% among the mild cases and 30% among the moderate cases). On the other hand, almost all the patients (93%) presented a rapid decrease during the sustained voluntary contraction. The same study showed differences between incontinent patients and the control group regarding the ability to maintain the contraction. Therefore, the ability to sustain the voluntary contraction could contribute to a better evaluation of the incontinent patient than just the maximum squeeze pressure.

An impaired internal anal sphincter can contribute to passive fecal incontinence, but on the other hand an impaired external anal sphincter can contribute to urge incontinence[27]. A previous study found a lower duration of the voluntary contraction among patients that presented urge-incontinence to liquid stools when compared to controls. This study also found an increment in the over all duration of the voluntary contraction in the patients that underwent biofeedback therapy[28].

More recent studies also found that a lower FRI in patients with inflammatory bowel disease is associated to urge-incontinence[21,22].

All this evidence is supported by the physiological fundament that the effective continence requires not only the anal resting pressure performed by the internal anal sphincter, but also the ability of the external anal sphincter, which is susceptible to fatigue, to sustain the contraction until the evacuation can take place in a proper social context.

The limitations of our study are its retrospective design, small sample and a study group composed only by patients with functional constipation.

CONCLUSION

The FRI can be feasible in children. The mean value in our study was lower than the reported in adults. Children with functional constipation and retentive fecal incontinence presented a higher FRI mean value than constipated children without retentive fecal incontinence. Future studies are important to assess the FRI among children with organic fecal incontinence.

Authors' contribution

Paganotti B: data collection, research execution, statistical analyses, text writing. Miasato M: data collection. Morais MB and Tahan S: research execution, statistical analyses, text writing and review.

Orcid

Bruno Paganotti: 0000-0002-1789-5133.
Márcio Miasato: 0000-0002-4741-1160.
Mauro Batista de Morais: 0000-0003-4014-5549.
Soraia Tahan: 0000-0002-4568-3314.

Paganotti B, Miasato M, Morais MB, Tahan S. O índice da taxa de fadiga é maior em crianças com constipação e incontinência fecal por retenção. Arq Gastroenterol. 2022;59(3):428-433.

RESUMO – Contexto – O índice de Taxa de Fadiga (ITF) é um parâmetro na manometria anorretal (MAR) que é utilizado para avaliar a contração voluntária sustentada, considerando a pressão máxima de contração e a fatigabilidade do esfíncter anal externo. Este parâmetro é utilizado em adultos para diagnóstico da incontinência fecal mesmo entre paciente que apresentem pressões máximas de contração normais. O ITF em pacientes adultos com constipação é similar a controles. **Objetivo –** Avaliar a factibilidade e os valores do ITF em crianças com constipação e incontinência fecal por retenção em relação aos valores previamente estabelecidos para adultos, e comparar os dados das crianças com constipação intestinal funcional com e sem incontinência fecal por retenção. **Métodos** – Este estudo retrospectivo avaliou 105 MAR realizadas de janeiro de 2014 a abril de 2015. 42 pacientes foram selecionados (foram capazes de realizar uma contração voluntária e não apresentavam outras comorbidades além da constipação). 14 destes pacientes cooperaram em manter a contração voluntária por 40 segundos, permitindo a avaliação do ITF. Pacientes com incontinência fecal por retenção secundária a constipação (n=7, 6 a 13 anos, seis meninos) constituíram nosso grupo de interesse. Pacientes com constipação funcional sem incontinência fecal por retenção. (n=7, 6 a 13 anos, quatro meninos) constituíram o grupo de referência. As MAR foram realizadas com cateter de perfusão de oito canais radiais (Dynamed™, São Paulo, Brazil) e o ITF foi calculado (Proctomaster 6.4) nos primeiros 20 segundos e também nos 40 segundos totais da contração voluntária sustentada. **Resultados –** Dos 42 pacientes selecionados, 14 (33%) colaboraram mantendo o platô de contração uniforme durante 40 segundos, permitindo a avaliação do ITF nos primeiros 20 segundos de contração, o grupo com incontinência fecal apresentou uma média de ITF significativamente mais alta (2,48±1,39 min) em comparação ao grupo de referência (1,13±0,72 min, P=0,042), o que não foi observado no intervalo de 40 segundos devido a contração menos uniforme. A pressão anal de repouso foi mais elevada no grupo com incontinência fecal (76,83 mmHg) do que no grupo de referência (54,13 mmHg), porém o estudo estatístico não atingiu significância (P=0,051). **Conclusão –** O ITF é factível em crianças. A média do ITF obtida neste estudo é mais baixa do que o reportado em adultos constipados (2,8 min). A média do ITF entre crianças constipadas com incontinência fecal por retenção fui superior ao do que observado em crianças constipadas sem incontinência fecal retentiva.

Palavras-chave – Manometria; constipação; criança; canal anal; incontinência fecal.

REFERENCES

.

1. Koppen IJN, Vriesman MH, Saps M, Rajindrajith, Shi X, van Etten-Jamaludin FS, et al. Prevalence Of Functional Defecation Disorders In Children: A Systematic Review and Meta-analysis. J Pediatr. 2018;pii:S0022-3476:30217-8. doi:10.1016/j.jpeds.2018.02.029.
2. Di Lorenzo C, Benigna MA. Pathophysiology of Pediatric Fecal Incontinence. Gastroenterology. 2004;126:S33-S40.
3. Faleiros FTV, Machado NC. Assessment of Health-Related Quality of Life in Children with Functional Defecation Disorders. J Ped. (Rio J). 2006;82:421-5.
4. Hong J. Clinical Applications of Gastrointestinal Manometry in Children. Neurogastroenterol Motil. 2002;14:553-9.
5. Remes-Troche JM, Rao SS. Neurophysiological testing in Anorectal Disorders. Expert Rev Gastroenterol Hepatol. 2008;2:323-335.
6. Mandaliya R, DiMarino AJ, Moleski S, Rattan S. Cohen S. Survey of Anal Sphincter Dysfunction Using Anal Manometry in Patients with Fecal Incontinence: a Possible Guide to Therapy. Ann Gastroenterology. 2015;28:469-74.
7. Rao SSC, Azpiroz F, Diamant N, Enck P, Tougas G, Wald A. Minimum Standards of Anorectal Manometry. Neurogastroenterol Motil. 2002;14:553–559.
8. Hyams J, di Lorenzo C, Saps M, Shulman J, Staiano A, Tiburg M. Childhood Functional Gastrointestinal Disorders: Child/Adolescent. Gastroenterology. 2016;150:1456-68.
9. Olson CH. Diagnostic Testing for Fecal Incontinence. Clin Colon Rectal Surg. 2014;27:85-90.
10. Fox M, Schwizer W, Menne D, Stutz B, Fried M, Thumshirn M. The Physical Properties of Rectal Contents Have Effects on Anorectal Continence: Insights from a Study Into the Cause of Fecal Spotting on Orlistat. Dis Colon Rectum. 2004;47:2147-2156.
11. Bharusha AE. Management of Fecal Incontinence. Gastroenterol Hepatol (N Y). 2008;4:807-17.
12. Saad LHC, Coy CSR, Fagundes JJ, Ariyzono ML, Shoji N, Góes JRN. Quantificação da Função Esfincteriana pela Medida da Capacidade de Sustentação da Pressão de Contração Voluntária do Canal Anal. Arq Gastroenterol. 2002; 39:233-9.
13. Marcello P, Barrett RC, Coller JA, Schoetz DJ Jr, Roberts PL, Murray JJ, Rusin L. Fatigue Rate Index as a New Measurement of External Sphincter Function. Dis Colon Rectum. 1998;41:336-43.
14. Telford KJ, Ali ASM, Lymer K, Hosker GL, Kiff ES, Hill J. Fatigability of the External Anal Sphincter in Anal Incontinence. Dis Colon Rectum. 2004 47:746-52.
15. Bilali S. Pfeifer J. Anorectal manometry: Are Fatigue Rate and Fatigue Rate Index of Any Clinical Importance? Tech Coloproctol. 2005;9:225-8.
16. Medeiros LC, Morais MB, Tahan S, Fukushima E, Motta ME, Fagundes-Neto U. Clinical Characteristics of Pediatric Patients with Chronic Constipation According to Age Group. Arq Gastroenterol. 2007;44:340-4.
17. L Silva, Dias F, Lahoz L, Tahan S, Morais M. Clinical Spectrum of Functional Constipation and Bowel-Habit Patterns of School Children Recruited from Two Elementary Schools and a Specialized Outpatient Clinic. Arq Gasstroenterol. 2022;59:263-7.
18. Kumar S, Ramadan S, Gupta V, Helmy S, Atta I, Alkholy A. Manometric Tests of Anorectal Function in 90 Healthy Children: a clinical study from Kuwait. J Pediatric Surgery. 2009;44:1786-90.
19. Rodriguez L, Sood M, Di Lorenzo C, Saps M. Na ANMS-NASPGHAN Consensus Document on Anorectal and Colonic Manometry in Children. Neurogastroenterol Motil. 2016;1-8.`
20. Athanasakos E, Cleeve S, Thapar N, Lindley K, Perring S, Cronin H, et al. Anorectal Manometry in Children with Defecation Disorders: BSPGHAN Motility Working Group Consensus statement. Neurogastroenterol Motil. 2020;32:e13797.
21. Athanasios A, Papathanasopoulos, Konstantinos H, Katsanos, AthinaTatsioni, Dimitrios K, et al. Increased Fatigability of External Anal Sphincter in Inflammatory Bowel Disease: Significance in Fecal Urgency and Incontinence. J Crohns Colitis. 2010;4:53-60.
22. Papathanasopoulos A, Oudenhove VL, Katsanos K, Christodoulou D, Tack J, Tsianos EV. Severity of Fecal Urgency and Incontinence in Inflammatory Bowel Disease: Clinical, Manometric and Sonographic. Inflamm Bowel Dis. 2013;19:2450-6.
23. Rajindrajith S, Devanarayana NM, Benninga MA. Review article: Faecal Incontinence in Children: Epidemiology, Pathophysiology, Clinical Evaluation and Management. Aliment PharmacolTher. 2013;37:27-48.
24. Yates G, Firedmacher F, Cleeve S, Athanasakos E. Anorectal Manometry in Pediatric Settings: A systematic review of 227 studies. Neurogastroenterol Motil. 2021;33:e14006.
25. Grasland M, Turmel N, Pouyau C, Leroux C, Charlanes A, Chesnel C, et al. External Anal Sphincter Fatigability: An Electromyographic and Manometric Study in Patients With Anorectal Disorders. J Neurogastroenterol Motil. 2021;27:119-26
26. Rao SS, Bharucha AE, Chiaroni G, Felt-Bersma R, Knowles C, Malcolm A, Wald A. Anorectal disorders. Gastroenterology. 2017;25:1-31.
27. Marola S, Ferrarese A, Gibin E, Capobianco M, Bertolotto A, Enrico S, et al. Anal Sphincter Dysfunction in Multiple Sclerosis: an Observation Manometric Study. Open Med. 2016;11:509-17.
28. Chiaroni G, Scattolini C, Bonfante F, Vantini I. Liquid Stool Incontinence with Severe Urgency: Anorectal Function and Effective Biofeedback Treatment. Gut, 1993;34:1576-80.