



QUANTITATIVE ASSESSMENT OF LIVER FAT FRACTION USING MRI-PDFF AND CT-ATTENUATION: A CORRELATION STUDY WITH VISCERAL ADIPOSITY IN THE INDUSTRIAL WORKFORCE OF WEST BENGAL

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Abstract

Background: In the industrial corridors of West Bengal, the "thin-fat" South Asian phenotype presents a high risk for metabolic-associated steatotic liver disease (MASLD), often despite a normal Body Mass Index (BMI). While ultrasonography is a common screening tool, it lacks the precision required for quantifying early-stage fat infiltration. This study evaluates the efficacy of **MRI-Proton Density Fat Fraction (MRI-PDFF)** and **CT-Attenuation** as high-precision quantitative markers for liver fat, correlating these findings with visceral adiposity in an industrial cohort.

Methods: A cross-sectional study was conducted at a tertiary care center in Durgapur involving **120 industrial workers** (aged 30–55 years). Participants underwent **NCCT (Non-Contrast Computed Tomography)** to measure hepatic attenuation in Hounsfield Units (HU) and **MRI-PDFF** using a multi-echo gradient-recalled echo sequence to map the fat fraction percentage. Visceral Adiposity was calculated using the **Visceral Adiposity Index (VAI)**, integrating waist circumference, triglycerides, and HDL levels.

Results: The mean MRI-PDFF in the cohort was **14.2% ± 6.8%**. A strong inverse correlation was observed between MRI-PDFF and CT-attenuation ($r = -0.84$, $p < 0.001$). Furthermore, VAI demonstrated a significant positive correlation with the MRI-quantified fat fraction ($r = 0.76$, $p < 0.001$). Interestingly, **32%** of participants with a BMI $< 23 \text{ kg/m}^2$ exhibited an MRI-PDFF $> 10\%$, indicating significant "hidden" steatosis. CT-attenuation showed a sensitivity of 82% in detecting steatosis compared to the MRI-PDFF gold standard.

Conclusion: MRI-PDFF provides superior quantitative precision in detecting early metabolic dysfunction in industrial workers compared to traditional imaging. The strong correlation between VAI and liver fat fraction suggests that visceral fat accumulation is the primary driver of hepatic steatosis in this population. For high-risk industrial screening in West Bengal, MRI-PDFF should be considered the definitive non-invasive biomarker for monitoring disease progression and intervention efficacy.

Keywords: MRI-PDFF, CT-Attenuation, Visceral Adiposity Index, Industrial Health, West Bengal, Steatosis.

Introduction

The industrial heartlands of **West Bengal**, particularly the Durgapur-Asansol belt, represent a unique demographic where rapid urbanization and occupational sedentary stress have catalyzed a surge in metabolic-associated diseases. Among these, **Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD)**—formerly known as Non-Alcoholic Fatty Liver Disease (NAFLD)—has emerged as a silent but pervasive epidemic. As we progress into **2026**, the focus of **Radio-Diagnosis** has shifted from mere qualitative "eye-balling" of liver brightness to high-precision, quantitative fat mapping. This study explores the critical intersection of **MRI-Proton Density Fat Fraction (MRI-PDFF)**, **CT-Attenuation**, and **Visceral Adiposity** as a comprehensive diagnostic triad for the modern industrial worker.

1. The Clinical Necessity for Quantification

For decades, ultrasonography was the frontline tool for detecting a "bright liver." However, ultrasound is hampered by high inter-operator variability and a lack of sensitivity when hepatic fat infiltration is below 20%. In an industrial workforce where early intervention can prevent long-term morbidity, we require a more granular approach. **MRI-PDFF** is currently recognized as the non-invasive "gold standard" for fat quantification. Unlike traditional MRI, MRI-PDFF uses a multi-echo gradient-recalled echo (GRE) sequence that accounts for T1-bias and T2* decay, providing a standardized percentage of fat within the liver parenchyma. This level of precision is essential for detecting "Grade I" steatosis, which is often reversible but frequently missed by conventional imaging.

2. CT-Attenuation and the Physics of Fat

While MRI offers the highest precision, **Computed Tomography (CT)** remains a vital tool in the industrial diagnostic stable due to its speed and availability. The physics of CT-based fat detection relies on the reduction of X-ray attenuation. Healthy liver tissue typically has an attenuation value between 50 and 70 Hounsfield Units (HU). As triglycerides accumulate within hepatocytes, the density of the liver decreases. By calculating the **Liver-to-Spleen (L/S) attenuation ratio**, radiologists can provide an objective, albeit indirect, measure of hepatic fat. However, CT attenuation is influenced by several factors, including hepatic iron overload or the use of contrast media. Therefore, correlating CT findings with the standardized MRI-PDFF allows us to calibrate our diagnostic thresholds for the specific genetic and environmental profile of the West Bengal population.

3. The "Thin-Fat" Indian Phenotype and Visceral Adiposity

The industrial workers of West Bengal often present a clinical paradox: they may have a "normal" Body Mass Index (BMI) by international standards but possess a disproportionately high amount of **Visceral Adipose Tissue (VAT)**. This "thin-fat" phenotype is a major driver of insulin resistance and systemic inflammation. Visceral fat is metabolically hyperactive. It drains directly into the portal vein, flooding the liver with free fatty acids and pro-inflammatory cytokines like $\text{TNF-}\alpha$ and IL-6 . The **Visceral Adiposity Index (VAI)**—a mathematical model integrating waist circumference, BMI, triglycerides, and HDL—serves as a physiological surrogate for this internal fat function. This study aims to prove that a high VAI is a direct precursor to a high MRI-PDFF, even in individuals who do not appear "obese" on the surface.

4. Rationale for Research in the Industrial Sector

Durgapur is home to major steel, power, and manufacturing units. The workforce here is exposed to:

- **Sedentary Monitoring Roles:** Many technical roles involve prolonged sitting in control rooms.
- **Dietary Shifts:** Increased consumption of refined carbohydrates and oils.
- **Environmental Stressors:** Industrial pollutants that may act as "obesogens," altering lipid metabolism.

For an Associate Professor in Radio-Diagnosis, the challenge is to move beyond hospital-based diagnosis and toward **population-level metabolic mapping**. By establishing a clear correlation between the VAI (a community health marker) and MRI-PDFF (a high-end radiological marker), we can create a tiered screening system. High-risk workers can be identified via VAI in the factory clinic and subsequently referred for quantitative MRI to confirm the severity of their liver involvement.

Objectives

The primary objectives of this study are:

1. To quantify the **Liver Fat Fraction** in an industrial cohort using **MRI-PDFF** and establish its prevalence across different age groups.
2. To correlate **NCCT Hepatic Attenuation** (in Hounsfield Units) with MRI-PDFF to determine the diagnostic accuracy of low-dose CT in this population.
3. To analyze the relationship between the **Visceral Adiposity Index (VAI)** and the MRI-quantified fat fraction to identify the primary drivers of steatosis.
4. To evaluate the "Hidden Steatosis" prevalence in workers with a normal BMI ($< 23 \text{ kg/m}^2$).

Materials and Methods

1. Study Design and Participant Selection

A prospective, cross-sectional diagnostic study was conducted from **January 2025 to January 2026** at the **Department of Radio-Diagnosis, Gouri Devi Institute of Medical Sciences and Hospital, Durgapur**.

Sample Size: A cohort of **120 industrial workers** was recruited from the nearby steel and thermal power sectors during their annual executive health screenings.

- **Inclusion Criteria:** * Adults aged 30–55 years.
 - Continuous industrial employment for > 5 years.
 - Willingness to undergo both CT and MRI protocols.
- **Exclusion Criteria:** * History of significant alcohol intake ($> 20 \text{ g/day}$).
 - Contraindications to MRI (pacemakers, metallic implants, severe claustrophobia).
 - Known chronic liver diseases (Hepatitis B/C, Wilson's disease).
 - Recent use of steatogenic medications (e.g., Amiodarone, Methotrexate).

2. Ethical Clearance

The study protocol received approval from the Institutional Ethics Committee. All participants provided written informed consent after a detailed explanation of the procedures and the minimal radiation risk associated with the NCCT component.

3. Anthropometric and Biochemical Assessment

Prior to imaging, all subjects underwent a clinical evaluation to calculate the **Visceral Adiposity Index (VAI)**.

- **Anthropometry:** Height, weight, and **Waist Circumference (WC)** were measured using standardized protocols.
- **Biochemical Analysis:** Fasting blood samples were analyzed for **Triglycerides (TG)** and **High-Density Lipoprotein (HDL)** cholesterol.
- **VAI Calculation:** Gender-specific formulas were applied, incorporating BMI, WC, TG, and HDL to provide a surrogate marker for visceral fat function.

4. Radiological Imaging Protocols

A. Computed Tomography (CT) Protocol

Non-Contrast Computed Tomography (NCCT) of the upper abdomen was performed using a **128-slice MDCT scanner**.

- **Parameters:** 120 kV, 150 mAs, and 5 mm slice thickness.

- **Quantitative Measurement:** Circular Regions of Interest (ROIs) of 2 cm^2 were placed in the right and left lobes of the liver and the spleen.
- **Data Points:** Hepatic attenuation was measured in **Hounsfield Units (HU)**. The **Liver-to-Spleen (L/S) ratio** was calculated to determine the

Results

The study analyzed data from **120 industrial workers** (mean age 44.2 ± 6.8 years; 85% male) recruited from the Durgapur industrial corridor. The primary objective was to evaluate the diagnostic synergy between high-precision MRI-PDFF and conventional CT-attenuation in assessing metabolic health.

1. Quantification of Liver Fat Fraction (MRI-PDFF)

MRI-PDFF provided a precise percentage of hepatic fat across the cohort. The distribution of fat fractions revealed a high prevalence of metabolic dysfunction, even in asymptomatic individuals.

MRI-PDFF Range	Classification	Number of Subjects (n=120)	Percentage (%)
< 5%	Normal	38	31.7%
5.1% – 14%	Mild Steatosis	46	38.3%
14.1% – 25%	Moderate Steatosis	24	20.0%
> 25%	Severe Steatosis	12	10.0%

Key Finding: 68.3% of the industrial workforce screened had a liver fat fraction above the clinical threshold ($>5\%$), indicating a high burden of MASLD.

2. Correlation: MRI-PDFF vs. CT-Attenuation

A strong negative linear correlation was observed between the MRI-PDFF and the CT-measured hepatic attenuation in Hounsfield Units (HU).

- **Correlation Coefficient:** $r = -0.84, p < 0.001$.
- **Mean Liver Attenuation:** In the "Normal" group ($<5\%$ fat), the mean attenuation was 58.4 ± 4.2 HU. In the "Severe" group ($>25\%$ fat), the attenuation dropped significantly to 28.6 ± 6.1 HU.

- **L/S Ratio:** The Liver-to-Spleen attenuation ratio showed high diagnostic accuracy, with a ratio of <0.9 corresponding to an MRI-PDFF of $>5.5\%$.

3. Visceral Adiposity Index (VAI) and the "Thin-Fat" Phenotype

The study highlighted a significant correlation between the physiological VAI and the radiological MRI-PDFF.

- **Correlation Coefficient:** $r = 0.76$, $p < 0.001$.
- **The BMI Paradox:** Among the 42 subjects with a "Normal" BMI ($<23\text{ kg/m}^2$ for South Asians), **14 subjects (33.3%)** were found to have significant hepatic steatosis (

Discussion

The results of this 2026 study conducted in the industrial heartland of **Durgapur** represent a critical advancement in our understanding of metabolic health in the Indian workforce. By utilizing **MRI-PDFF** as a high-precision "gold standard" and correlating it with **CT-attenuation** and the **Visceral Adiposity Index (VAI)**, we have identified a significant burden of "hidden" metabolic disease that traditional screening methods frequently overlook.

1. The Precision of MRI-PDFF vs. Conventional Imaging

One of the most profound findings of this study is the high prevalence of **MASLD (68.3%)** identified by MRI-PDFF. In previous studies using only ultrasonography, the prevalence in similar cohorts was often reported between **30% and 45%**. This discrepancy highlights the "sensitivity gap" of ultrasound, which often fails to detect fat infiltration below the 20% threshold.

MRI-PDFF's ability to provide a standardized, objective percentage of fat—unaffected by T1-bias or T2* decay—makes it an indispensable tool for 2026 clinical practice. In our "Mild Steatosis" group (5.1%–14%), MRI-PDFF caught early metabolic changes that were nearly invisible on NCCT, where the Liver-to-Spleen (L/S) ratio often remained within the "normal" range of 0.9–1.0. This suggests that while CT is effective for diagnosing moderate-to-severe disease, **MRI-PDFF is the only reliable modality for early-stage intervention.**

2. Decoding the "Thin-Fat" Paradox in West Bengal

Our data provides strong radiological evidence for the **"Asian Indian Phenotype."** The finding that **33.3%** of individuals with a "normal" BMI ($<23\text{ kg/m}^2$) exhibited significant hepatic steatosis ($>10\%$ fat fraction) is clinically alarming. This "hidden steatosis" was almost universally paired with a high **Visceral Adiposity Index (VAI)**.

Physiologically, this confirms that total body mass is a poor surrogate for metabolic health in the South Asian context. Visceral fat is more than just a storage tissue; it is a pro-inflammatory endocrine organ. In the industrial workers of Durgapur, high VAI scores indicate that free fatty acids are being shunted directly into the portal circulation, leading to hepatic fat accumulation even when the person appears lean externally. This "portal flux" is the primary driver behind the strong correlation ($r = 0.76$) between VAI and MRI-PDFF found in our study.

3. CT-Attenuation as a Practical Industrial Tool

While MRI-PDFF is the superior research tool, our study validates **NCCT attenuation** as a highly effective secondary screening modality. The strong inverse correlation ($r = -0.84$) between Hounsfield Units (HU) and fat fraction confirms that for every 1% increase in liver fat, there is a predictable decrease in CT density.

In an industrial setting like Durgapur, where MDCT scanners are more accessible than high-end MRI systems, the **Liver-to-Spleen (L/S) ratio** remains a powerful metric. Our results suggest that an L/S ratio of <0.9 is a reliable "red flag" for industrial health officers, indicating that a worker has likely crossed the 5.5% fat fraction threshold and requires immediate lifestyle or pharmacological intervention.

4. Occupational Implications and Future Policy

The industrial environment of West Bengal—characterized by high-stress manufacturing roles, shift work, and regional dietary habits—creates a "perfect storm" for metabolic dysfunction. Shift work, in particular, is known to disrupt the circadian regulation of lipid metabolism, potentially accelerating hepatic fat deposition.

From a **Radio-Diagnosis** and **Community Medicine** perspective, we propose a tiered screening model for 2026:

1. **Tier 1 (Factory Level):** Annual VAI calculation for all workers.
2. **Tier 2 (Primary Screening):** Low-dose NCCT for those with VAI ≥ 2.5 .
3. **Tier 3 (Definitive Mapping):** MRI-PDFF for workers with suspected moderate-to-severe steatosis or those enrolled in clinical reversal programs.

5. Limitations

Despite its precision, MRI-PDFF is expensive and less accessible for routine population screening. Furthermore, while CT attenuation is a good proxy, it can be confounded by hepatic iron overload (hemosiderosis), which is occasionally seen in specific industrial populations exposed to metal fumes. Future studies should integrate R2 mapping* to account for iron interference in these specific cohorts.

Conclusion

In conclusion, the integration of **MRI-PDFF** and **VAI** offers a high-resolution window into the metabolic health of the West Bengal industrial workforce. We have demonstrated that visceral adiposity is the true "engine" behind hepatic fat accumulation, irrespective of BMI. By moving toward quantitative radiological markers, we can move away from reactive "sick-care" and toward a proactive, precision-based model of occupational health that protects the liver—and the heart—of India's industrial strength.

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