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Prevalence and predictive factors of undernutrition and low bone mineral density in children with chronic pancreatitis

Anshu Srivastava [a, *], Nidhi Saini [a], Amrita Mathias [a], Asmita Arya [b], Sunil Jain [b], S.K. Yachha [a]

[a] Department of Pediatric Gastroenterology, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India
[b] Department of Radiodiagnosis, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India

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ABSTRACT

Background: Malnutrition and bone disease are common in adults with chronic pancreatitis (CP). We studied the nutritional status and bone mineral density (BMD) of children with CP and the factors predicting them.

Methods: CP children were prospectively evaluated with a detailed questionnaire, anthropometry, 25-hydroxy vitamin D, fecal elastase and BMD [total body less head (TBLH), spine and hip] by dual energy x-ray absorptiometry. Body mass index (BMI) Z score of −1 to −1.9, −2 to −2.9 and <-3 was taken as mild, moderate and severe malnutrition respectively. Low BMD and osteoporosis were defined as per International Society for Clinical Densitometry.

Results: 83 children (46 boys, 14[4.3–21]years) with CP were enrolled. Majority had Cambridge IV (51,62.2%) or III (15,18.3%) changes. 34(41%) had undernutrition (mild-37.3%, moderate-2.4%, severe-1.2%). Overweight and obesity were present in 3.6% and 1.2% cases. BMI had a significant correlation with haemoglobin, serum albumin, percentage body fat and BMD. A majority had low fecal elastase (69 [84.1%], <100 μg/g) and vitamin D deficiency (70[84.3%],<20 ng/ml). 9 cases had a history of fractures. 14/75(18.6%) cases had low TBLH-BMD and this group had a lower BMI (−1.3[-1.9 to 0.34] vs 0.8 [-2.1 to 5.50; p = 0.03) than patients with normal BMD. There was no difference in age, disease duration, vitamin D, fecal elastase and Cambridge grade between normal and low BMD.

Conclusions: 41% CP children have undernutrition with a majority having mild undernutrition. Nearly 20% have low BMD, with osteoporosis in none. Subjects with low BMI have lower BMD and percentage body fat.

Introduction

Chronic pancreatitis (CP) is a condition characterized by irreversible parenchymal damage and development of exocrine and endocrine insufficiency, which causes maldigestion, diabetes mellitus, and metabolic derangements [1]. The incidence and prevalence of pancreatic disorders including CP is increasing both in adults and children [2]. Undernutrition in CP is attributed to poor oral intake due to pain, pancreatic exocrine insufficiency and increased metabolic activity due to the disease. Exocrine pancreatic insufficiency (EPI) leads to maldigestion, deficiency of fat-soluble vitamins and weight loss [3].Few clinical studies have assessed nutritional status and shown that 8.3%–45.8% adult CP patients were undernourished(4–6). The data on malnutrition in children with CP is scarce [7].

Adults with CP have also been shown to be at a higher risk of developing bone disease. In a recent meta-analysis, the pooled prevalence for osteoporosis and osteopenia was 23.4% and 39.8% respectively [8].Undernutrition, pancreatic exocrine insufficiency along with high rates of vitamin D deficiency are thought to be contributing to the bone disease [9,10]. Poor bone health is an underappreciated source of morbidity in patients with CP. However, no studies have looked at the bone health of children with CP.

Abbreviations: CP, Chronic pancreatitis; EPI, Exocrine pancreatic insufficiency; BMD, bone mineral densitys; IAP, Indian Academy of Pediatrics; DXA, Dual-energy X-ray absorptiometry; TBLH, total body less head; MPD, main pancreatic duct; MRCP, magnetic resonance cholangiopancreatography; HbA1c, Glycosylated haemoglobin; TSFT, triceps skin fold thickness; ISCD, International Society for Clinical Densitometry; FE, fecal elastase.

* Corresponding author.
E-mail addresses: avanianshu@yahoo.com, anshusri@sgpgi.ac.in (A. Srivastava).

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Timely recognition and treatment of undernutrition and osteopenia have the potential to improve nutritional status, bone health and quality of life.

The objective of our prospective study was to determine the nutritional status and bone mineral density (BMD) of children with CP and to evaluate the factors predicting poor bone health and undernutrition.

Methods

Children (3-18y) of age with chronic pancreatitis (CP) diagnosed as per the *International Study Group of Pediatric Pancreatitis: in search for a cure (INSPIRE)* definition were enrolled in this study [11]. Both new cases diagnosed during the study period and old cases in follow-up were included. The flowchart depicting patient enrollment and evaluation is shown in Fig. 1. An effort was made to exclude patients with systemic diseases (known or having features at enrollment) which could affect the nutritional status or bone health of subjects. All patients were subjected to the following evaluation-

Anthropometry: Weight and height were measured using an electronic weighing scale with a precision of 0.1 kg and stadiometer with a precision of 0.1 cm. Z scores for weight, height and BMI were calculated using Indian Academy of Pediatrics (IAP) growth charts [12].The triceps skin-fold thickness was measured using the skin-fold calipers from the left arm, with the patient standing upright and arms hanging loosely by the side at a point halfway between the olecranon process of the ulna and acromion process of the scapula. Average of two readings was used for analysis and Z scores were calculated using Indian reference centile curves [13].Pubertal status was determined using Sexual Maturity Rating (Tanner staging) [14]. Patients were classified as mild, moderate and severe undernutrition, based on the recommendations of The Academy of Nutrition and Dietetics [15]. Mild, moderate and severe undernutrition was labeled based on BMI Zscore of −1 to −1.9, −2 to −2.9 and <-3 respectively. Overweight and obesity was defined as BMI Z score of >1.04 and ≥ 1.65 respectively.

Bone mineral density: Bone mineral density (BMD) and fat percentage was measured by Dual-energy X-ray absorptiometry(DXA; Discovery A, Hologic QDR 4500A Instruments). BMD was measured at the lumbar spine (mean of first lumbar to fourth lumbar vertebrae), femur neck and subtotal body (total body less head [TBLH]). The BMD was further corrected in accordance with the height of the patient. For our study, height age was determined as the age at which the child's height was the median value for height from the revised IAP growth chart. Z-scores for BMD were then calculated using height age (substituting height age for chronological age).None of our patients had delayed puberty, hence no adjustments for pubertal status were required. BMD parameters adjusted for height age were compared with age and gender-matched white Caucasian database provided by Hologic as controls and Z scores were calculated [16]. Z score of ≤ -2SD was taken as low BMD, as per the International Society for Clinical Densitometry (ISCD) Position Statement, 2013 [17].

Fecal elastase (FE): Quantitative estimation of human pancreatic fecal elastase was done by enzyme-linked immunosorbent assay (ELISA) method using Bioserv Diagnostics GmbH (Rostock, Germany). The test was done on formed stool and value of FE was expressed as μg/g of stool. A value of fecal elastase of >200 μg/g was taken as normal and <100 μg/g as severe exocrine pancreatic insufficiency (EPI) [18].

Serum 25-hydroxyvitamin D (25[OH] D): Sera was stored at −70C after separation. Quantitative determination of total 25 hydroxy vitamin D was done by the immuno-chemiluminescent assays using "Cobas" (Roche Diagnostics GmbH, Manheim Germany). Based on ESPGHAN recommendations, a value of <50 nmol/L (20 ng/ml) was taken as the cut-off for deficiency [19]. Value ≥ 75 nmol/L (≥30 ng/ml) was taken as vitamin D sufficiency and those between 50 and 74.9 nmol/L (20–29.9 ng/ml) as vitamin D insufficiency[20].

Magnetic resonance cholangiopancreatography (MRCP)- All patients were evaluated with an MRCP within 6 months of study enrolment and graded as per the Cambridge classification [21].

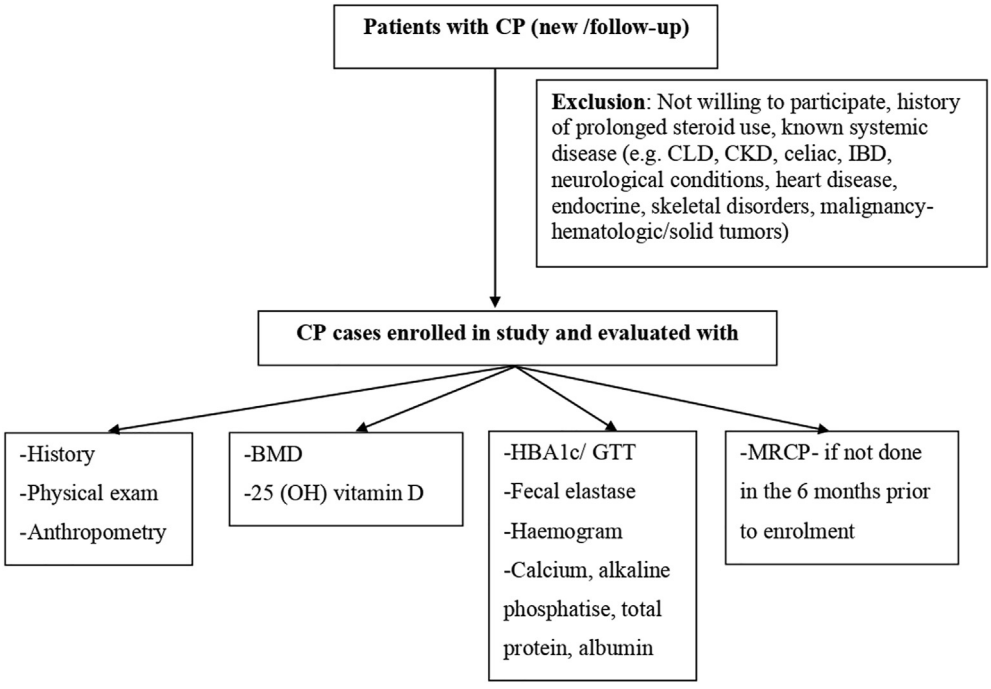

Fig. 1. Flow chart showing the enrollment and evaluation of the subjects with chronic pancreatitis.

Other tests: Glycosylated haemoglobin (HbA1c) and glucose tolerance test (fasting and 2 h after 1.75 g/kg of glucose, max 75g) were determined by standard technique. Diagnosis of DM was based on American Diabetes Association (ADA) criteria [22].

Ethics: The Institutional ethics committee of Sanjay Gandhi Postgraduate Institute of Medical Sciences approved the study before initiation (IEC 2015-117-IMP-87, dated 14th October 2015). Written informed consent was obtained from the parent or guardian of all participants. The study conforms to the declaration of Helsinki.

Statistical Analysis- The data is expressed as median with range and proportions. SPSS version 18 was used for statistical analysis. Mann Whitney *U* test was used for comparison of quantitative data and the chi-square test/Fischer's exact test for discrete variables. Correlation between factors was assessed by Spearman's correlation test. A p-value of <0.05 was taken as significant.

Results

Demography, clinical and laboratory profile

A total of 83 children (46 boys, 14 [4.3–21] years) with idiopathic CP were prospectively enrolled**.** The age at disease onset was 10.3 (3.8–17.8) years and duration of disease at enrollment was 30 (2–180) months. 23/80 (28.8%) subjects were prepubertal, while 57 (71.3%) were pubertal. None had delayed puberty. A majority (70, 84.3%) had required hospitalization with a median of 2(0–4) hospital admissions per year. Twenty-one (25.3%) had loss of appetite and 33.7% (n-28) complained of not gaining weight. Only 7 (8.4%) cases had loose, bulky stools suggestive of clinical steatorrhea. Examination showed anemia in 27 (32.5%) and vitamin A deficiency in 2 (2.4%). None had edema, jaundice, rickets or coagulopathy. At enrolment, 13/83 (15.6%) were on pancreatic enzyme replacement therapy (PERT).

Anthropometry

The anthropometric indices of the patients as per undernutrition classification are shown in Table 1**.**Based on BMI, 34 (41%) had undernutrition (31/34 [91.2%] with mild, 2/34 [5.8%] with moderate and 1/34[2.9%] with severe undernutrition). Only 3/83 (3.6%) were overweight and 1/83 (1.2%) was obese. The median Z score of triceps skin-fold thickness (TSFT, n-79) was 0.69 (−1.02 to 3.15). A majority (78/79, 98.7%) of the cases had a normal TSFT Z score of ≥ −0.9 and only 1 case (1.3%) had a Z score between −1 and −1.9. The median percentage body fat was 23.9 (10.5–44.8)% for the entire group and the percentage fat Z score was −0.35 (−1.33 to 1.59).

There was no significant difference in the Z score of weight for age (−1.0[-3 to 1.05] vs. −0.89[-2.5 to 3.9]; p = 0.5), height for age (−0.82[-3.0 to 1.49] vs. −0.86[-3.9 to 1.7]; p = 0.8), and BMI (−0.93 [-3.0 to 1.38] vs. −0.82[-2.1 to 5.6]; p = 0.4 between boys and girls. There was no difference in the Z score of percentage fat between boys and girls (−0.42[-1.06 to 0.86] vs −0.21[-1.33 to 1.59]; p = 0.2).The comparison of the patients with and without undernutrition as per BMI is shown in Table 2.After excluding the cases on PERT (n-13), the patients with (n-30) and without undernutrition (n-40) had similar FE value (11.5 [0–280] vs 24.5[0–248]; p = 0.3) and proportion of cases with severe EPI (27/30 vs 33/40; p = 0.6).

The BMI Z score showed a significant correlation with haemoglobin (r = 0.25, p = 0.02), serum albumin (r = 0.28, p = 0.01), Z score of triceps skin-fold thickness (TSFT, r = 0.60; p=<0.001), Z score of percentage body fat (r = 0.65, p = 0.0001), Z score BMD (spine, r = 0.41, p < 0.001) (Fig. 2a–e).

Laboratory parameters, imaging, exocrine and endocrine insufficiency

The laboratory parameters for the whole group are shown in Table 3. Severe EPI was present in 69 (84.1%) cases and 4 (4.8%) had diabetes mellitus (DM).

Bone mineral density and vitamin D status

The median 25 OH vitamin D level was 9.3(3–30.1) ng/ml, with 70 (84.3%) cases having value of <20 ng/ml. The vitamin D levels were significantly lower in girls than boys (5.9[3–28.6] vs 13.3 [3–30.1] ng/ml; p = 0.03). There was no significant correlation between vitamin D and FE levels (r = −0.07, p = 0.5).

Based on the total body less head (TBLH)-BMD, 14/75 (18.6%) cases had low TBLH-BMD (Z score ≤ -2SD). The comparison of these 2 groups (normal vs. low TBLH-BMD) is shown in Table 4. The low TBLH-BMD was further corroborated by the lower femur neck (−2.01[-2.6 to −0.58] vs −0.87 [-2.6 to 2.3]; p < 0.001) and lumbar spine BMD Z score (−1.35[-2.3 to 0.10] vs −0.10 [-1.9 to 2.2]; p < 0.001) in them as compared to subjects with normal TBLH-BMD. The only factor which was significantly different between the two groups was BMI; being lower (−1.3[-1.9 to 0.34] vs 0.8 [-2.1 to 5.50; p = 0.03) in patients with low TBLH-BMD. There was no difference in age, disease duration, vitamin D level, FE and Cambridge grade between the groups. No significant correlation was seen between TBLH-BMD and fecal elastase, vitamin D, disease duration or Cambridge grade of CP. Low TBLH-BMD was equally common in prepubertal and pubertal children (4/17 vs. 10/55; p = 0.7).

The groups with normal and low TBLH-BMD were similar in terms of FE (22 [0–280] vs. 30 [0–248]; p = 0.5) and proportion of cases with severe EPI (45/51 vs. 7/11; p = 0.2) after exclusion of those who were on PERT at time of study.

Nine cases had a history of fractures (forearm −5 (left-2, right-3), right arm-1, right wrist-1, right ankle-1, left foot-phalanx) after trauma and 69 never had a fracture. In 5 cases, the parent was not sure about this information.

Table 1
Nutritional status of children with chronic pancreatitis (n = 83).

Parameter	Normal nutrition Z score ≥ - 0.9	Mild malnutrition Z score −1.0 to −1.9	Moderate malnutrition Z score −2 to −2.9	Severe malnutrition Z score <-3
Weight for age	43 (51.8%)	36 (43.4%)	3 (3.6%)	1(1.2%)
Height for age	48 (57.9%)	26 (31.3%)	6 (7.2%)	3 (3.6%)
BMI for age*	49 (54.2%)	31 (37.3%)	2 (2.4%)	1 (1.2%)

* Classification of nutritional status as per BMI (body mass index). One (1.2%) subject had obesity (BMI Z score ≥1.65) and 3 (3.6%) were overweight (BMI Z score>1.04). Z score calculated as per reference 12.

Table 2
Comparison of CP children with and without malnutrition.

Parameter	Malnutrition present (n-34)	Malnutrition absent (n-49)	p value
Male: female	20:14	26:23	0.6
Age at disease onset (years)	10(3.8–17.8)	10.5(4.1–16.0)	0.7
Disease duration (months)	24 (2–120)	36 (2–180)	0.1
Diet- normal: fat restricted	27:6	37:10	0.8
Bulky stools (yes)	3/34 (8.8%)	4/49 (8.2%)	1.0
Poor appetite	10/34 (29.4%)	11/49 (22.4%)	0.6
Not gaining weight	15/34 (44.1%)	13/49 (26.5%)	0.1
History of bone fracture (yes)	3/33 (9.1%)	6/45 (13.3%)	0.7
TSFT Z score (n-79)	−0.02 (−0.73 to 1.05)	0.94 (−1.02 to 3.15)	<0.001
Haemoglobin (g/dL)	12 (7.8–15.3)	12.4(9.1–15.9)	0.1
Serum albumin (g/dL)	4.4 (3.1–5.2)	4.5(2–5.2)	0.1
Serum total calcium (mg/dL)	9.4 (7.5–10.9)	9.5(4.2–10.4)	0.9
Diabetes mellitus present	1/34 (2.9%)	3/49 (6.1%)	0.7
Fecal elastase (μg/g)	17.5 (0–280)	24.5(0–279)	0.6
Severe EPI (FE < 100 μg/g)	29/34 (85.3%)	40/48 (83.3%)	0.9
Vitamin D (ng/ml)	14.25 (3–28.6)	7.3 (3–30.0)	0.06
Vitamin D (<20 ng/ml)	28/34 (82.4%)	42/49 (85.7%)	0.2
Percent body fat Z score*	−0.60 (−1.33 to 0.0)	−0.07 (−0.94 to 1.59)	<0.001
Calcific CP	24/34 (70.5%)	27/49 (55.1%)	0.1
Cambridge II: III-IV	7: 26	9:40	0.7

TSFT: Triceps skin fold thickness, BMD: bone mineral density, All continuous variables are expressed as median with range, *available in n-77cases.

Discussion

In this prospective study of 83 CP children, 41% cases had undernutrition with a majority having mild undernutrition. Only 5% cases were overweight or obese. Exocrine insufficiency was present in a majority (84%) while DM was uncommon (4.8%). Nearly 84% cases were vitamin D deficient and 11% cases had a history of fracture. BMI had a significant correlation with haemoglobin, serum albumin, triceps skin-fold thickness, percentage body fat and BMD. One in 5 CP cases had a low BMD (TBLH Z score < -2), with BMI being lower in those with lower TBLH-BMD. None had osteoporosis.

Although 41% cases were undernourished, only 3.6% cases had a BMI < -2SD, which suggests that the majority has relatively preserved nutrition. Kolodzie et al. evaluated 208 children and found 25% to be malnourished, with most having moderate undernutrition [7]. However, they used Cole's ratios to classify malnutrition, which although BMI-based, is not directly comparable to our data. In adults, 8.3–45.8% CP cases were malnourished based on BMI [4–6].

Disease duration, alcohol intake, smoking, opioid treatment, EPI and DM are the main risk factors for undernutrition in adults with CP[5], [23–25].Adults and children with CP differ in many ways. In children, DM is uncommon, seen only in 4.8%–7.2% cases [7,26], while 23–50% adults with CP have DM [27]. Alcohol intake and smoking are uncommon in children. We found no difference in the disease duration, diabetes, exocrine insufficiency and Cambridge grade between patients with and without undernutrition, which is similar to the observation of Kolodzie et al. in children [7]. We feel that reduced oral intake due to pain, dietary restriction and exocrine insufficiency with maldigestion are the main risk factors in children. However, both the pediatric studies have not done a formal assessment of the dietary intake.

As per ISCD 2013, body fat estimation is useful for evaluation of nutritional status in children with chronic disease [17]. We observed a significantly lower body fat [-0.60 (−1.33 to 0.0 vs. −0.07 (−0.94 to 1.59); p < 0.001] in undernourished CP patients as compared to those without undernutrition. Body fat had a good correlation with BMI. Nutritional status has been associated with poorer quality of life in terms of physical functioning and poorer global health in adults with CP [5,28].

In children, osteoporosis is defined as BMD < -2SD with clinically significant fractures, while only low BMD is labeled as low bone density [17]. Further, total body less head (TBLH) and the posterior-anterior spine are the preferred measurement sites. As per TBLH-BMD, nearly 20% children with CP had low bone density but none had osteoporosis. 11% of our children had a history of fractures but none were clinically significant (vertebral compression, long bone of lower limb, ≥ 2 in number or without trauma). In a large cohort of 9496 healthy Indian children (10.4 ± 3.3years old), 9% had at least one fracture which is similar to the fracture rate in our CP cases [29].Additionally, 8/9 fractures in our study occurred in subjects with normal BMD which further supports that these were not secondary to reduced BMD.

There are no other pediatric studies of BMD in children with CP for comparison. However, our findings are different from those in adults with CP(8). In a meta-analysis of 10 studies with 513 adults, 39.9% (29.1–51.6%) had osteopenia and 23.4% (16.6–32.0%) had osteoporosis, with either i.e osteopathy in 65%(54.7–74.0%) cases [8]. Adults with CP also have a >3 fold higher risk of fracture [30]. Disease duration, vitamin D levels, FE, BMI, Vitamin K and Cambridge grade are associated with a low BMD in adults with CP. However, there is variation across studies in terms of factors showing significant differences [10,31–35]. We found BMI to correlate with BMD in children which is similar to studies in adults [31–34]. Vitamin D levels [31–33,35], FE [32,33,35], disease duration [33–35], and Cambridge grade [32] were not significantly different between cases with low vs. normal BMD which is similar to our observation.

In a systematic review of fat-soluble vitamin deficiency in adults with CP (12 studies), 57.6% (95% CI 43.9–70.4%) cases were vitamin D deficient. However, vitamin D deficiency was equally common in CP and controls with a pooled OR of 1.17(95% CI 0.7–1.7) [27]. 84% of our CP cases were vitamin D deficient (<20 ng/ml), which is similar to the 40.2–85% prevalence of vitamin D deficiency in healthy Indian children [36,37].However, 30.1% of our CP cases had severe (<5 ng/ml), 20.5% had moderate (5–10 ng/ml) and 33.7% had mild (10–20 ng/ml) deficiency as per Lips classification [38]. In healthy children, only 4.9% of upper socioeconomic and 11.2% of lower SES children had severe deficiency [37].This suggests that CP patients more often had severe vitamin D deficiency. Seasonal variation of vitamin D levels is seen in India, with exacerbation of vitamin D deficiency during winters due to poor sun exposure [39]. As patients were enrolled all around the year, seasonal variation could have affected the vitamin D levels in our study. Vitamin K

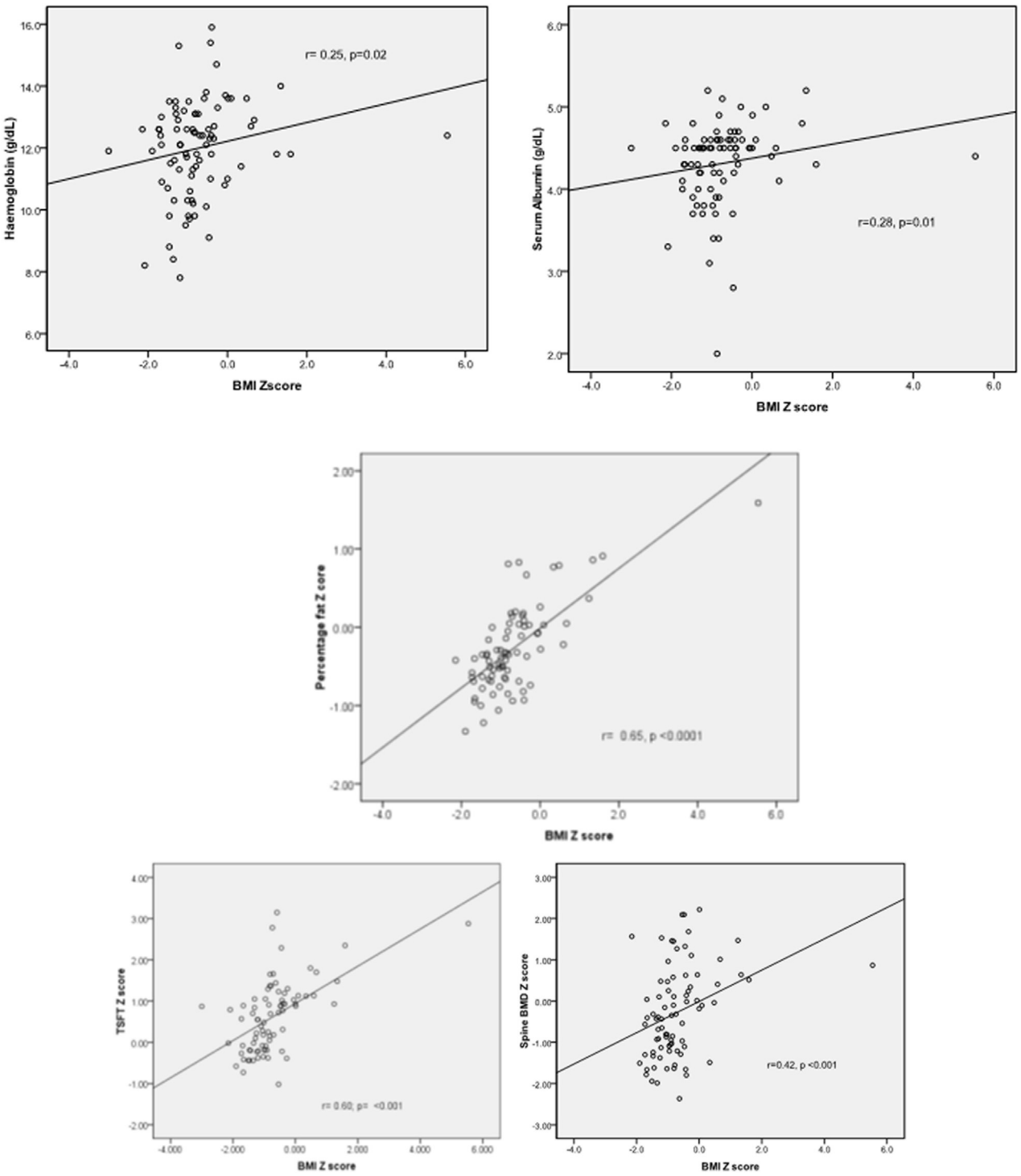

Fig. 2. a–e. Correlation of BMI- Z score with haemoglobin (a), albumin (b), percent body fat- Z score (c), triceps skinfold thickness- Z score (d) and lumbar spine bone mineral density-Z score (e).

deficiency and hypogonadism related to opioid use have been shown to contribute to low BMD in CP[33], [40], but we have not assessed them.

Both cystic fibrosis (CF) and CP are chronic diseases with EPI. Studies in CF children show a good correlation between BMI and BMD and sequential BMDs suggest that patients failing to gain weight with growth were failing to maintain/acquire bone also. These findings confirm that nutritional status is a major determinant of BMD [41,42].Poor bone health is less common in children (20% in our study) than adults (~65%) with CP. Even in CF, bone disease increases with age, with low BMD being more frequent in adults than children [43]. This could be due to shorter disease duration, lower frequency of diabetes and alcohol/smoking in children. As nearly 80% of the adult bone strength is acquired by late adolescence so the opportunity to positively influence bone mineralization is maximum in childhood and adolescence[44]. Both the AGA and 2020 ESPEN

Table 3
Laboratory parameters of the subjects with chronic pancreatitis.

Parameter	Value
Haemoglobin*	12.3[7.8–15.9] g/dL
Serum albumin	4.5[2–5.2] g/dL
Total protein	7.4 [4.8–9.0] g/dL
INR (International normalized ratio)	1.08[0.88–1.4]
Total serum calcium	9.4[4.2–10.9] mg/dL
Ionized calcium	4.7[2.8–5.5] mg/dL
Alkaline phosphatase	178[49–659] U
Fecal elastase (FE, n-82)	21.5 (0–280) μg/g.
FE > 200 μg/g	6 (7.3%)
FE between 100 and 200 μg/g	7(8.5%)
FE value of <100 μg/g.	69 (84.1%)
Diabetes mellitus.	4 (4.8%)
Imaging(n-82)	
Calcific disease	51 (61.4%)
Cambridge IV	51 (62.2%)
Cambridge III	15 (18.3%)
Cambridge II	16 (19.5%)

*Girls had lower haemoglobin than boys (11.8[7.8–13.7] vs 12.6[8.2–15.9]; p = 0.01).
There was no difference between girls and boys in the other laboratory parameters.

Table 4
Comparison of CP patients with low total body less head (TBLH)-BMD and normal TBLH-BMD.

Parameter	TBLH- BMD Normal (n-61)	TBLH-BMD Low (n-14)	p value
Male: female	36:25	6:8	0.3
Age at disease onset (y)	11.2 (4.1–17.8)	10.3 (4.8–13.8)	0.5
Age at study (y)	14.4 (8.1–21)	14.4 (9–17.3)	0.5
Disease duration in mo	36 (2–180)	37 (2.5–84)	0.8
Diet- normal: fat restricted	46:13	12:2	0.7
Fracture (yes)	8/57	1/13	1.0
Prepubertal: pubertal (n-72)	13:45	4:10	0.7
Weight for age Z score	−0.9 (−2.5 to 3.9)	−0.99 (−1.9 to −0.14)	0.3
Height for age Z score	−0.86 (−3.9 to 1.7)	−0.41 (−2.8 to 0.67)	0.1
BMI Z score	−0.82 (−2.1 to 5.5)	−1.3 (−1.9 to 0.34)	0.03
TSFT Z score (n-79)	0.69 (−1.02 to −2.8)	0.67 (−0.73 to −3.15)	0.94
Haemoglobin (g/dL)	12.4 (7.8–15.9)	12.4 (8.8–13.6)	0.8
Serum albumin (g/dL)	4.4 (2–5.2)	4.5 (3.9–5.1)	0.9
Total calcium (mg/dL)	9.5 (4.2–10.9)	9.3 (8.7–10.0)	0.5
Diabetes (present, n%)	4 (6.5%)	0 (0%)	0.5
Severe EPI (FE < 100 μg/g)	51/61 (83.6%)	10/14 (71.4%)	0.2
Fecal elastase (μg/g)	23 (0–280)	25 (0–248)	0.9
25 OH Vitamin D (ng/ml)	8.5 (3–30.1)	11.1 (3–28.6)	0.4
25 OHVitamin D (<20 ng/ml)	53/61 (86.8%)	11/14 (78.5%)	0.5
Calcific: non calcific CP	36:25	9:5	0.7
Cambridge II: III-IV	14:46	2:12	0.7
BMD FN Z score	−0.87(-2.6 to 2.3)	−2.01 (−2.6 to-0.58)	0.000
BMD PAS Z score	−0.10 (−1.9 to 2.2)	−1.35 (−2.3 to 0.10)	0.000

TSFT: Triceps skin fold thickness, BMD: bone mineral density, FN- femor neck, PAS-posterior anterior spine. All continuous variables are expressed as median with range. CP: chronic pancreatitis.

guidelines recognize the higher risk of undernutrition, bone disease, fractures and fat-soluble vitamin deficiencies in CP and recommend periodic evaluation for the same, with preventive measures [45,46].

All cases were counseled by the dietician, and those with EPI were prescribed PERT (~1000U/kg with every meal and 500 U/kg with every snack). As only 5% of our cases had weight < -2SD and none had weight loss so tube feeds or special formulae were not used. Adequate blood sugar control and oral vitamin D3 supplementation (60,000 U/week for 8 weeks followed by a maintenance dose of vitamin D and calcium) was done in those with diabetes and vitamin D deficiency respectively [47,48]. We feel that children with CP should be monitored closely for their nutritional status and exocrine insufficiency. Importance of weight-bearing exercises and avoidance of smoking and alcohol should be explained to adolescents. In our opinion, high-risk patients i.e. malnourished or with a history of significant fractures may be screened with BMD.

Our study has certain limitations. Dietary assessment of the caloric intake and details of opiod use were not recorded. We did not measure vitamin K levels. Although we have excluded subjects with known systemic diseases, we have not screened all the enrolled cases for conditions like celiac disease. Further, the interpretation of DXA in children is not as straightforward as in adults and has its own limitations.

However, this is the first study to comprehensively assess the nutritional status with anthropometry, laboratory parameters (vitamin D, anemia, calcium), exocrine and endocrine insufficiency and BMD of children with CP. Multicentre studies with larger numbers of patients are needed to confirm our observations. Differences in prevalence of obesity and vitamin D deficiency, hours of physical activity, management strategies for CP (opiod use, nutritional support, screening frequency for EPI and timing of PERT) may affect the BMD across populations.

In conclusion, ~20% of the CP children in India have low BMD but none have osteoporosis. Although 40% have undernutrition, it is mild in a majority. Subjects with lower BMI have lower BMD and percentage body fat. Efforts targeted towards early diagnosis and prevention of undernutrition in CP children may be useful.

Conflict of interest

There is no conflict of interest of any of the authors.

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