World Digestive Health Week: WDHW 2025



Anthropometric Indices and Body Composition



Azam Doustmohammadian, PhD in Nutrition,
Associate Professor,
Gastrointestinal and Liver Diseases Research Center (GILDRC),
Iran University of Medical Sciences (IUMS).

Foundational Anthropometric Measurements

Basic Measurements

Height, weight, and circumferences (waist, hip, limbs) form the foundation of anthropometric assessment. These simple yet powerful measurements provide initial screening data and longitudinal tracking capabilities.

Skinfold Measurements

Calipers measure subcutaneous fat at standardized sites (triceps, subscapular, suprailiac, etc.). While operator-dependent, proper technique yields valuable estimates of regional fat distribution.

Derived Indices

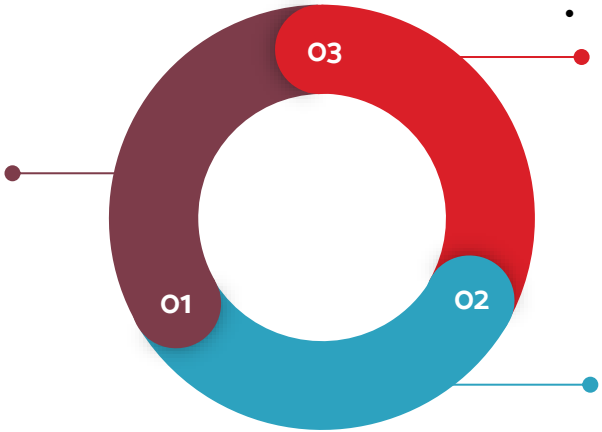
Mathematical calculations including BMI, waist-to-hip ratio, and waist-to-height ratio provide clinically relevant risk stratification metrics correlated with metabolic health outcomes.

Wu et al., *International journal of environmental research and public health*. 2024;21(6):757.

Body Mass Index: Applications and Limitations

Clinical utility

- BMI provides a rapid population-level screening tool correlating with certain health outcomes and mortality risks. Its simplicity enables widespread adoption in clinical practice and epidemiological research.
- Established reference ranges facilitate standardized risk classification across diverse healthcare settings with minimal resource requirements



Physiological limitations

- BMI fails to distinguish between fat, muscle, and bone mass, potentially misclassifying athletic individuals with high muscle mass or elderly persons with sarcopenia.
- Cannot assess regional fat distribution, particularly visceral adiposity, which carries a greater metabolic risk than subcutaneous fat.

Demographic considerations

- Significant ethnic and racial variations exist in body composition relative to BMI. Asian populations typically have higher body fat percentages at equivalent BMI values compared to Caucasian counterparts.
- Age and sex-specific adjustments are necessary for accurate interpretation across different demographic groups.

WHO WPRO, The Asia-Pacific Perspective, 2000
Wu et al., *International journal of environmental research and public health*. 2024;21(6):757.
Kivimäki et al., *The lancet Diabetes & endocrinology*. 2022;10(4):253-63.

Anthropometric indices & Health Risk Assessment

Index	Formula/Measurement method
Body Mass Index (**BMI**)	BMI = Weight (kg) / Height $(m)^2$
Waist Circumference (**WC**)	Directly measured
Waist-to-Hip Ratio (**WHR**)	WHR = WC / HC
Waist-to-Height Ratio (**WHtR**)	WHtR = WC / Height
Conicity Index (**CI**)	$CI = WC / (0.109 \times \sqrt{(Weight / Height)})$
Abdominal Volume Index (**AVI**)	$AVI = [2 \times WC^2 + 0.7 \times (WC - HC)^2] / 1000$
Sagittal Abdominal Diameter (**SAD**)	Direct or 3D scan
A Body Shape Index (**ABSI**)	$ABSI = WC / (BMI^{(2/3)} \times Height^{(1/2)})$
Body Roundness Index (**BRI**)	$BRI = 364.2 - 365.5 \times \sqrt{(1 - (WC / (2\pi \times Height))^2)}$
Neck Circumference (**NC**)	Directly measured
Transverse Abdominal Diameter (**TAD**)	Directly measured or via 3D
Sagittal-Transverse Ratio (**STR**)	STR = SAD / TAD
Weight-Adjusted Waist Index (**WWI**)	WWI = WC (cm) / √Weight (kg)
Tri-Ponderal Mass Index (**TMI**)	TMI = Weight (kg) / Height $(m)^3$

Definitions: Conicity Index (**CI**): Describes trunk conicity related to abdominal obesity**;** Sagittal Abdominal Diameter (**SAD**): Distance from back to upper abdomen in supine position; Abdominal Volume Index (**AVI**): Estimates abdominal volume from WC and HC; A Body Shape Index (**ABSI**): Combines WC, BMI and height; Body Roundness Index (**BRI**): Estimates body roundness based on WC and height; Neck Circumference (**NC**): Neck girth related to upper body fat; Transverse Abdominal Diameter (**TAD**): Horizontal distance of abdomen width; Sagittal-Transverse Ratio (**STR**); Ratio of sagittal to transverse abdominal diameter; Weight-Adjusted Waist Index (**WWI**): Waist circumference adjusted for weight; used for fat-muscle distribution.

Piqueras, et al., *Front. Psychol*. (2022); 12:631179. doi: 10.3389/fpsyg.2021.631179
Tang et al., *Frontiers in Cardiovascular Medicine*. 2024;11:1341476.

Established Indices with Validated Classification and Clinical Utility

- Body Mass Index **(BMI)**
- Waist Circumference (**WC**)
- Waist-to-Hip Ratio (**WHR**)
- Waist-to-Height Ratio (**WHtR**)
- Conicity Index (**CI**)
- Sagittal Abdominal Diameter (**SAD**)
- Abdominal Volume Index (**AVI**)
- A Body Shape Index (**ABSI**)
- Body Roundness Index (**BRI**)
- Tri-Ponderal Mass Index (**TMI**)

Emerging Indices Under Investigation for Clinical Application

- Neck Circumference (**NC**)
- Transverse Abdominal Diameter (**TAD**)
- Sagittal-Transverse Ratio (**STR**)
- Weight-Adjusted Waist Index (**WWI**)

Piqueras, et al., *Front. Psychol*. (2022); 12:631179. doi: 10.3389/fpsyg.2021.631179

Composite Metabolic Indices & Associated Diseases

Index	Formula/Measurement method	Classification	Associated diseases
Visceral Adiposity Index (**VAI**)	VAI = [WC / (39.68 + (1.88 × BMI))] × (TG / 1.03) × (1.31 / HDL)	Yes	Type 2 diabetes, CVD, NAFLD, all-cause mortality
Visceral/Subcutaneous Fat Ratio (**VSR**)	VSR = VAT / SAT	Emerging	CVD, type 2 diabetes, NAFLD, increased mortality
Lipid Accumulation Product (**LAP**)	LAP = (WC - 65) × TG [men], (WC - 58) × TG [women]	Yes	Type 2 diabetes, metabolic syndrome, NAFLD, CVD
Waist-Triglyceride Index (**WTI**)	WTI = WC × TG	Emerging	CVD, type 2 diabetes, NAFLD, chronic kidney disease (CKD)
Visceral Obesity Index (**VOI**)	Sex-specific formula involving WC, BMI, TG, HDL	Yes	Metabolic syndrome, type 2 diabetes, CVD
Triglyceride-Glucose Index (**TyG Index**)	TyG = ln [TG (mg/dL) × Glucose (mg/dL)/2]	Yes	Type 2 diabetes, CVD, ischemic stroke, CKD
Thin Outside, Fat Inside (**TOFI**)	No standard formula; typically identified using MRI, CT, or DXA to assess visceral fat in normal-BMI individuals.	Emerging	Type 2 diabetes, metabolic syndrome, CVD

- **VAI**: Estimates visceral fat using lipids and WC.
- **VSR**: Ratio between visceral and subcutaneous fat volumes.
- **LAP**: Product of WC and triglycerides; predicts metabolic syndrome.
- **WTI**: Combined index using waist and triglycerides.
- **VOI**: Estimates visceral fat using anthropometric and lipid measures.
- **TyG Index**: Insulin resistance marker based on fasting TG and glucose.
- **TOFI**: Phenotype characterized by normal BMI but high internal/visceral fat, undetectable through conventional anthropometry.

Zhang et al., *Frontiers in endocrinology*. 2023;13:1036146.
Czeczelewski et al., *Obesity Medicine*. 2020;17:100171.

Body Composition Indices & Associated Diseases

- **Body Fat Percentage (BFP)**= (FM / Body Mass) × 100

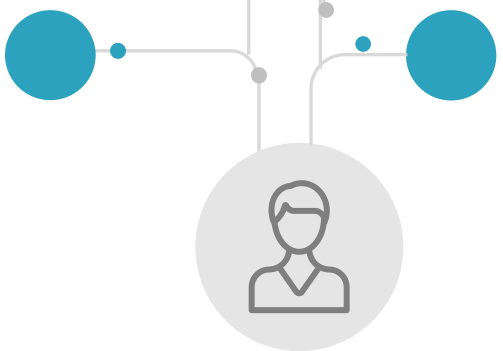
Classification: Yes
Associated Diseases: diabetes, hypertension, metabolic syndrome, CVDs

- **Fat Mass (FM)** = Body Mass × (BFP / 100)

Classification: Yes
Associated Diseases: diabetes, CVDs, metabolic syndrome, depression

- **Fat Mass Index (FMI)**= FM (kg) / Height²

Classification: Yes
Associated Diseases: diabetes, metabolic syndrome, CVDs



- **Normal Weight Obesity (NWO)=** BMI 18.5–24.9 + High BFP (>30% women, >25% men)

Classification: Yes
Associated Diseases: diabetes, metabolic syndrome, CVDs

- **Fat Free Mass Index (FFMI)** = FFM (kg) / Height²

Classification: Yes
Associated Diseases: diabetes, hypertension, metabolic syndrome, CVDs

BFP: Percent of total fat mass;
FMI: Fat mass normalized for height;
FFMI: Lean mass normalized for height.
FM: Total mass of all fat tissue in the body.

Zhang et al., *Frontiers in endocrinology*. 2023;13:1036146.
Czeczelewski et al., *Obesity Medicine*. 2020;17:100171.

Body Composition Indices & Associated Diseases (Cont.)

Index	Formula/Measurement method	Classification	Associated Diseases
Visceral Adipose Tissue Area (**VATA**)	Estimated from 3D or DXA	Emerging	CVDs, diabetes, hypertension, breast & colorectal cancer
Primary Shape and Shape Tendency (**PS&ST**)	3D scan algorithms	Emerging	Cardiometabolic disorders, metabolic syndrome, insulin resistance
Trunk Fat (**TF**)	Derived from imaging or 3D	Limited	CVDs, diabetes mellitus, metabolic complications
Trunk Fat Percentage (**TFP**)	TFP = Trunk Fat / Total Fat × 100	Limited	Atrial fibrillation, hemorrhagic stroke
Body Volume Index (**BVI**)	3D imaging algorithm output	Emerging	Central obesity, CVDs, stroke, diabetes
Subcutaneous Adipose Tissue Area (**SATA**)	From imaging (MRI/3D)	Emerging	NAFLD, insulin resistance, chronic inflammation
Leg Fat Mass Percentage (**LFM%**)	LFM% = Leg Fat Mass / Total Fat Mass × 100	Emerging	Metabolic syndrome, insulin resistance (inverse association)

VATA: Area of visceral fat usually assessed via imaging.
PS&ST: Global shape estimation based on 3D geometry;
TF: fat mass in the trunk region.
TFP: Proportion of fat in the trunk area relative to body fat;
BVI: 3D-based index reflecting fat distribution and body volume;
SATA: fat tissue area under the skin.

Zhang et al., *Frontiers in endocrinology*. 2023;13:1036146.
Czeczelewski et al., *Obesity Medicine*. 2020;17:100171.

Exploring Body Composition Analysis

- Dual-Energy X-ray Absorptiometry (DXA)

Gold standard for measuring bone mineral density, fat mass, and lean mass with high precision. Provides regional body composition data but requires specialized equipment.

- Bioelectrical Impedance Analysis (BIA)

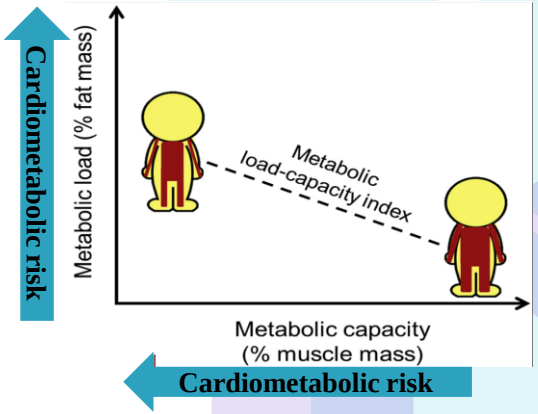
Measures electrical impedance through body tissues to estimate fat and lean mass. Portable and non-invasive, though accuracy can be affected by hydration status.

- Computed Tomography (CT)

Offers detailed cross-sectional imaging to quantify visceral fat, subcutaneous fat, and muscle quality. Provides excellent tissue differentiation but involves radiation exposure.

Body composition analysis delves deeper into internal physiology, quantifying the relative proportions of fat mass, lean mass, muscle mass, and bone mineral content. These assessments provide a more granular view of body structure, enabling clinicians to differentiate between metabolically active tissues.

Understanding Load-Capacity Indices (LCIs): Concept and Clinical Relevance



Fat Mass / Fat-Free Mass (FM/FFM) $\frac{\text{Fat Mass (kg)}}{\text{Fat-Free Mass (kg)}} = \text{FM/FFM}$

- Most widely used LCI; predictive of MetS, insulin resistance, and dyslipidemia

Fat Mass / Muscle Mass (FM/MM) $\frac{\text{Fat Mass (kg)}}{\text{Muscle Mass (kg)}} = \text{FM/MM}$

- Used to detect sarcopenic obesity and all-cause mortality

Trunk Fat Mass / Appendicular Skeletal Muscle Mass (TrFM/ASM $\frac{\text{Trunk Fat Mass (kg)}}{\text{ASM (kg)}} = \text{TrFM/ASM}$

- Segmental LCI; strong indicator of visceral fat burden and metabolic dysfunction

Fat Mass / Lean Mass (FM/LM) $\frac{\text{Fat Mass (kg)}}{\text{Lean Mass (kg)}} = \text{FM/LM}$

- Associated with metabolic syndrome, insulin resistance, and cognitive decline

Guan et al., *Advances in Nutrition*. 2025:100364.
Gätjens et al., *Obesity Facts*. 2021;14(6):593-603.
Orsso et al., *Pediatric Obesity*. 2024;19(3):e13098.

Advanced Load-Capacity Indices: Precision Tools for Metabolic Risk Assessment

Visceral Fat Area / Skeletal Muscle Area (VFA/SMA)

$$\frac{\text{Visceral Fat Area (cm}^2\text{)}}{\text{Skeletal Muscle Area (cm}^2\text{)}} = \text{VFA/SMA}$$

- Used in CT-based analysis of metabolic risk and NAFLD

Appendicular Muscle Mass / Trunk Fat Mass (ASM/TrFM)

$$\frac{\text{ASM (kg)}}{\text{Trunk Fat Mass (kg)}} = \text{ASM/TrFM}$$

- Inverse of TrFM/ASM; higher values indicate better metabolic capacity

Fat Mass Index / Fat-Free Mass Index (FMI/FFMI)

$$\frac{\text{FM (kg/m}^2\text{)}}{\text{FFM (kg/m}^2\text{)}} = \text{FMI/FFMI}$$

- Indexed LCI for standardized assessments across body sizes

Paraspinal or Thigh Muscle Area / Visceral Fat Area (PMA/VFA, TMA/VFA)

$$\frac{\text{Thigh Muscle Area (cm}^2\text{)}}{\text{VFA (cm}^2\text{)}} = \text{TMA/VFA}$$

- Emerging in advanced imaging studies; linked to CVD and diabetes risk

Guan et al., *Advances in Nutrition*. 2025:100364.
Gätjens et al., *Obesity Facts*. 2021;14(6):593-603.
Orsso et al., *Pediatric Obesity*. 2024;19(3):e13098.

Integrative Approaches to Risk Assessment

❑ Basic Anthropometric Screening

Initial assessment using BMI, waist circumference, and other accessible measures to identify potential risk categories.

❑ Targeted Body Composition Analysis

For individuals with concerning anthropometric profiles, employ more detailed body composition assessment to quantify fat and muscle distribution.

❑ Integrated Risk Stratification

Combine findings from both modalities to create a comprehensive risk profile that accounts for both structural and functional aspects of body composition.

- An **integrated approach** that combines both anthropometric and body composition modalities is now favored for comprehensive risk assessment. This stepwise methodology allows for efficient resource allocation while ensuring that high-risk individuals receive appropriate detailed evaluation.

- Recent innovations such as **load-capacity indices (LCIs)**, which express the **ratio of fat-derived metabolic load to lean-derived functional capacity**, have emerged as powerful tools to bridge the gap between simple measurements and complex physiological relationships.

Reviews
new studies

Advances in Nutrition 16 (2025) 100364

Advances in Nutrition
AN INTERNATIONAL REVIEW JOURNAL
journal homepage: https://advances.nutrition.org/

Review

Beyond Traditional Body Composition Metrics: Load-Capacity Indices Emerge as Predictors of Cardiometabolic Outcomes—A Systematic Review and Meta-Analysis

Zhongyang Guan [1,*,†], Marianna Minnetti [2,†], Steven B Heymsfield [3], Eleonora Poggiogalle [2], Carla M Prado [4], Marc Sim [5,6], Blossom CM Stephan [7], Jonathan CK Wells [8], Lorenzo M Donini [2], Mario Siervo [1,7]

Conceptual Model	**Load-Capacity Model of body composition:** Ratio of metabolic load (fat mass) to metabolic capacity (lean mass)
Anthropometric indices/ Body composition	**Load-Capacity Indices (LCIs), including:** FM/FFM, FM/MM, TrFM/ASM, FM/LM, VFA/SMA, and ASM/FM
Assessment technique	Bioelectrical Impedance Analysis (BIA), Dual-energy X-ray Absorptiometry (DXA), Computed Tomography (CT), Air Displacement Plethysmography (ADP), Ultrasound (US)
Outcome	Sarcopenic Obesity (SO), Metabolic Syndrome (MetS), type 2 diabetes, cardiovascular diseases (CVDs), insulin resistance, NAFLD, mortality, cognitive function, bone mineral density, physical function and limitation, inflammation (CRP)
Key findings	Higher values of LCIs, such as FM/FFM, FM/MM, and TrFM/ASM, were significantly associated with increased odds of cardiometabolic disorders, including metabolic syndrome (OR = 4.24), type 2 diabetes (OR = 1.64), and overall cardiometabolic risk (pooled OR = 2.22). The estimated pooled prevalence of Sarcopenic Obesity (SO) identified by LCIs was 14.5%.

Guan et al., *Advances in Nutrition*. 2025:100364.

American Journal of Preventive Cardiology 21 (2025) 100936

Contents lists available at ScienceDirect

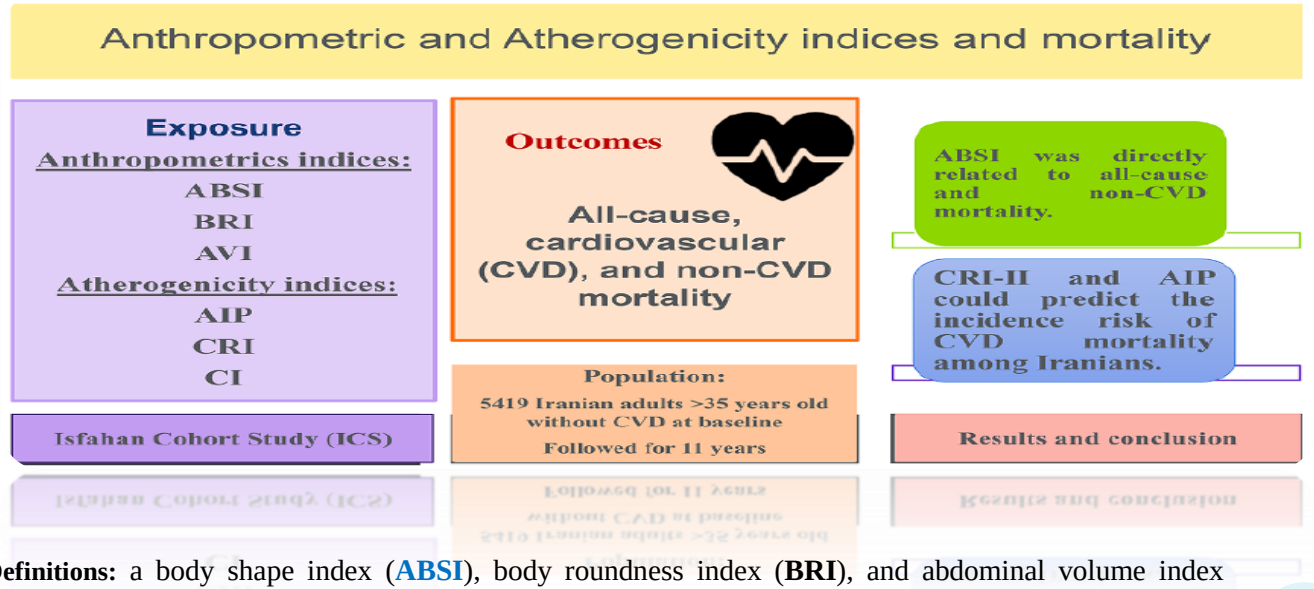
American Journal of Preventive Cardiology

journal homepage: www.journals.elsevier.com/american-journal-of-preventive-cardiology

Original Research

Comparing the association of novel Anthropometric and atherogenicity indices with all-cause, cardiovascular and non-cardiovascular mortality in a general population of Iranian adults

Parisa Hajihashemi [a,†], Noushin Mohammadifard [b,†], Motahare Bateni [b], Fahimeh Haghighatdoost [c,*], Maryam Boshtam [c], Jamshid Najafian [d], Masoumeh Sadeghi [e], Niloufar Shabani [e], Nizal Sarrafzadegan [e]



Definitions: a body shape index (**ABSI**), body roundness index (**BRI**), and abdominal volume index (**AVI**), and three atherogenicity indices: atherogenic index of plasma (**AIP**), Castelli risk index (**CRI**), and the cholesterol index (**CI**)

Hajihashem et al., *American Journal of Preventive Cardiology*. 2025;21:100936.

scientific reports

OPEN

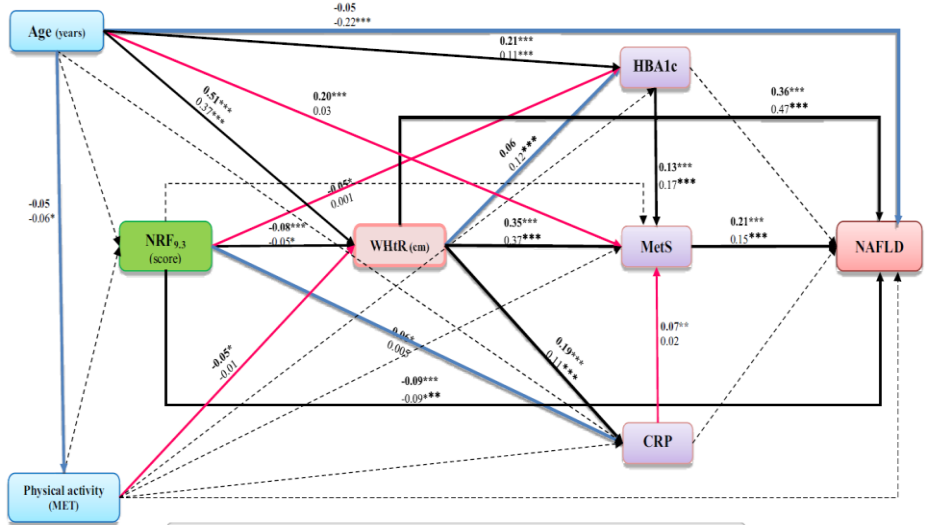
Path analysis model to identify the effect of poor diet quality on NAFLD among Iranian adults from Amol Cohort Study

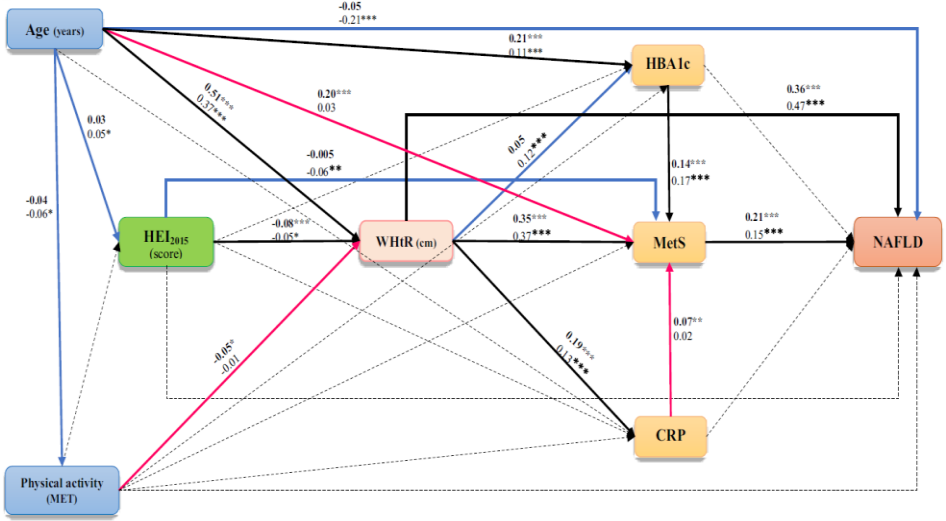
Azam Doustmohammadian[1], Bahareh Amirkalali[1], Barbora de Courten[2], Saeed Esfandyari[3], Nima Motamed[4], Mansooreh Maadi[1], Hossein Ajdarkosh[1], Esmaeel Gholizadeh[1], Samira Chaibakhsh[1] & Farhad Zamani[1]✉

Final study population eligible for analysis (n 2956)

Data	**Physical activity & Dietary Index assessments** validated international physical activity questionnaire (IPAQ) & validated semi-quantitative food-frequency questionnaire-168 item (FFQ-168item)	**Anthropometric & Clinical assessment** BMI, WHtR, WC, HbA1c, FBS, CRP, TG, TC, HDL, LDL, DBP, SBP, ALT, AST, GGT, ALKP
Data Reduction	Nutrient Rich Food 9.3 score ($NRF_{9.3}$) Healthy Eating Index 2015 (HEI_{2015})	
Data Analysis	Nutrient Density and Healthy Eating Index to predict NAFLD by sex using SEM	

Males
Females
Total





Doustmohammadian et al., *Scientific Reports*. 2024;14(1):19935.

Clinical Implications and Future Directions

Enhanced Risk Prediction

LCIs offer superior cardiometabolic risk assessment compared to traditional metrics like BMI alone, potentially improving early identification of high-risk individuals.

Standardized Clinical Guidelines

Future research should focus on establishing standardized thresholds and clinical guidelines for implementing LCIs in routine healthcare settings.

Integration with Advanced Technologies

Combining LCIs with 3D body scanning and AI-driven analysis could revolutionize population-level screening and personalized health monitoring.

From waist circumference to muscle-fat ratios, the evolution of metrics must parallel the sophistication of our approach to digestive and metabolic health.

Thank you for your attention

Azam Doustmohammadian, MSPH, Ph.D. in Nutrition
Associate Professor,
Gastrointestinal and Liver Diseases Research Center, Iran University of Medical Sciences.
Email:
doost_mohammadi@yahoo.com,
mohammadian.az@iums.ac.ir
Gmail:
doustmohamady@gmail.com
ORCID: 0000-0001-6249-2520

