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Computed tomography morphometric comparison of the pelvis in children with and without rectal prolapse in Niger

Salifou Seyni Taoueye[a,b,*], Innoussa Daouda Bako[c], Christel Laleye[a], Armel Hadonou[a], Alido Soumana[e], Habibou Abarchi[f], Yacouba Harouna Guimba[d], Sani Rachid[d], Gervais Hounnou[g], Augustin Agossou Voyeme[a], Christine Chappard[b]

[a] Laboratoire D'Anatomie Humaine de La Santé de Cotonou, Cotonou, Benin
[b] Laboratoire Biologie Bioingénierie Bioimagerie OstéoArticulaire, Université de Paris Cité, UMR 7052, CNRS, U 1271 Inserm, Paris, France
[c] Service de Radiologie et D'imagerie Médicale, Hôpital Général de Reference de Niamey, Niamey, Niger
[d] Service de Chirurgie Viscérale de L'Hôpital National de Niamey, Niamey, Niger
[e] Service de Pédiatrie de L'Hôpital Amirou Boubacar Diallo, Niamey, Niger
[f] Service de Chirurgie Pédiatrique de L'Hôpital Amirou Boubacar Diallo, Niamey, Niger
[g] Service de Chirurgie Pédiatrique Du Centre Hospitalier Universitaire Hubert Koutougou Maga, Cotonou, Benin

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ABSTRACT

Background: Rectal prolapse is a public health problem that affects all sexes at different ages. It is one of the most frequent reasons for consultation in pediatric surgery. The main causes are chronic constipation and diarrhea or both. The increase in abdominal pressure, whatever its cause, is an essential factor favoring the occurrence of rectal prolapse. The anatomical factors related to the morphology of the pelvis and sacrum are unknown. The objective of this work was to compare the morphometric variations of the pelvis in children aged from 0 to 15 years with and without rectal prolapse.

Methods: This was a case-control study of 128 children (64 males) living in Niger, children without rectal prolapse (controls) were paired to those with rectal prolapse by age for both sexes. Morphometric parameters were measured on computed tomography scans. The length, concavity and slope of the sacrum were measured. Antero-posterior, bi-ischiatic, and sub-sacro-sub-pubic diameters were measured on the pelvis.

Results: In girls and boys with rectal prolapse, with the generalized linear model the sacral length was significantly increased with $p = 0.0005$ and sacral concavity decreased as compared with controls with $p = 0.0007$. The sacral slope has probably also an effect but impaired by large variations. There were no significant changes in other pelvic parameters.

Conclusion: The morphology of the sacrum is an anatomical factor probably related to the occurrence of rectal prolapse in children.

1. Introduction

The pelvis is formed by two coxal bones laterally and anteriorly and the sacrum and coccyx posteriorly, with a main role of protecting the pelvic viscera [1]. The pelvis is generally considered the most important structure in sex determination [2]. The sacrum and coccyx are entities of the vertebral axis with a low polar location and composition of fused vertebrae with arcuate morphology [1]. The female pelvis is more frequently studied because of its implications in childbirth [3], but the male or child pelvis is rarely studied.

Rectal prolapse is one of the most frequent reasons for consultation in pediatric surgery, leading to a significant decrease in quality of life of children, and is due to excess length and mobility of the rectum. There are two types of rectal prolapse. Mucosal rectal prolapse affects only the rectal mucosa and occurs during the effort of defecation and is restored spontaneously afterwards. Total or complete prolapse of the rectum extends to all the layers or tunics of the rectal wall. In Brazzaville Hospital, Congo, the frequency of rectal prolapse was 22 over 2276 children with a sex ratio of 9 boys to 13 girls [4]. In pediatric European populations [5–7] factors favoring rectal prolapse were predominantly

* Corresponding author. Laboratoire d'Anatomie Humaine de la faculté des Sciences de la santé de Cotonou, Cotonou, Benin.
E-mail address: seyni.salifou89@gmail.com (S.S. Taoueye).

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chronic constipation (53%–63% of cases) and both constipation and diarrhea (6%–18%), diarrhea diseases (8%–18%). In a recent review, authors mentioned rare diseases as a cause of rectal prolapse such as cystic fibrosis and neuropathic anatomical abnormalities such as myelomeningocele, imperforate anus, spina bifida occulta [8]. In Africa, a study from Brazzaville, Congo, the causes found were diarrhea (n = 5 cases, 23%), constipation diarrhea (n = 3, 14%), constipation (n = 10, 45%), and broncho-pneumopathy (n = 4, 18%) [4]. In Mali, the etiopathogenic factors were transit disorders (85%), anemia (28%), intestinal parasitosis (21%) and broncho-pneumonia (7.3%) [9].

Factors favoring the occurrence of rectal prolapse are linked to the force of gravity in the standing position, the means of suspension and the support of the rectum, which are permanently opposed to the weight of the viscera. In all situations, the increase in abdominal pressure, whatever its cause, is an essential factor favoring the occurrence of rectal prolapse [8]. Anatomical factors that tend to predispose the development of rectal prolapse in children include the vertical course of the rectum, low rectal position in relation to other pelvic organs, and lack of elevator support as well as a flat sacrum and coccyx [9]. To our knowledge, no study has investigated the association of the morphology of the pelvis and sacrum with rectal prolapse.

There are three techniques for exploring the bony pelvis: plain radiographs, computed tomography (CT) and magnetic resonance imaging (MRI). Plain radiographs are limited in evaluating this complex region, have potential gaseous superimpositions that can mask the sacrum and coccyx [1]. The Three dimensional (3D) available techniques are CT and MRI. CT was previously used to explore the morphology of the pelvis [3,11,12].

The aim of this study was firstly to determine morphological variations in the children's pelvis according to age and gender and secondly, to determine morphological factors that could be related to the occurrence of rectal prolapse in children. CT was the chosen imaging technique because it is the most convenient for children, providing high contrast between bone and soft tissue in an acquisition time of a few minutes.

2. Materials and methods

2.1. Patients

It is a case control-study of children from Niger. Children with rectal prolapse were recruited in the pediatric and surgical pediatric services of three hospitals: National Hospital of Niamey, National Hospital of Lamordé and Regional Hospital of Niamey. Children without rectal prolapse (controls) were recruited among those that have been referred for abdominal or urological CT in Niamey Hospital. Children with and without rectal prolapse were matched by age for both genders and were divided into two groups of 64 children each: without rectal prolapse (32 boys and 32 girls) and with rectal prolapse (32 boys and 32 girls). The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee for studies involving humans: Comité National d'Ethique de la République du Niger (Protocole N°51, date of approval: september 20, 2021). Written informed consent has been obtained from the children's parents to publish this paper.

2.2. Methods

2.2.1. CT scans and measurements

Pelvic CT scans of the pelvis of 128 children aged 0–15 years old of both genders (sex ratio = 1) were obtained. For all CT scans, a multidetector scanner (HITACHI Medical System Europe, 16 raw multidetectors) was employed. The examination was carried out in helical mode with the acquisition parameters 120 kVp, 250 mAs, pitch 1.75. The pixel size was 0.33*0.33 mm with slice thickness 0.625 mm.

Data were exported in Digital Imaging and Communication in Medicine (DICOM) format. Measurements were performed with the Radiant 2000.2 software. One sagittal and one transversal views were used for measurements. The sagittal plane passes through the pubic symphysis, which allows the concomitant visualization of the sacral canal, posterior sacral foramina, and intervertebral foramina. The transversal plane passes through the center of the femoral head and the ischial spines.

All pelvic morphometric parameters were measured in millimeters (mm) and are described in Fig. 1. On the sagittal plane, sacral morphometric parameters were measured such as the sacral length (SL) from the promontory to the lower edge of the last sacral vertebra (parameter "a" in Fig. 1) [13] and the sacral concavity (SC) from the deepest point of the curvature of the sacrum (at the level of S2–S3) which cuts tangentially the sacral length (parameter "b" in Fig. 1) [14]. The sacral slope (SS) was measured in degrees on the sagittal plane from a straight-line tangent to the upper plateau of S1 and a horizontal line passing the end of the tangent at the sacrum promontory corner (parameter "c" in Fig. 1) [15,16]. On the sagittal plane, the antero-posterior diameter (APD) was measured from the promontory to the upper posterior edge of the pubis (parameter "d" in Fig. 1) [17] and the sub-sacro-sub-pubic diameter (SSSPD) from the sacroiliac joint to the lower edge of the pubis (parameter "e" in Fig. 1) [17]. On cross-sectional CT images of the pelvis passing through the center of the femoral head and the ischial spines, the bi-ischiatic diameter of the middle strait (BID) was measured from the right ischiatic spine to the left ischiatic spine (parameter "f" in Fig. 1) [17].

Morphological measurements between controls and children with rectal prolapse for both genders according to age were compared. Corrected BMI corresponded to an African children population were calculated [18]. To avoid the age and BMI effects, ratios between all morphological parameters were also calculated. NCSS (2006, Kaysville, Utah) for Kolmogorov Smirnov normality tests with a p value set at $p = 0.05$, correlation analysis and the Student test was used to compare ratios between controls and rectal prolapse separately for girls and boys. Finally, R was used to correlate the pelvic parameters and the occurrence of rectal prolapse in girls and boys based on Generalized Linear Model test with a binomial function. The same observer (SST) performed two times the morphological measurements at distant periods for 12 controls and 12 cases. The precision measurements were assessed by Root Mean Square Standard Deviation (RMSSD, mm) and Coefficient of Variation (RMSCV, %) [19].

3. Results

The distribution of different etiologies of rectal prolapsus is in Table 1. In 50% of children the cause was the constipation. The distribution of children by type of rectal prolapse is in Table 1, with mucous prolapse frequency of 87%. For children with rectal prolapse, the main activity of their parents was in 86% of cases farmers.

The individual morphometric parameters for the two individuals aged from 0 to 15 years are displayed separately for girls and boys for sacrum in Fig. 2 and for pelvis in Fig. 3. The mean ± SD, minimum and maximum are presented with Root Mean Square_Difference (RMS_Diff) in Table 2.

All parameters were normally distributed except APD for boys with rectal prolapse and control girls. Girls and boys did not differ statistically in any of the measurements. For both genders, the SL increased with age. SL values were higher for girls with rectal prolapse than controls but the difference was less obvious for boys (Fig. 2). The SC values increased gradually until 12 years and more strongly till 15 years and were systematically lower for both boys and girls with rectal prolapse than controls. The SS values decreased between age 0 and 2 years and then remained relatively stable between age 2 and 4 years with finally a gradual increase between age 4 and 15 years (Fig. 2).

For both genders, APD increased with age with an acceleration after 12 years with a tendency of lower values in boys with rectal prolapse and it is less obvious for girls. The SSSPD values increased gradually

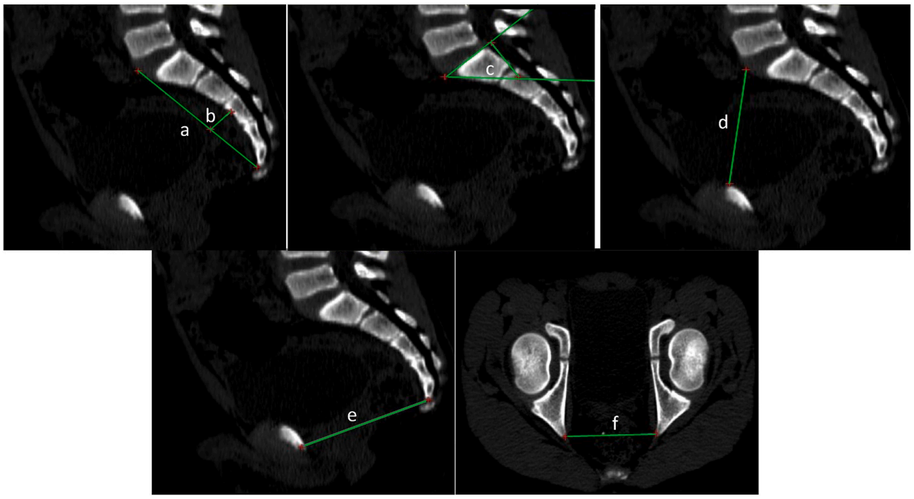

Fig. 1. Morphometric measurements of pelvis parameters. The sagittal section is passing through the pubic symphysis for parameters "a,b,c,d,e", cross sectional section is passing through the center of the femoral head and the ischial spines for parameters "f". The parameter "a" is the sacral length (SL) in mm, the parameter "b" is the sacral concavity "(SC) in mm, the parameter "c" is the sacral slope (SL) in degree. The parameter "d" is the sub-sacro-sub-pubic diameter (SSSPD) in mm, the parameter "e" is antero-posterior diameter (APD) in mm, and the parameter "f" is the bi-ischiatic diameter (BID) in mm.

Table 1
Distribution of children according to contributing factors and type of rectal prolapse.

	Numbers	Percentage (%)
Contributing factors		
Constipations	32	50
Constipation and diarrhea	9	14
Diarrheal disease	3	4
Chronic cough	2	3
Not found	17	26
Other factors	1	1
Type of prolapse		
Mucosal prolapse	56	87
Total prolapse	8	13

with age and were systematically higher in girls with rectal prolapse than controls (Fig. 3). The BID values gradually increased between age 0 and 15 years and with higher values in children with rectal prolapse.

For both genders, the correlation between pelvic parameters and the occurrence of rectal prolapse according to the generalized linear model test with a binomial function showed a significant relationship for the 2 parameters SL with $p = 0.0005$ and SC with $p = 0.0007$.

The results of Pearson correlation coefficients for morphometric parameters compared between each other, with age and corrected BMI for African population are in Table 3 for boys and Table 4 for girls. For both controls and rectal prolapse boys and girls, values for all morphometric parameters of the sacrum and pelvis except SS were highly correlated with age, with Pearson correlation coefficients from 0.87 to 0.98. In controls, there are negative correlation coefficients between BMIc and all morphological parameters which were significant for SL and BID for both genders and SSSPD only for girls. In cases, these tendencies did not appear.

For both genders of controls and children with rectal prolapse, values for all morphometric parameters of the sacrum and pelvis were correlated and highly significant with each other with correlation coefficients from 0.79 to 0.98 ($p < 0.01$) except for SS. These later values were slightly correlated with other morphologic sacral and pelvis parameters, with correlation coefficients from 0.49 to 0.64 for controls and 0.37 to 0.54 ($p < 0.01$) for children with rectal prolapse. For both sexes, the correlation coefficients for SS were systematically lower for children with rectal prolapse than controls.

All ratios results are presented in Table 5. All ratios with SL normalized over others morphological parameters were significantly higher in rectal prolapse than controls for both males and females with $0.001 < p < 0.0001$. All ratios with SC as numerator were not significantly different between controls and rectal prolapse except SC/BID for males with $p = 0.01$ and SC/SSSPD for females with $p = 0.0006$. For BID as numerator, all ratios were significantly higher in rectal prolapse for both genders with $0.02 < p < 0.0001$ except for the BID/SSSPD ratio for females. The SSSPD/APD ratios were significantly higher in rectal prolapse compared to controls for both genders with $0.007 < p < 0.0001$. The SSPD/SS was higher for females with rectal prolapse ($p = 0.0002$) but not in case of males. The APD/SS ratios were not significantly different for both genders.

The RMSCV and RMSSD were not different between controls and cases. For the SC, SL, DBI, SSSPD, and APD parameters, the RMSSD were inferior to 0.05 mm and the RMSCV% inferior to 0.06%. For SS, the RMSSD = 1,2° and RMSCV = 2.4%. The RMMSD for each parameter are very large in front The RMS_Diff displayed in Table 2.

4. Discussion

Our study supports the hypothesis that probably a few anatomical factors related to the morphology of the sacrum have an impact on rectal prolapse occurrence. In the present study, SL and SC were the two main anatomical factors related to rectal prolapse in children in Niger. The SS variation has probably also an influence but less obvious. Indeed, LS was greater in children with rectal prolapse than controls and SC was much more pronounced in control children than those with rectal prolapse. The SL have probably a great impact because when combining with others pelvic parameters, the differences between controls and rectal prolapse were highly significant in both genders. In the present study, the vertical sacrum at birth becomes more horizontal, especially after age 12 years and the concavity widens as the child grows. Indeed, the concavity of the sacrum increases gradually until age 15. The SC was greater in controls at all ages. Probably when the SC is hollowed out, the fixation of the pelvic rectum is improved. On the contrary, children with rectal prolapse may have retarded curvature growth of the sacrum. SS probably has an effect but it is probably more difficult to detect because of a large dispersion of values with less precision.

Data on age, BMIc, and morphometric pelvic parameters were correlated between them for controls and children with rectal prolapse separately in girls and boys. All morphological parameters were strongly age-dependent but their relationships with BMIc vary between controls and rectal prolapse for both genders. It was already noticed that pelvic morphology is depending of age and nutrition [20]. As it was found by the same author, any sexual differences in pelvic variability were found [20]. All pelvic parameters were highly correlated with each other and with age for both sexes with rectal prolapse and controls, except for SS, which was less correlated than the other parameters. Moreover, the SS

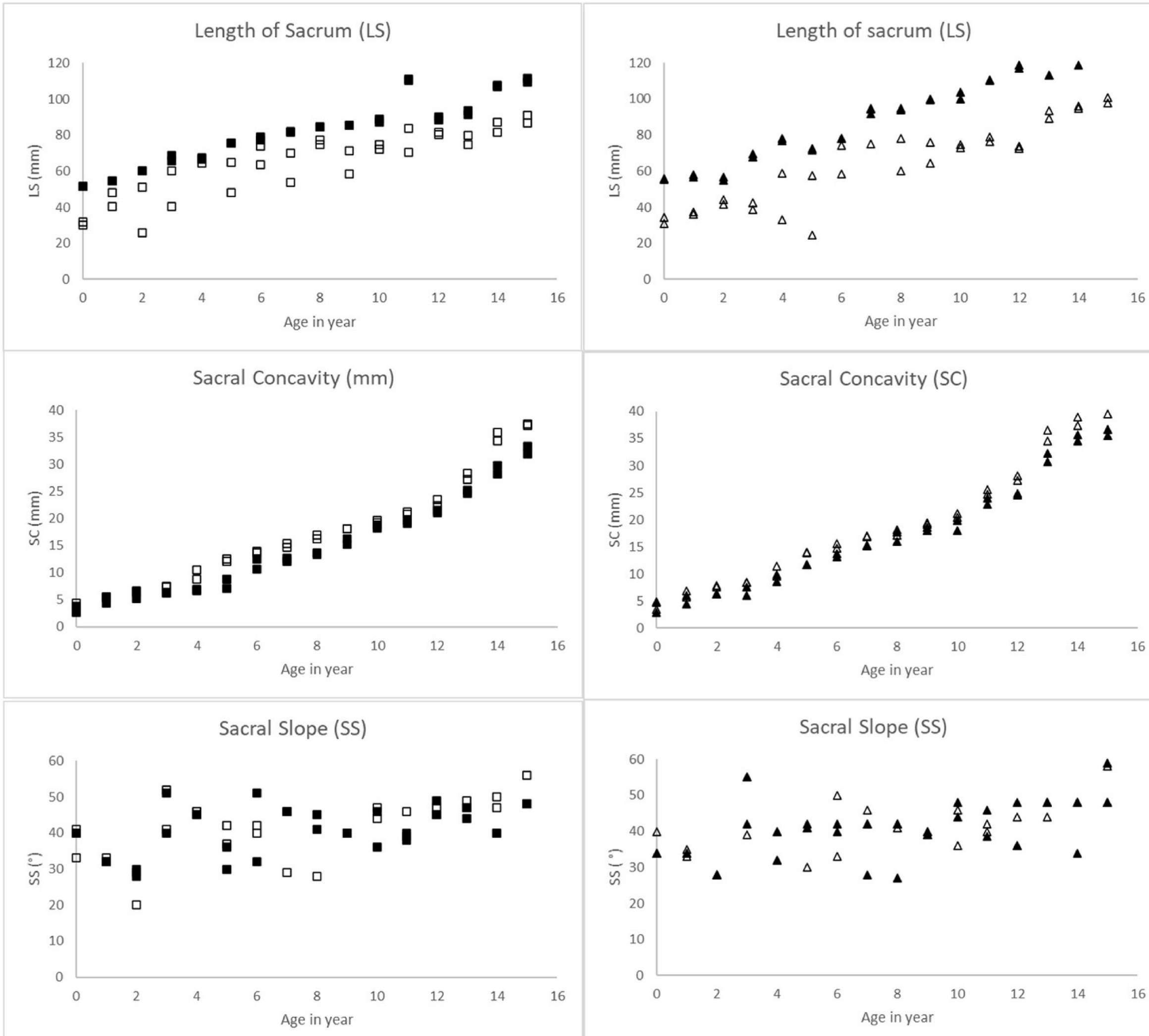

Fig. 2. Individual values of morphological parameters of the sacrum: Sacral length (SL, mm), Sacral Concavity (SC, mm), and sacral slope (SS, degrees) for boys on left and girls on right.

coefficient correlations decreased in rectal prolapse compared to control groups for both genders which indicates a probable influence.

In the previous study, the population of children with rectal prolapse is representative of usual populations in the literature. Indeed, mucosal prolapse is by far the most common cases about 87% in our study and accounts for 95% of cases in most literature series [4,5,21]. As in most of the literature series, constipation was the main cause of rectal prolapse, with a rate of 50% of cases, and requires long-term treatment to facilitate defecation [5]. In our series, the rate of rectal prolapse in children without cause was 26%, these results are close to others series ranging from 26% to 31% [4,5,7,22]. In children, especially those 0–5 years old, rectal prolapse has dietary and hygienic causes [4,23]. Constipation, diarrhea disease, dysentery and malnutrition were found linked to rectal prolapse, especially in developing countries [7,9,22]. In the present study, 43% of girls and 50% of boys with rectal prolapse had BMIc under the 5th percentiles, most (86%) of them had a rural origin, with farming parents and probably undernourished with growth retardation.

The means of suspension and support of the rectum are permanently opposed to the weight of the viscera, linked to the force of gravity in the standing position. The increase in abdominal pressure, whatever the cause, is an essential factor favoring rectal prolapse [8]. The lack of ischiorectal fat and thus rectal support was previously reported [10]. In the presence of resistance in the opposite direction (e.g., efforts to expel constipated objects), the piston effect may cause detachments or ruptures between different tissues and weaken the visceral walls with the formation of hernia or flap valve of the lining or rectal prolapse [14].

Flat SC and verticalization of the sacrum could explain why any abdominal pressure exerted in the ano-rectal axis could lead to rectal prolapse in children, in whom the anal mucosa is not yet well anchored to the underlying layers.

The present case-control study showed an association between rectal prolapse and morphological changes of the sacrum. However, these results must be confirmed by prospective studies to show a real causative link between them.

Computed tomography was useful to understand the physiopathology of rectal prolapse in children but cannot be recommended in clinical routine. Transit problems and developmental delay for dietary reasons must be corrected in these children.

5. Conclusions

Rectal prolapse is a benign pathology but with great concern for the child's family. Mucous prolapse is the most frequently observed as compared with total prolapse and is often a complication of constipation. In the present study, morphological parameters of the sacrum, mostly SL and SC were determining. The SL was greater in cases compared to controls. The SC was more pronounced in controls than children with rectal prolapse. Thus, long and flat sacrum are probably

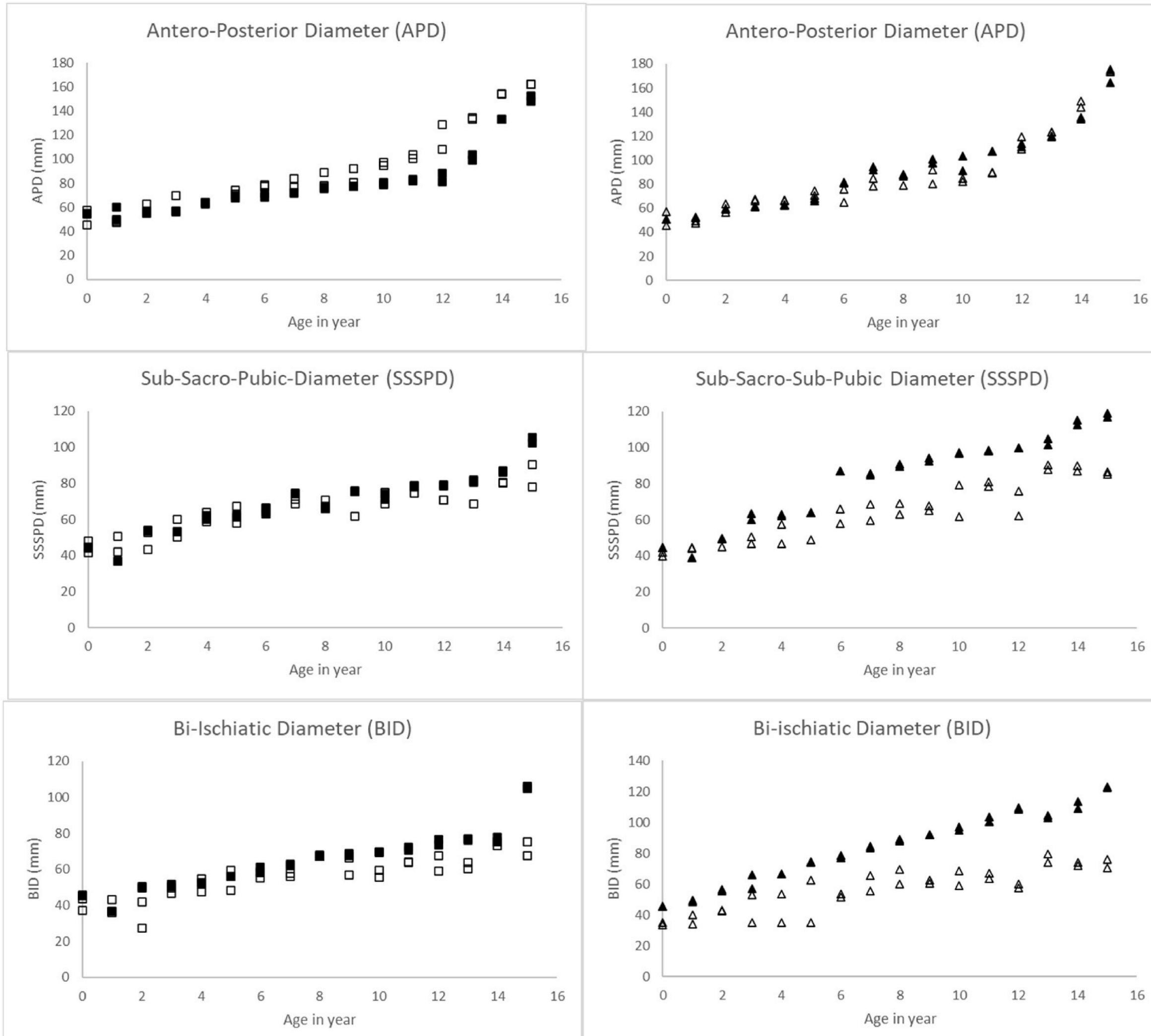

Fig. 3. Individual values of morphological parameters of the pelvis: antero-posterior diameter (APD, mm), sub-sacro-sub-pubic diameter (SSSPD, mm), and bi-ischiatic diameter (BID, mm) for boys on left and girls on right.

Table 2
Mean ± SD, minimum and maximum of corrected Bone Mass Index and sacrum and pelvis morphometrics parameters for controls and cases in both genders. The Root Mean Square differences (RMS_Diff in mm) between controls and rectal prolapse are also displayed.

Gender	Controls/Cases Parameters	BMIc	LS (mm)	CS (mm)	SS (degree)	APD (mm)	SSSPD (mm)	DBI (mm)
Boys	Control							
	Mean ± SD	23.9 ± 8.7	65.0 ± 17.6	17.0 ± 9.9	41.5 ± 7.9	90.6 ± 34.5	65.5 ± 12.3	56.4 ± 11.7
	(Min-Max)	(14-7-56.0)	(26.1–91.1)	(2.8–37.5)	(20–56)	(45.5–162.4)	(41.5–90.2)	(27.5–75.5)
	Rectal prolapse							
	Mean ± SD	14.8 ± 2.7	81.5 ± 18.2	14.6 ± 8.8	41.0 ± 6.4	80.2 ± 27.0	68.4 ± 16.4	64.0 ± 16.0
	(Min-Max)	(11–22)	(51.5–111.6)	(2.7–33.4)	(28–51)	(50.1–152.4)	(37.0–105.2)	(36.6–105.6)
	RMS_diff	67.7	19.8	2.9	6.5	16.1	7.8	11.9
Girls	Controls							
	Mean ± SD	23.9 ± 5.0	65.1 ± 22.9	19.2 ± 11.2	40.8 ± 7.3	88.7 ± 34.1	64.4 ± 15.9	56.4 ± 14.1
	(Min-Max)	(17.0–33.3)	(24.4–101)	(3.47–40.5)	(28–58)	(45.8–174.1)	(39.7–90.4)	(33.5–79.6)
	Rectal prolapse							
	Mean ± SD	16.2 ± 4.7	90.1 ± 23.6	17.3 ± 10.3	40.3 ± 7.8	91.1 ± 32.4	81.7 ± 24.4	68.7 ± 20.2
	(Min-Max)	(10.5–30.6)	(55.2–126.6)	(2.9–36.7)	(27–59)	(50.7–175.7)	39.0–119.1)	(37.0–109.6)
	RMS_diff	53	27.4	2.3	7.6	9.6	20.8	16.3

anatomical factors favoring the occurrence of rectal prolapse in children and also probably related to growth retardation. Increased knowledge of the child's pelvis, especially morphological variations, could provide a better understanding of the state of the pelvic viscera, particularly the rectum. This data must be confirmed in future research.

Table 3
Pearson correlation coefficients of sacral and pelvic parameters with age and size and between each other for control/rectal prolapse boys. The critical value is 0.35 for p = 0.05, significant correlation coefficients are in bold.

Variables	Age	BMIc	SL	SC	SS	APD	BID
Age	1						
BMIc	−0.25/-0.16	1					
SL (mm)	**0.88/0.95**	**−0.39**/-0.17	1				
CS (mm)	**0.96/0.97**	−0.17/-0.06	**0.84/0.92**	1			
SS (degree)	**0.59/0.44**	−0.24/-0.06	**0.56/0.38**	**0.59/0.40**	1		
APD (mm)	**0.94/0.87**	−0.13/-0.01	**0.79/0.83**	**0.98/0.94**	**0.59/0.35**	1	
BID (mm)	**0.87/0.93**	**−0.43**/-0.20	**0.90/0.89**	**0.85/0.94**	**0.55/0.49**	**0.79/0.90**	1
SSSPD (mm)	**0.90/0.94**	−0.27/-0.25	**0.87/0.93**	**0.87/0.93**	**0.49/0.46**	**0.83/0.88**	**0.90/0.97**

Table 4
Pearson correlation coefficients of sacral and pelvic parameters with age and size and between each other for control/rectal prolapse girls.

Variables	Age	BMIc	SL	SC	SS	APD	BID
Age	1						
BMIc	**−0.35**/0.16	1					
SL (mm)	**0.89/0.98**	**−0.40**/0.16	1				
CS (mm)	**0.96/0.97**	−0.27/0.22	**0.88/0.94**	1			
SS (degree)	**0.58/0.53**	−0.15/0.32	**0.60/0.50**	**0.59/0.52**	1		
APD (mm)	**0.90/0.95**	−0.13/0.12	**0.80/0.93**	**0.98/0.96**	**0.60/0.53**	1	
BID (mm)	**0.88/0.96**	**−0.43**/0.12	**0.94/0.94**	**0.85/0.95**	**0.56/0.54**	**0.80/0.96**	1
SSSPD (mm)	**0.93/0.97**	**−0.39**/0.10	**0.92/0.97**	**0.88/0.93**	**0.50/0.52**	**0.83/0.93**	**0.90/0.97**

Table 5
Ratios of all combinations between morphometric parameters to avoid age and BMI effects and comparison with a Student test between controls and rectal prolapse. A Wilcoxon test is used in case of non Normality *(in italics)*.

	Boys			Girls		
	Controls n = 32	Rectal prolapse n = 32	p	Controls n = 32	Rectal prolapse n = 32	p
SL/SC	4.82 ± 2.16	7.38 ± 3.61	0.001	4.08 ± 1.58	6.79 ± 3.40	*<0.0001*
SL/BID	1.14 ± 0.16	1.28 ± 0.12	0.0001	1.13 ± 0.18	1.33 ± 0.13	0.0001
SL/SSSPD	0.98 ± 0.16	1.20 ± 0.11	<0.0001	0.99 ± 0.17	1.12 ± 0.12	0.0005
SL/APD	0.75 ± 0.17	1.05 ± 0.14	<0.0001	0.75 ± 0.18	1.02 ± 0.11	0.0001
SL/SS	1.58 ± 0.40	2.01 ± 0.43	0.0001	1.58 ± 0.44	2.26 ± 0.58	<0.0001
SC/BID	0.28 ± 0.12	0.21 ± 0.09	0.01	0.32 ± 0.13	0.23 ± 0.08	0.002
SC/SSSPD	0.24 ± 0.11	0.20 ± 0.08	ns	0.28 ± 0.11	0.19 ± 0.07	*<0.0001*
SC/APD	0.17 ± 0.05	0.17 ± 0.06	ns	0.20 ± 0.06	0.17 ± 0.05	ns
SC/SS	0.40 ± 0.19	0.35 ± 0.19	ns	0.45 ± 0.05	0.42 ± 0.05	ns
BID/SSSPD	0.86 ± 0.08	0.94 ± 0.05	<0.0001	0.87 ± 0.08	0.84 ± 0.06	ns
BID/APD	0.66 ± 0.15	0.82 ± 0.09	<0.0001	0.67 ± 0.13	0.77 ± 0.08	0.0004
BID/SS	1.38 ± 0.29	1.57 ± 0.33	0.02	1.39 ± 0.28	1.72 ± 0.46	0.001
SSSPD/APD	0.77 ± 0.16	0.87 ± 0.11	0.007	0.76 ± 0.13	0.91 ± 0.10	<0.0001
SSSPD/SS	1.62 ± 0.37	1.68 ± 0.36	ns	1.59 ± 0.31	2.04 ± 0.59	0.0002
APD/SS	0.50 ± 0.15	0.54 ± 0.14	ns	0.50 ± 0.14	0.48 ± 0.15	ns

Ethical statements

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Comité National d'Ethique de la République du Niger (Protocole N°51, date of approval: september 20, 2021) for studies involving humans. Written informed consent has been obtained from the children's parents to publish this paper.

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CRediT authorship contribution statement

Salifou Seyni Taoueye: Formal analysis, Investigation, Resources, Data curation, Project administration, Funding acquisition. **Innoussa Daouda Bako:** Conceptualization, Writing – review & editing. **Christel Laleye:** Conceptualization. **Armel Hadonou:** Methodology. **Alido Soumana:** Software. **Habibou Abarchi:** Validation. **Yacouba Harouna Guimba:** Validation, Supervision. **Gervais Hounnou:** Validation, Supervision. **Augustin Agossou Voyeme:** Formal analysis, Writing – review & editing. **Christine Chappard:** Methodology, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tria.2023.100253.

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