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DISH on chest radiographs: A skeletal clue to hidden cardiovascular risk

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Abstract

Introduction:

Diffuse idiopathic skeletal hyperostosis (DISH) is a common but frequently underrecognized skeletal disorder, and epidemiological data from Latin America are lacking. This study aimed to estimate the prevalence of DISH and investigate factors associated with the disease in a Brazilian population.

Methods

In this cross-sectional study, digital chest radiographs (posteroanterior and lateral views) and medical records from a private pulmonology outpatient clinic were reviewed. DISH was diagnosed according to the Resnick and Julkunen criteria. Vertebral fractures and thoracic aortic calcification were assessed using Genant's semiquantitative method and the classification proposed by Symeonidis et al., respectively. Associations between DISH and demographic and clinical variables were evaluated using Pearson's chi-square test and multivariable logistic regression analyses.

Results

A total of 1,005 individuals were included. The prevalence of DISH was 25.9% (n = 260) and 17.3% (n = 174) according to the Julkunen and Resnick criteria, respectively. Interobserver agreement was substantial for the Julkunen criteria (κ = 0.763; 95% CI 0.607–0.862) and almost perfect for the Resnick criteria (κ = 0.879; 95% CI 0.790–0.932). DISH prevalence increased significantly with age, reaching 35.7% and 24.7% among individuals aged ≥ 60 years according to the Julkunen and Resnick criteria, respectively, with no significant sex differences. In multivariable analyses, age ≥ 60 years, diabetes mellitus, and aortic calcification remained independently associated with DISH according to both classification systems.

Conclusion

DISH was highly prevalent among middle-aged and older adults and was independently associated with aging, diabetes mellitus, and aortic calcification. Recognition of DISH on routine chest radiographs may help identify individuals with an unfavorable cardiometabolic profile.

INTRODUCTION

Diffuse idiopathic skeletal hyperostosis (DISH), also known as Forestier's disease, is a non-inflammatory disease that affects the entheses and longitudinal ligaments with a predilection for the axial skeleton (axial DISH), but which can also involve peripheral joints (extra-axial DISH). The first reports appeared in 1950 by Forestier and Rote's-Querol, who described a case of enthesopathy and hyperostosis. DISH is characterized by progressive ossification of the anterior longitudinal ligament and bone proliferation in the enthesis, which becomes ossified. Although asymptomatic in most of cases, it can cause pain, functional impairment, including axial stiffness and reduced range of motion, as well as dysphagia, spinal canal stenosis and vertebral fragility fractures (1, 2).

One of the characteristics of DISH is the involvement, mainly of the thoracic spine, with typically coarse osteophytes that lead to the formation of anterolateral bridges with ossification of the posterior longitudinal ligament generally located to the right of the spine. This phenomenon appears to be correlated with the inhibitory factor of the effect of the pulsating aorta on the left side, since bone bridges on the left side were demonstrated among patients who had an aorta located on the right (3). Extraspinal locations, including ossifications at the insertion, have been reported like sites of tendons and ligaments in the shoulders, knees, hips, pelvis, feet, ankles, and hands.

The etiology is still unknown. It is known that it occurs more frequently in individuals over 50 years of age, it becomes more prevalent with increasing age and men are predominantly more affected than women (4). The diagnostic definition is made by radiography or computed tomography of the spine. The most widely accepted set of criteria was proposed by Resnick and Niwayama in 1976, where there are 3 essential points for the diagnosis: 1- gross calcification and ossification along the anterolateral surface of at least 4 contiguous vertebrae; 2- absence of significant degenerative discopathy in the segments involved; 3- absence of significant changes in interapophyseal and sacroiliac joints (5) Another criterion used was proposed by Julkunen, characterized by the presence of a prominent and complete bony bridge connecting two vertebrae in two or more distinct locations in the dorsal column (6).

The main risk factors are the metabolic conditions that are often associated with DISH, including metabolic syndrome, diabetes mellitus (DM), hyperuricemia, dyslipidemia, obesity, high blood pressure (HBP), coronary heart disease and aortic aneurysm (4, 7–10). More recent studies point to a higher prevalence of risk factors for metabolic syndrome in patients with DISH compared to control groups (11, 12). In addition, growing evidence suggests that DISH may be associated with vascular calcification and increased cardiovascular risk, supporting the hypothesis that DISH reflects a broader systemic metabolic and osteogenic process rather than an isolated skeletal disorder (13, 14). Around 26 studies have assessed the prevalence of DISH, most carried out in Asia, approximately one third of them were carried out in Japan (Table 1).

Table 1
Summary of diagnostic criteria proposed for diffuse idiopathic skeletal hyperostosis (DISH).

JULKUNEN ET AL, 1975	RESNICK ET AL, 1976	MODIFIED RESNICK – CASSIM ET AL, 1990	MODIFIED RESNICK MODIFICADO – KISS ET AL, 2002	MODIFIED RESNICK FOR THE DIAGNOSIS OF DISH BASED ON CT- OUDKERK ET AL, 2017
Presence of a prominent and complete bony bridge connecting two vertebrae at two or more locations in the dorsal column;	1- Gross calcification and ossification along the anterolateral surface of at least 4 contiguous vertebrae; 2- Absence of significant degenerative disc disease in the segments involved; 3- Absence of significant changes in interapophyseal and sacroiliac joints;	1- Presence of calcification and fluid ossification along the anterolateral aspects of at least four contiguous vertebral bodies; 2- Relative preservation of disc height in the areas involved; 3- Absence of extensive degenerative disease;	1- Ligament calcification continually exceeds two or more intervertebral spaces; 2- The heights of the intervertebral discs are relatively maintained; 3- Absence of erosion, ankylosis and other symptoms of inflammation in the sacroiliac joints and small joints of the spine;	1- At least four contiguous vertebrae or, alternatively, three discs at contiguous bridge level; 2- Fixed settings (bone) to avoid false positive and false negative cases; 3- The angle formed by an osteophyte in relation to the vertebral bodies must be greater than 90°; 4- In cases of mild or moderate degenerative disc changes in combination with fluid ossifications, the diagnosis of DISH can be established;

DISH: diffuse idiopathic skeletal hyperostosis, CT: computed tomography

Because DISH can be readily identified on routine chest radiographs, it may represent an opportunistic imaging marker of underlying cardiometabolic abnormalities. Given the widespread use of chest radiography in clinical practice, recognition of DISH could provide additional information beyond musculoskeletal disease and contribute to the identification of patients at increased cardiometabolic risk.

Considering high prevalence with potential complications that can lead to poor morbidity and quality of life, as well as excessive healthcare costs, epidemiological knowledge of DISH and awareness is crucial. Previous studies have shown higher prevalence in Japanese and lower prevalence in African, North American and other Asian countries but no study on DISH prevalence has been carried out in Latin America, and none performed in Brazil (15–19). The wide variation in prevalence reported across epidemiological studies suggests that both genetic and environmental factors, including lifestyle, may contribute to DISH and partly explain its association with metabolic syndrome.

Therefore, this study aimed to determine the prevalence of DISH in a Brazilian population and to explore its associations with metabolic and cardiovascular-related conditions detectable in routine clinical practice.

METHODS

Study Design and Population

This cross-sectional study was designed to estimate the prevalence of diffuse idiopathic skeletal hyperostosis (DISH) and investigate its associations with demographic and clinical characteristics in a consecutive outpatient imaging cohort. The study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Digital chest radiographs (posteroanterior and lateral views) and corresponding medical records were obtained from sequential patients attending a private pulmonology outpatient clinic. Chest radiography was selected because it is routinely performed in outpatient clinical practice and provides adequate visualization of the thoracic spine, the anatomical region most commonly affected by DISH. Additionally, chest radiographs allow opportunistic assessment of thoracic spinal abnormalities without requiring additional imaging examinations or radiation exposure (20).

Participants

Patients aged 40 years or older were eligible for inclusion. Eligibility required the availability of complete medical records and adequate chest radiographs in both posteroanterior and lateral projections. Exclusion criteria included incomplete clinical data, a diagnosis of ankylosing spondylitis, and radiographic artifacts that could interfere with image interpretation, including sternotomy wires and cardiac pacemakers.

Radiographic Assessment

Chest radiographs were independently reviewed by two experienced musculoskeletal radiologists blinded to patients clinical information. Disagreements were resolved by consensus. Interobserver agreement was assessed using Cohen's kappa coefficient.

Several diagnostic criteria for DISH have been proposed over the past decades and are summarized in Table 1. However, only the criteria developed by Julkunen et al. and Resnick and Niwayama were applied in the present study because they were specifically designed for conventional radiography and have been widely adopted in epidemiological studies of thoracic DISH.

DISH was classified according to the criteria proposed by Resnick and Niwayama and by Julkunen. According to Resnick and Niwayama, DISH was defined by: (1) flowing calcification and ossification along the anterolateral aspect of at least four contiguous vertebral bodies; (2) preservation of intervertebral disc height without significant degenerative disc disease; and (3) absence of sacroiliac joint erosion, sclerosis, or ankylosis. The Julkunen criteria required the presence of complete bony bridges connecting adjacent vertebrae in at least two distinct thoracic spinal locations.

Representative examples of DISH identified on chest radiographs are shown in Figs. 1A-B and 2A-B.

Aortic calcification was evaluated on lateral chest radiographs according to the grading system proposed by Symeonidis et al., and grades 1–3 were considered indicative of vascular calcification. Vertebral fractures were assessed using Genant's semiquantitative method, with vertebral deformity defined as a reduction greater than 20% in the anterior, middle, or posterior vertebral body height.

Clinical Variables and Data Collection

Clinical information was obtained through review of medical records and documentation of continuous-use medications at the time of imaging. The following comorbidities were recorded: dyslipidemia (DLP), hypertension (HBP), diabetes mellitus (DM), hypothyroidism (HT), osteoporosis (OP), asthma, chronic obstructive pulmonary disease (COPD), vertebral fracture, aortic calcification, and other reported medical conditions.

To contextualize the prevalence findings, a structured literature search was conducted in MEDLINE (via PubMed) using the terms "Diffuse Idiopathic Skeletal Hyperostosis" OR "DISH" combined with "epidemiology" OR "prevalence". Both MeSH terms and free-text variations were employed to maximize sensitivity. The search was restricted to studies involving adult human populations and was used to identify previously published prevalence studies included in Table 2.

Table 2
Prevalence of diffuse idiopathic skeletal hyperostosis (DISH) reported in previous epidemiological studies

YEAR	AUTHOR	COUNTRY	AGE (YEAR)	"N"	MÉTHODS	CRITERIA	TOTAL PREVALENCE (%)	MEN (%)	WOI (%)
1975	JULKUNEN (6)	Finland	≥ 40	8933	Case-control, X-ray, quiz	Presence of a complete bony bridge connecting two vertebrae at two or more different locations in the spine	2,6%	3,8%	2,6%
1976	RESNICK (32)	USA	Between 49 to 88	215 cadavers and 100 patients with DISH	X-ray, histological and radiographic analysis of cadavers	1- Gross calcification and ossification along the anterolateral surface of at least 4 contiguous vertebrae; 2- Absence of significant degenerative disc disease in the involved segments; 3- absence of significant changes in interapophyseal and sacroiliac joints	12% among cadavers (all male)	96% of patients with DISH	4% o pati with
1984	BLOOM (17)	Israel	> 40	1236	X-ray	Resnick	18%	22,4%	13,4
1990	CASSIM (16)	South Africa	≥ 40	1000 (retrospective) 500 (prospective)	Chest X-ray (profile), questionnaire	Modified Resnick	3,9%	3,8%	4,2%
1997	WEINFELD (33)	USA	> 50	2364	Chest X-ray (PA and profile), questionnaire	Resnick	Not included	25%	15%
2002	KISS (18)	Hungary	Between 50 to 79	635	Thoracic and lumbar spine x-ray (profile)	Resnick Modified Resnick	19.8% (Resnick) and 3.6% (Modified Resnick)	27.3% (Resnick) and 6.1% (Modified Resnick)	12.8 (Res and (Mo Resi
2004	KIM (15)	South Korea	> 50	3595	Thoracic spine X-ray (profile)	Resnick and Julkunen	Resnick: 2,9%; Julkunen: 4,1%	Resnick: 5,4%; Julkunen: 7,1%	Resi 0,8% Julk 1,6%
2008	WESTERVELD(34)	Netherlands	> 50	501	Chest X-ray (PA and profile)	Resnick	17%	22,7%	12,1
2014	KAGOTANI (35)	Japan	Between 23 to 94	1647	Questionnaire, anthropometric measurements, X-ray of the thoracic, cervical and lumbar spine (PA and profile)	Resnick	10,8%	22%	4,8%

USA: United States of America

DISH: diffuse idiopathic skeletal hyperostosis

PA: posteroanterior

CT: computed tomography

BMI: body mass index

PET: positron emission tomography

vs: versus

YEAR	AUTHOR	COUNTRY	AGE (YEAR)	"N"	MÉTHODS	CRITERIA	TOTAL PREVALENCE (%)	MEN (%)	WOI (%)
2016	HIRASAWA (36)	Japan	Between 40 and 89	558	Chest and abdomen (PA) X-ray and CT of the chest and abdomen, including pelvis	Resnick	17.6% (X-ray) and 27.2% (CT)	23.3% (X-ray) and 38.7% (CT)	10.8 ray) 14.0
2016	FUJIMORI (37)	Japan	Between 21 to 94	1500	Full body PET CT, questionnaire	Resnick	12%	16%	6,2%
2016	MORI (38)	Japan	Between 16 to 97	3013	Chest CT, questionnaire	Resnick	8,7%	13%	2,5%
2017	TOYODA (19)	Japan	≥ 18	281	Whole column X-ray, questionnaire	Resnick	25,6%	30,1%	19,5
2017	BATEMAN (39)	Pacific Islands vs other countries	> 50	459 Pacific islands: 96 Other countries: 363	Chest X-ray	Resnick	30%	Pacific: 43% Other: 33%	Pac Othe
2018	HIRASAWA (40)	Sweden and Japan	Between 40 to 90	Sweden: 418 Japan:558	Full body CT	Resnick	Sweden: 24.4% Japan: 27.2%	Sweden:32.4% Japan:38.6%	Swe 10.4 Jap
2018	HIYAMA (41)	Japan	> 20	1479	Total spine CT	Resnick	19,5%	21,1%	16%
2018	KIM (42)	South Korea	> 16	164	Total spine CT	Modified Resnick	24,4%	31,7%	15,8
2018	ADEL (26)	Pakistan	Between 50 to 65	416	CT of the chest and full abdomen, questionnaire	Resnick	30,8%	34,8%	23,3
2018	SIRASANAGANDLA (43)	Oman	> 50	1305	Chest X-ray (PA and profile)	Resnick	10%	12%	7,7%
2020	UEHARA (44)	Japan	Between 50 to 80	411	Total spine X-ray (profile, questionnaire)	Resnick	17,5%	27,8%	7,7%
2021	YOSHIHARA (45)	USA	3299 self-declared as black	3299	Chest CT, questionnaire	Modified Resnick	7,7%	7,1%	8,7%
2021	SINGH (46)	India	> 18	2500	Full body CT and total spine CT	Resnick	6,9%	8,4%	4,1%
2021	AUÐUNSSON (47)	Iceland	Between 68 and 96	5321	Thoracic spine CT, questionnaire	Resnick	7,5%	13,7%	2,8%
2022	IKUMA (25)	Japan	67.8 ± 19.5 78.8 ± 10.1	1519	CT chest to pelvis, questionnaire	Resnick	17,4%	Not included	Not inclu
2022	CIAFFI (12)	Italy	≥ 18	1012	X-ray of the thoracic spine (PA and profile), lumbosacral	Resnick	12,8%	16,8%	10,3

USA: United States of America

DISH: diffuse idiopathic skeletal hyperostosis

PA: posteroanterior

CT: computed tomography

BMI: body mass index

PET: positron emission tomography

vs: versus

YEAR	AUTHOR	COUNTRY	AGE (YEAR)	"N"	MÉTHODS	CRITERIA	TOTAL PREVALENCE (%)	MEN (%)	WOI (%)
					spine (PA and profile) and X-ray of the pelvis, questionnaire				
2022	HARLIANTO (14)	Netherlands	Between 18 to 79	4703	Chest X-ray, questionnaire	Resnick	9,4%	Not included	Not incl
USA: United States of America									
DISH: diffuse idiopathic skeletal hyperostosis									
PA: posteroanterior									
CT: computed tomography									
BMI: body mass index									
PET: positron emission tomography									
vs: versus									

Statistical Analysis

The dependent variable was the presence of DISH according to the Resnick and Julkunen classification systems, which were analyzed separately. Independent variables included sex (male/female), age group (40–59 years and ≥ 60 years), dyslipidemia, hypertension, diabetes mellitus, hypothyroidism, osteoporosis, chronic obstructive pulmonary disease (COPD), asthma, other comorbidities, aortic calcification, and vertebral fracture.

Categorical variables were summarized as absolute and relative frequencies. The prevalence of DISH was estimated for each diagnostic criterion as the proportion of affected individuals among the total study population and according to sex and age group, together with their respective 95% confidence intervals (95% CIs). Associations between DISH and demographic or clinical variables were initially evaluated using Pearson's chi-square test.

Multivariable logistic regression analyses were performed separately for the Resnick and Julkunen classifications to identify factors independently associated with DISH. Variables selected a priori based on clinical relevance and findings from the bivariate analyses, including age group, sex, diabetes mellitus, hypertension, dyslipidemia, and aortic calcification, were simultaneously entered into the models. Adjusted odds ratios (ORs) and corresponding 95% confidence intervals (95% CIs) were calculated.

A two-sided p-value < 0.05 was considered statistically significant. Statistical analyses were performed using R software version 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria).

Ethical Considerations

The requirement for written informed consent was waived because the study was based exclusively on secondary data obtained from existing medical records and imaging archives. All data were anonymized before analysis. The study was approved by the Permanent Committee on Ethics in Research Involving Human Beings of the State University of Maringá (protocol no. 67681417.0.0000.0104).

RESULTS

A total of 1,100 chest radiographs and corresponding medical records were reviewed. Ninety-five individuals were excluded because of missing clinical information (n = 80), ankylosing spondylitis (n = 5), or radiographic artifacts that could interfere with image interpretation (n = 10), including sternotomy wires and cardiac pacemakers. The final study population consisted of 1,005 participants, including 498 men (49.6%) and 507 women (50.4%).

According to the Julkunen and Resnick criteria, the prevalence of DISH was 25.9% (260/1,005) and 17.3% (174/1,005), respectively. Interobserver agreement was substantial for the Julkunen criteria (κ = 0.763; 95% CI 0.607–0.862) and almost perfect for the Resnick criteria (κ = 0.879; 95% CI 0.790–0.932). Participant characteristics and prevalence estimates according to sex and age group are summarized in Table 3.

Table 3
Prevalence of diffiuse idiopathic skeletal hyperostosis according to sex and age group using Julkunen and Resnick diagnostic criteria.

Julkunen criteria					
Variable	Julkenen DISH +/ Total	Prevalence (%)	OR	95% CI	p
Male	135/498	27.1	0.9	0.66–1.17	0.374
Female	125/507	24.7	1		
≥ 60 years	212/594	35.7	4.2	3.02–5.83	< 0.001
40–59 years	48/411	11.7	1		
Resnick Criteria					
Variable	Resnick DISH +/ Total	Prevalence (%)	OR	95% CI	p
Male	94/498	18.9	1.2	0.90–1.72	0.194
Female	80/507	15.8	1		
≥ 60 years	147/594	24.7	4.7	3.12-7.00	< 0.001
40–59 years	27/411	6.6	1		

Among men, the prevalence of DISH was 27.1% (135/498) according to the Julkunen criteria and 18.9% (94/498) according to the Resnick criteria. Among women, the corresponding prevalence rates were 24.7% (125/507) and 15.8% (80/507), respectively. However, no statistically significant differences were observed between sexes according to either classification system. In contrast, the prevalence of DISH was significantly higher among participants aged 60 years or older according to both classification systems ($p < 0.001$)

According to the Julkunen criteria, DISH was significantly associated with dyslipidemia (OR = 1.9; 95% CI 1.32–2.76; $p < 0.001$), hypertension (OR = 2.0; 95% CI 1.47–2.65; $p < 0.001$), diabetes mellitus (OR = 2.9; 95% CI 1.91–4.26; $p < 0.001$), osteoporosis (OR = 6.8; 95% CI 2.11–22.2; $p = 0.001$), and aortic calcification (OR = 3.0; 95% CI 2.21–4.12; $p < 0.001$). Similar findings were observed using the Resnick criteria, with significant associations identified for dyslipidemia (OR = 2.0; 95% CI 1.33–3.00; $p < 0.001$), hypertension (OR = 2.4; 95% CI 1.71–3.32; $p < 0.001$), diabetes mellitus (OR = 3.9; 95% CI 2.58–5.84; $p < 0.001$), osteoporosis (OR = 7.4; 95% CI 2.48–22.1; $p < 0.001$), and aortic calcification (OR = 2.8; 95% CI 1.97–4.10; $p < 0.001$). In contrast, hypothyroidism, chronic obstructive pulmonary disease, asthma, other reported comorbidities, and vertebral fracture were not significantly associated with DISH according to either diagnostic criteria (Tables 4 and 5).

Table 4
Bivariate analysis of clinical characteristics according to DISH status, as defined by the Julkunen criteria.

Variables	DISH +		DISH -		OR	95%IC	p
	n	%	n	%			
Sex							
Male	135	13.4	363	36.1	0.9	0.66–1.17	0.374
Female	125	12.4	382	38.1	1		
Age							
60 or +	212	21.1	382	38.0	4.2	3.02–5.83	< 0.001
40–59	48	4.8	363	36.1			
Dyslipidemia							
Yes	54	5.4	90	8.9	1.9	1.32–2.76	< 0.001
No	206	20.5	655	65.2	1		
Hypertension							
Yes	103	10.3	186	18.5	2.0	1.47–2.65	< 0.001
No	157	15.6	559	55.6	1		
Diabetes Mellitus							
Yes	49	4.9	56	5.6	2.9	1.91–4.26	< 0.001
No	211	21.0	689	68.7	1		
Hypothyroidism							
Yes	24	2.4	59	5.9	1.2	0.72–1.94	0.508
No	236	23.5	686	68.2	1		
Osteoporosis							
Yes	7	0.7	3	0.3	6.8	2.11–22.2	0.001
No	253	25.2	742	73.8	1		
Chronic Obstructive Pulmonary Disease							
Yes	35	3.5	91	9.1	1.1	0.74–1.70	0.601
No	225	22.4	654	65.0	1		
Asthma							
Yes	41	4.1	106	10.5	0.9	1.31–0.60	0.544
No	219	21.8	639	63.6	1		
Other morbidities							
Yes	84	8.4	215	21.4	1.2	0.87–1.59	0.294
No	176	17.5	530	52.7			
Aortic Calcification							
Yes	197	19.6	379	37.7	3.0	2.21–4.12	< 0.001
No	63	6.3	366	36.4	1		
Vertebral fracture							
Yes	15	1.5	45	4.5	0.9	0.521–1.73	0.873
No	245	24.4	700	69.6	1		

Table 5
Bivariate analysis of clinical characteristics according to DISH status, as defined by the Resnick criteria

Variables	DISH +		DISH -		OR	IC	p
	n	%	n	%			
Sex							
Male	94	9.4	404	40.2	1.2	0.90–1.72	0.194
Female	80	7.9	427	42.5	1		
Age							
60 or +	147	14.6	447	44.5	4.7	3.12-7.00	< 0.001
40–59	27	2.7	384	38.2			
Dyslipidemia							
Yes	39	3.9	105	10.4	2.0	1.33-3.00	< 0.001
No	135	13.4	726	72.3	1		
Hypertension							
Yes	78	7.8	211	21.0	2.4	1.71–3.32	< 0.001
No	96	9.5	620	61.7	1		
DM							
Yes	42	4.2	63	6.3	3.9	2.58–5.84	< 0.001
No	132	13.1	768	76.4	1		
Hypothyroidism							
Yes	18	1.8	65	6.5	1.4	0.79–2.35	0.271
No	156	15.5	766	76.2	1		
Osteoporosis							
Yes	6	0.6	4	0.4	7.4	2.48–22.1	< 0.001
No	168	16.7	827	82.3	1		
Chronic Obstructive Pulmonary Disease							
Yes	24	2.4	102	10.2	1.1	0.71–1.84	0.582
No	150	14,9	729	72.5	1		
Asthma							
Yes	24	2.4	123	12.2	1.1	0.68–1.74	0.732
No	150	14.9	708	70.5	1		
Other morbidities							
Yes	59	5.9	240	23.9	1.3	0.89–1.79	0.187
No	115	11.4	591	58.8			
Aortic Calcification							
Yes	133	13.2	443	44.1	2.8	1.97–4.1	< 0.001
No	41	4.1	388	38.6	1		
Vertebral fracture							
Yes	12	1.2	48	4.7	1.2	0.62–2.32	0.570
No	162	16.1	783	77.9	1		

Multivariable logistic regression analyses demonstrated that age ≥ 60 years, diabetes mellitus, and aortic calcification remained independently associated with DISH according to both the Resnick and Julkunen criteria (Table 6).

Table 6
Multivariable logistic regression analyses of factors independently associated with DISH according to the Julkunen and Resnick criteria.

Variable	Resnick OR (95% CI)	p	Julkunen OR (95% CI)	p
Age ≥ 60 years	3.09 (1.91–5.15)	< 0.001	2.81 (1.90–4.20)	< 0.001
Male sex	1.31 (0.92–1.86)	0.130	1.17 (0.87–1.59)	0.298
Dyslipidemia	1.12 (0.70–1.77)	0.630	1.24 (0.81–1.87)	0.321
Hypertension	1.30 (0.87–1.91)	0.194	1.11 (0.78–1.56)	0.569
Diabetes mellitus	2.62 (1.59–4.29)	< 0.001	1.97 (1.23–3.16)	0.005
Aortic calcification	1.55 (1.01–2.41)	0.049	1.76 (1.22–2.56)	0.003

In the Resnick model, participants aged 60 years or older had approximately three times greater odds of presenting DISH (OR = 3.09; 95% CI 1.91–5.15; p < 0.001). Diabetes mellitus (OR = 2.62; 95% CI 1.59–4.29; p < 0.001) and aortic calcification (OR = 1.55; 95% CI 1.01–2.41; p = 0.049) were also independently associated with the disease.

Similar findings were observed in the Julkunen model, in which age ≥ 60 years (OR = 2.81; 95% CI 1.90–4.20; p < 0.001), diabetes mellitus (OR = 1.97; 95% CI 1.23–3.16; p = 0.005), and aortic calcification (OR = 1.76; 95% CI 1.22–2.56; p = 0.003) remained significant predictors of DISH. In contrast, sex, hypertension, and dyslipidemia were no longer independently associated with DISH after multivariable adjustment.

DISCUSSION

To our knowledge, this is the first study to estimate the prevalence of diffuse idiopathic skeletal hyperostosis (DISH) and investigate its associated factors in a Brazilian population, as well as the first report from Latin America. Depending on the diagnostic criteria applied, the prevalence of DISH ranged from 17.3% to 25.9%, representing an intermediate frequency compared with previous studies conducted in Israel (18%), Hungary (19.8%) and the Netherlands (17%) using the Resnick criteria (17–19). In addition, although several cardiometabolic conditions were associated with DISH in unadjusted analyses, only age ≥ 60 years, diabetes mellitus, and aortic calcification remained independently associated with the disease after multivariable adjustment.

Most epidemiological studies have reported a higher prevalence of DISH in men; however, no statistically significant sex differences were observed in the present investigation, regardless of the classification criteria adopted. Among the 26 studies included in our review, only two reported a higher prevalence in women, both involving selected populations (16, 21), whereas three studies did not provide sex-stratified analyses or found no significant differences between sexes (21–23). The similarity in prevalence estimates observed in our cohort suggests that sex-related differences in DISH may be population-specific and influenced by genetic background, environmental exposures, and lifestyle factors rather than by the diagnostic criteria themselves.

A marked increase in DISH prevalence was observed with advancing age, particularly after 60 years. Age remained one of the strongest independent predictors of DISH in both multivariable models, increasing the odds of disease by approximately threefold. Similar findings have been described in populations from Pakistan, Japan and Italy, reinforcing the concept that DISH is predominantly a disease of older adults (12, 19, 24–26). The strong association between aging and DISH may reflect cumulative exposure to metabolic and biomechanical stimuli over time, in addition to age-related alterations in osteogenic pathways, including increased activity of bone morphogenetic proteins and dysregulation of Wnt signaling, which may favor progressive entheseal ossification.

Among the cardiometabolic conditions evaluated, diabetes mellitus emerged as an independent factor associated with DISH according to both the Resnick and Julkunen criteria. This observation corroborates previous reports from South Africa and Pakistan demonstrating a higher prevalence of type 2 diabetes among individuals with DISH (16, 26). Hyperinsulinemia and increased circulating levels of insulin-like growth factor 1 (IGF-1) have been proposed as potential mechanisms linking diabetes to ectopic bone formation by stimulating osteoblast proliferation and differentiation (21, 23, 27). The persistence of diabetes mellitus as an independent predictor after adjustment for age, sex, hypertension, dyslipidemia, and vascular calcification suggests that disturbances in glucose metabolism may contribute directly to the pathophysiology of DISH rather than merely reflecting the aging process.

Hypertension and dyslipidemia were significantly associated with DISH in the bivariate analyses but lost statistical significance after multivariable adjustment. Similar attenuation has been reported in previous investigations and may indicate that these conditions act primarily as markers of aging and overall cardiometabolic burden rather than as independent determinants of ligamentous ossification. Moreover, differences among studies regarding diagnostic criteria, imaging modalities, population characteristics and adjustment strategies may partially explain the heterogeneity of findings reported in the literature.

Aortic calcification was highly prevalent among individuals with DISH and remained independently associated with the disease in both multivariable models. Using the Resnick criteria, 76.4% of individuals with DISH exhibited aortic calcification compared with 53.3% of controls, while comparable proportions were observed using the Julkunen criteria. Oudkerk et al. reported a significantly higher prevalence of coronary artery calcification among individuals with DISH than among controls (66.8% versus 46.9%, p < 0.001) (23). Likewise, Harlianto et al. demonstrated a higher prevalence of thoracic aortic calcification in patients with DISH and an association with more severe atherosclerosis (14).

These findings support the hypothesis that vascular and skeletal mineralization may share common biological pathways, including chronic low-grade inflammation, oxidative stress, and osteogenic differentiation of vascular smooth muscle cells. Although the clinical implications of these observations

remain uncertain, recognition of DISH on routine chest radiographs may warrant increased attention to cardiovascular risk factors, particularly in older adults.

An association between DISH and osteoporosis was observed in the bivariate analyses, but this relationship was not retained after multivariable adjustment. In addition, the relatively small number of osteoporotic individuals in our cohort resulted in wide confidence intervals, suggesting that this finding should be interpreted cautiously. Nevertheless, previous studies have proposed that abnormalities in bone remodeling pathways may explain the paradoxical coexistence of localized hyperostosis and systemic bone fragility. Reduced circulating levels of sclerostin and Dickkopf-1, together with increased expression of receptor activator of nuclear factor kappa-B ligand (RANK-L), have been implicated in the pathogenesis of DISH and may contribute simultaneously to entheseal ossification and generalized skeletal fragility (10, 28). Similar interactions between new bone formation and vascular calcification have also been described in aging populations and in patients with axial spondyloarthritis (29–31).

This study has several strengths. It represents the first epidemiological investigation of DISH in Brazil and Latin America and includes a relatively large sample of more than one thousand individuals. Additional strengths comprise blinded radiographic assessment by experienced musculoskeletal radiologists, evaluation of interobserver agreement, and the simultaneous assessment of vertebral fractures and vascular calcification using a single imaging examination.

However, some limitations should be acknowledged. The cross-sectional design precludes causal inferences, and the study population was derived from a pulmonology outpatient clinic, which may limit generalizability to the broader Brazilian population. Information regarding body mass index, waist circumference, laboratory markers of metabolic syndrome, sleep disorders, pain, stiffness, spinal mobility, functional impairment, and manifestations of peripheral DISH was unavailable. Furthermore, vertebral fracture assessment was restricted to the thoracic spine because chest radiographs do not adequately visualize lumbar vertebrae, potentially leading to underestimation of fracture prevalence.

The high prevalence of DISH observed on chest radiographs and its independent association with diabetes mellitus and aortic calcification suggest that DISH should no longer be regarded solely as an incidental radiographic finding. Instead, its identification may represent a marker of increased cardiometabolic vulnerability, particularly among individuals aged 60 years or older. Future prospective studies are warranted to clarify the temporal relationship between DISH, vascular calcification and metabolic dysfunction, as well as to determine whether systematic cardiovascular assessment in patients with DISH may improve clinical outcomes.

CONCLUSION

DISH was highly prevalent in this Brazilian cohort and was independently associated with aging, diabetes mellitus, and aortic calcification. These findings suggest that DISH visible on routine chest radiographs may represent more than an incidental skeletal finding and could serve as a marker of increased cardiometabolic vulnerability. Prospective studies are warranted to evaluate its potential role in cardiovascular risk stratification.

Abbreviations

CI
Confidence Interval
COPD
Chronic Obstructive Pulmonary Disease
DISH
Diffuse Idiopathic Skeletal Hyperostosis
DLP
Dyslipidemia
DM
Diabetes Mellitus
HBP
High Blood Pressure
HT
Hypothyroidism
IGF
1–Insulin–like Growth Factor 1
MeSH
Medical Subject Headings
OP
Osteoporosis
OR
Odds Ratio
PA
Posteroanterior
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology
κ

Cohen's kappa coefficient

Declarations

COMPLIANCE WITH ETHICAL STANDARDS

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

DATA AVAIABILITY

The data used in this study are available from the corresponding author upon reasonable request.

CONTRIBUTIONS

All authors contributed equally to the work.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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Figures

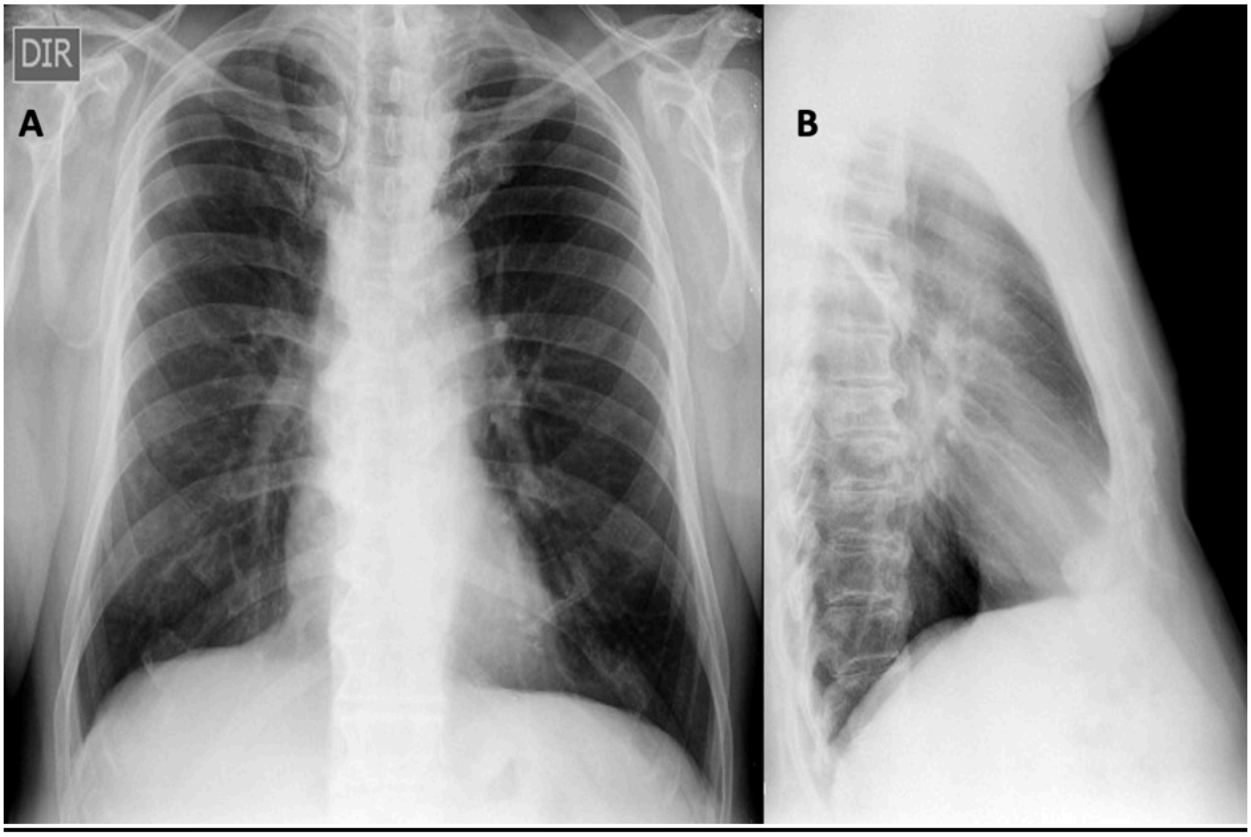


Figure 1

A–B. Chest radiographs of a male patient with diffuse idiopathic skeletal hyperostosis (DISH). (A) Posteroanterior view demonstrating flowing ossification along the right anterolateral aspect of the thoracic spine involving at least five contiguous vertebral levels. (B) Lateral view confirming extensive bridging ossifications consistent with the Resnick and Niwayama criteria

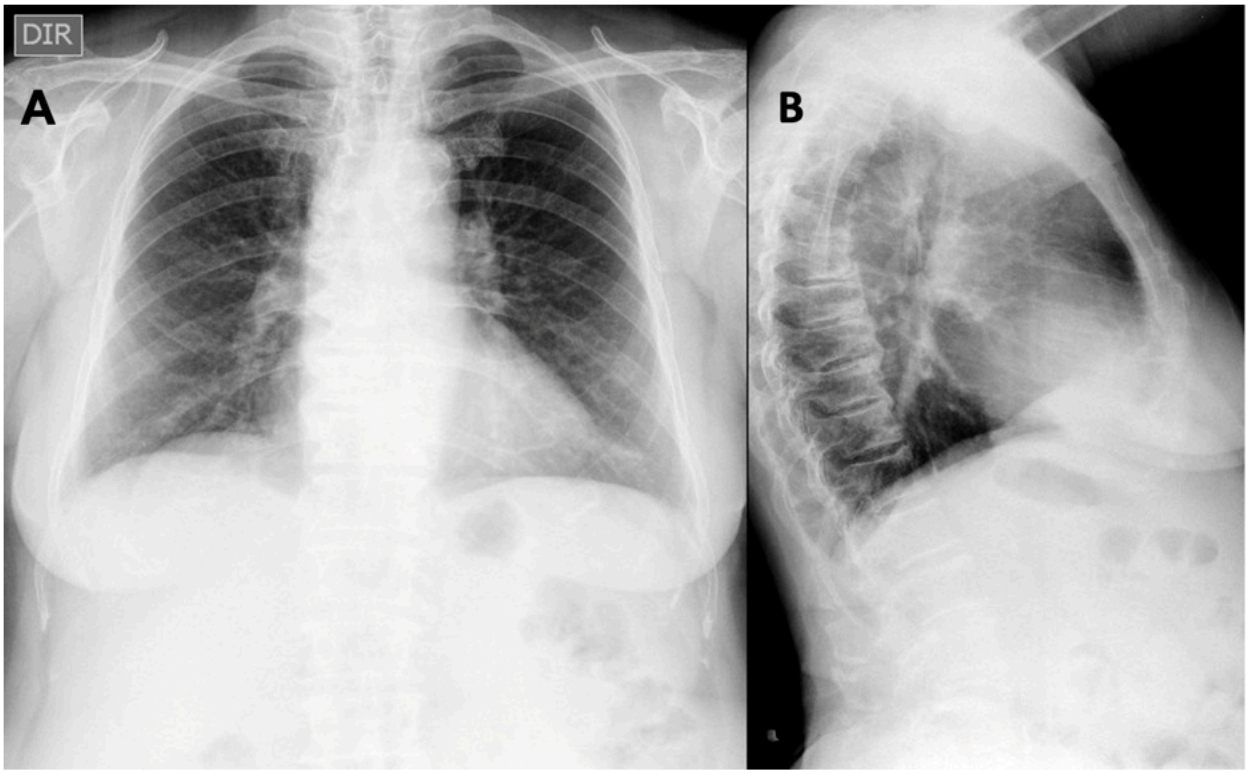


Figure 2

A–B. Chest radiographs of a female patient with diffuse idiopathic skeletal hyperostosis (DISH). (A) Posteroanterior view showing right-sided flowing ossification involving multiple contiguous thoracic vertebrae. (B) Lateral view demonstrating thoracic bridging ossifications. Mild aortic arch calcification is also visible.