Monitor 30+ health metrics through a face scan using any camera

A non-contact, camera-based approach to real-time health monitoring

Introduction

Shen AI is a software-based health monitoring solution that uses standard cameras and computer vision techniques to extract clinically relevant physiological signals.
This document outlines the metrics available through Shen AI's SDK, accompanied by standard definitions and contextual notes. All measurements are contactless and captured via a 30-second face scan, without the need for traditional medical equipment or wearables.

Measurement methodology

Shen AI utilizes camera-based signal acquisition to extract physiological parameters without physical contact. The system combines two complementary remote sensing methods:

Remote Photoplethysmography (rPPG)
rPPG estimates blood volume pulse by detecting subtle variations in skin color caused by the pulsatile flow of blood. These changes are extracted from video frames captured under ambient light conditions using standard cameras.

Remote Ballistocardiography (rBCG)
rBCG measures micro-movements of the head induced by cardiac ejection. These subtle tilts, typically imperceptible to the human eye, are captured and analyzed for timing-based characteristics that reflect underlying cardiovascular activity, such as heart rate, variability between beats, and mechanical pulse dynamics.

Signal quality is assessed in real time, and preprocessing is applied to reduce the influence of motion, lighting variation, and noise. Proprietary algorithms extract temporal and frequency features, which are then used to estimate physiological metrics via machine learning models trained on clinically validated datasets.

All computations are performed locally on the device, ensuring compliance with data privacy standards and eliminating the need for cloud transmission or video storage.

Health metrics

Heart Rate (HR)

number of heartbeats per minute (bpm), reflecting the heart's activity and overall cardiovascular function. It is a fundamental physiological parameter influenced by various factors, including age, fitness level, stress, medications, and overall health.

We estimate heart rate by analyzing changes in light reflection from the skin, which are caused by blood volume variations with each heartbeat.

In adults, a normal resting heart rate typically ranges between **60–100 bpm**, with lower values generally indicating better cardiovascular efficiency. However, a resting HR above **80 bpm** has been associated with an increased risk of cardiovascular diseases.

HR can fluctuate throughout the day due to physical activity, emotions, or autonomic nervous system regulation. While a consistently low or high HR may be normal for some individuals, significant deviations from typical ranges can signal potential health concerns and should be evaluated in a clinical context.

Heart Rate Variability (HRV)

measures the variation in time intervals between consecutive heartbeats, reflecting the current state of the heart and the autonomic nervous system. Here, we assess HRV using the **SDNN** index (Standard Deviation of Normal-to-Normal Interbeat Intervals), a widely recognized indicator of autonomic regulation.

In general, **higher HRV is associated with better adaptability and cardiovascular health**, while lower HRV suggests reduced autonomic flexibility and is considered an independent risk factor for cardiovascular events and mortality. *High HRV in populations is related to good health, low stress levels, and low risk of sudden death and it is a useful measure of positive adaptation, performance, and outcomes (Kubota et al., 2017). On the contrary, low HRV is associated with decreased physical fitness, high stress levels, increased risk of cardiovascular and neurodegenerative diseases, and poor adaptations (Souza et al., 2021).*

However, HRV is influenced by several factors, including **age, gender, time of day, lifestyle, and fitness level,** meaning there is no universal "normal" range for HRV values, including SDNN.

In general, HRV is influenced by several factors and frequently shows very high inter- and intraindividual variability, thus limiting its large use in clinical practice as a diagnostic and or prognostic biomarker.
The broad diffusion of HRV into the clinical practice is hindered by the absence of standardized cutoff values for HRV measures. Establishing clinical decision limits requires a thorough understanding of the biological variability of HRV, which is notably high due to a wide number of physiological, such as food intake, exercise, body position (supine or standing), and time of the day (Hayano et al., 2001, Hayano et al., 1990), and pathological conditions, even at subclinical stages.

It's also important to note that SDNN values depend on the duration of measurement. The HRV results obtained from this 1-minute measurement should not be directly compared with results from longer or shorter recordings, as measurement duration significantly impacts the outcome.

To track HRV trends effectively, it's best to compare readings taken at the same time of day. HRV typically peaks in the early morning (around 6–7 AM) and reaches its lowest levels in the early evening. A drop in HRV compared to your usual values may indicate fatigue, stress, poor fitness, or overtraining. You can work on improving your HRV by focusing on better sleep, recovery, and regular physical activity.

Main resource:
1. Olivieri F, Biscetti L, Pimpini L, Pelliccioni G, Sabbatinelli J, Giunta S. Heart rate variability and autonomic nervous system imbalance: Potential biomarkers and detectable hallmarks of aging and inflammaging. Ageing Res Rev. 2024 Nov;101:102521. doi: 10.1016/j.arr.2024.102521. Epub 2024 Sep 27. PMID: 39341508.

Breathing Rate (BR)

frequency of respiratory cycles, expressed in breaths per minute (bpm). Respiration is monitored by detecting chest or upper body movements during breathing, or by analyzing subtle variations in skin color associated with oxygenation and blood flow. Breathing rate is estimated using spectral analysis by selecting the signal with the most distinct peak within the 0.1–0.5 Hz range (6–30 breaths per minute), ensuring it represents a true peak rather than a slight variation from neighboring values.

Normal ranges for breathing rate:

- Adults: 12–20 bpm
- Adults over 65 years: 12–28 bpm
- Adults over 80 years: 10–30 bpm

The Stress Index (SI)

is a metric derived from heart rate variability (HRV) analysis, reflecting the overall state and functional reserve of cardiovascular regulatory systems, particularly the balance between the sympathetic and parasympathetic branches of the autonomic nervous system.
SI is calculated using a modified version of Baevsky's method, which analyzes the distribution of heartbeat intervals rather than relying solely on traditional statistical measures. This approach incorporates quartile-based dispersion measures and the overall shape of the histogram of interbeat intervals.
The Stress Index is scaled from **0 to 10**, with values between **0 and 4 considered normal**. Mild emotional or physical stress may cause a moderate increase, while significant stress can lead to much higher values:

- Values above 5 may indicate a high level of stress, often linked to severe psycho-emotional strain, overwork, or cardiovascular dysfunction.
- Values above 9 may suggest a critical state, potentially indicating a preinfarction condition.

It's important to note that both the Stress Index and the subjectively perceived level of stress are highly individual, varying based on personal physiological and psychological factors.

Parasympathetic Activity (PA)

a measure of parasympathetic nervous system activity based on spectral analysis of heart rate variability (HRV).
It is calculated as follows:

1. **Signal Processing** – The RR interval tachogram is low-pass filtered (up to 0.4 Hz) to remove high-frequency noise.
2. **Spectral Analysis** – Power spectral density (PSD) is computed, and power is extracted from two frequency bands:
    - **Low Frequency** (LF): 0.04–0.15 Hz
    - **High Frequency** (HF): 0.1–0.4 Hz
3. **PA Calculation** – The relative contribution of HF power (associated with parasympathetic activity) to the total power in both bands: **HF / (LF + HF) × 100%**

PA reflects the dominance of parasympathetic modulation in heart rate control, with higher values indicating greater parasympathetic influence.

Several studies demonstrated age- and gender-related variations in long-term HRV, assessed by means of a 24-hour ECG, reporting that autonomic activities diminish with age in both genders and that gender-related variation in parasympathetic regulation decreases during aging (Porta et al., 2001, Voss et al., 2015). (...) the aging process appears to dramatically influence the autonomic nervous system

activity. Indeed, heart rate (HR), HRV, and ANS modulation are all profoundly affected by age, even in the absence of disease, consistent with the idea that aging itself is a disease (Lakatta, 2015).

Main resource:

1. Olivieri F, Biscetti L, Pimpini L, Pelliccioni G, Sabbatinelli J, Giunta S. Heart rate variability and autonomic nervous system imbalance: Potential biomarkers and detectable hallmarks of aging and inflammaging. Ageing Res Rev. 2024 Nov;101:102521. doi: 10.1016/j.arr.2024.102521. Epub 2024 Sep 27. PMID: 39341508.

Cardiac workload

is calculated as the product of heart rate and systolic blood pressure (measured in mmHg/s), also known as the **rate-pressure product (RPP)** —a key indicator of cardiac oxygen consumption. The higher the systolic arterial blood pressure, the harder the heart must work to eject a given amount of blood with each heartbeat. Similarly, at higher heart rates, cardiac oxygen demand increases, even if the work performed per heartbeat remains unchanged, as the cardiac muscles consume more oxygen during their excitation-contraction processes.

A **lower heart rate and systolic blood pressure reduce the overall stress on the heart**, while higher values indicate increased cardiac demand. The normal range for cardiac workload is **90–216 mmHg/s**, derived from standard reference values for heart rate and systolic blood pressure.

Resources:

1. Hetzenecker A, Buchner S, Greimel T, Satzl A, Luchner A, Debl K, et al. Cardiac workload in patients with sleep-disordered breathing early after acute myocardial infarction. Chest. 2013;143:1294-301.
2. Westerhof N. Cardiac work and efficiency. Cardiovasc Res. 2000;48:4-7.
3. Baller D, Bretschneider HJ, Hellige G. Validity of myocardial oxygen consumption parameters. Clin Cardiol. 1979;2:317-27.
4. Kitamura K, Jorgensen CR, Gobel FL, Taylor HL, Wang Y. Hemodynamic correlates of myocardial oxygen consumption during upright exercise. J Appl Physiol. 1972;32:516-22.

Blood pressure

is the force per unit area exerted by circulating blood on the walls of arteries, expressed in millimeters of mercury (mmHg). It is defined by two values: systolic blood pressure (SBP), which represents the maximum arterial pressure during left ventricular systole, and diastolic blood pressure (DBP), which corresponds to the minimum arterial pressure during diastole, when the heart relaxes and refills with blood. BP is a critical parameter in cardiovascular health, influenced by factors such as vascular resistance, cardiac output, autonomic regulation, and individual health conditions.

Our method for estimating blood pressure primarily relies on pulse wave analysis (PWA), which focuses on the morphology of the pulse waveform extracted from facial video. Subtle variations in the shape, amplitude, and timing of the waveform provide key insights for BP prediction. This approach, based on empirical correlations observed in population data, supports non-invasive estimation without requiring direct physical contact.
We also analyze pulse wave velocity (PWV) using pulse transit time (PTT), which refers to the time it takes for the arterial pulse to travel between two points. This is indirectly inferred from facial scans. Changes in facial skin color, heart rate, and pulse are analyzed to compute systolic and diastolic BP values without the need for traditional cuff measurements. Shen.AI 's approach leverages Multi-Tonal Sensing (MTS) technology, making it possible to measure BP across various lighting conditions, minor head movements, and diverse skin tones, ensuring a camera-based solution for BP monitoring.

2024 ESC Guidelines on BP Classification
The 2024 ESC guidelines have updated the BP classification to support more accurate diagnosis and management:

- Normal BP (Non-elevated): SBP 90–120 mmHg, DBP 60–70 mmHg
- Elevated BP: SBP 121–135 mmHg, DBP 71–85 mmHg
- Hypertension: SBP ≥135 mmHg, DBP ≥85 mmHg

These values are used to guide treatment decisions and monitor patient outcomes, with an emphasis on Home Blood Pressure Monitoring (HBPM) for a more reliable assessment.

Resource:
1. McEvoy JW, McCarthy CP, Bruno RM, Brouwers S, Canavan MD, Ceconi C, Christodorescu RM, Daskalopoulou SS, Ferro CJ, Gerdts E, Hanssen H, Harris J, Lauder L, McManus RJ, Molloy GJ, Rahimi K, Regitz-Zagrosek V, Rossi GP, Sandset EC, Scheenaerts B, Staessen JA, Uchmanowicz I, Volterrani M, Touyz RM; ESC Scientific Document Group. 2024 ESC Guidelines for the management of elevated blood pressure and hypertension. Eur Heart J. 2024 Oct 7;45(38):3912-4018. doi: 10.1093/eurheartj/ehae178. PMID: 39210715.

Body Mass Index (BMI)

a widely used method to assess an individual's body weight relative to their height. It is calculated by dividing a person's weight in kilograms by the square of their height in meters (kg/m^2). BMI provides a simple and effective way to categorize individuals into different weight ranges: underweight, normal weight, overweight, or obese. It is commonly used as an indicator of potential health risks related to body weight, such as cardiovascular diseases, diabetes, and metabolic disorders.

BMI Categories:

- Underweight: BMI < 18.5
- Normal weight: BMI 18.5–24.9
- Overweight: BMI 25–29.9
- Obesity: BMI ≥ 30

We estimate BMI using facial scans, leveraging advanced image processing algorithms to analyze facial features and proportions that correlate with body mass index.

Wellness Score 2.0

Wellness Score 2.0 calculates the user's wellness score using their physiological data averaged over a historical time window, making it stable and reliable across day-to-day fluctuations.

Key health metrics are averaged across your stored measurement history. Only valid readings are included, and the score begins calculating once at least two data points are available.

The score will indicate the time range it's based on (for example, "Average of the last 7 days"), giving the user transparency into how it was calculated. The user's personal profile information always reflects your current details. Wellness Score takes into account:

Physiological metrics:

- Heart Rate (HR)
- Heart Rate Variability (HRV)
- Breathing Rate (BR)
- Blood Pressure (BP)
- Cardiac Stress Index
- Cardiac Workload
- Body Mass Index (BMI)

User-provided data:

- Age
- Gender
- Cholesterol Levels (Total and HDL)
- Diabetes Status (Yes/No)
- Smoking Status (Yes/No)
- Hypertension Treatment (Yes/No)

Categorization for the Wellness Score (WS) along with descriptions:

0–20: Critical (Very Low Wellness)
This range indicates a critical state of wellness, often characterized by multiple significant health risks or conditions. Immediate medical attention and lifestyle changes are likely required to improve overall health. Key metrics in this range may be severely out of balance.

21–40: Poor (Low Wellness)
Scores in this range reflect below-average wellness, with several health parameters in the suboptimal range. There is a heightened risk of chronic conditions, and meaningful interventions, such as better management of diet, exercise, or medical conditions, are necessary.

41–60: Moderate (Average Wellness)
This range represents moderate wellness. While there may not be any immediate critical health risks, there is considerable room for improvement. It reflects a need for steady focus on maintaining or improving key health metrics to ensure long-term wellness.

61–80: Good (High Wellness)
Scores in this range indicate above-average health and wellness. Most key health metrics are in optimal or near-optimal ranges, and the individual is likely practicing healthy lifestyle habits. Minor adjustments could further enhance overall wellness.
81–100: Excellent (Very High Wellness)
This range reflects excellent wellness. Key health parameters are in ideal ranges, and the individual likely has strong protective factors against chronic disease and aging-related risks. This score reflects optimal health and resilience, with little need for further improvement.

81–100: Excellent (Very High Wellness)
This range reflects excellent wellness. Key health parameters are in ideal ranges, and the individual likely has strong protective factors against chronic disease and aging-related risks. This score reflects optimal health and resilience, with little need for further improvement.

Vascular age

is calculated as the age of a person with the same predicted overall risk for developing atheros

The vascular age model is based on studies with subjects aged 30 to 74. Therefore, for individuals younger or older than that range, the estimated vascular age might be artificially higher or lower than their true value.
Depending on which data is provided, the calculations are done either based on cholesterol levels (more accurate) or on body mass index (less accurate).

1. Framingham Heart Study, D'Agostino RB, et al., Circulation. 2008;117(6):743–753.

Atherosclerotic cardiovascular disease (CVD)

the estimated 10-year risk of atherosclerotic cardiovascular disease is based on multivariable, gender-specific risk prediction algorithms derived from the well-known Framingham Heart Study (Framingham risk functions). These functions consider age, high systolic blood pressure (treated or untreated), dyslipidemia (total and high-density lipoprotein cholesterol) or high body mass index (BMI), smoking, and diabetes. The Framingham risk functions are primarily based on data from Caucasian/white populations; therefore, for other races, the actual risk may differ. In particular, compared to Caucasian/white populations, cardiovascular risk is generally higher for African American and American Indian populations, and lower for Hispanic/Latino and Asian populations.

The CVD risk model is based on studies with subjects aged 30 to 74. Therefore, for individuals younger or older than that range, the estimated risk might be artificially higher or lower than their true risk.

The 10-year risk of future ASCVD is categorized into those at:

low (<5%)

borderline (5-<7.5%)

intermediate (7.5-<20%)

high (≥20%) risk.

Specific CVD risks:

- Coronary heart disease (myocardial infarction, coronary death, coronary insufficiency, angina)
- Stroke (ischemic stroke, hemorrhagic stroke, transient ischemic attack)
- Heart failure
- Peripheral vascular disease (intermittent claudication)

Risks of specific diseases are calculated by multiplying the overall CVD risk by the appropriate factor.

Resource:
1. Framingham Heart Study, D'Agostino RB, et al., Circulation. 2008;117(6):743–753.
2. Wong ND, Budoff MJ, Ferdinand K, Graham IM, Michos ED, Reddy T, Shapiro MD, Toth PP. Atherosclerotic cardiovascular disease risk assessment: An American Society for Preventive Cardiology clinical practice statement. Am J Prev Cardiol. 2022 Mar 15;10:100335. doi: 10.1016/j.ajpc.2022.100335. PMID: 35342890; PMCID: PMC8943256.

Cardiovascular Event Risk

the estimated risk of a first hard atherosclerotic cardiovascular event in the next 10 years (coronary death, myocardial infarction, or stroke) for someone without CVD. The estimation is based on the race- and gender-specific Pooled Cohort Equations developed in 2013 by the Risk Assessment Work Group of the American College of Cardiology/American Heart Association, using a combination of risk factors (age, high systolic blood pressure (treated or untreated), dyslipidemia (total and high-density lipoprotein cholesterol), smoking, and diabetes) examined in several cohorts of patients in the USA. For races other than Caucasian/white or African American, the risk estimation is based on the model validated on Caucasian/white populations; hence the actual risk may differ. In particular, compared to Caucasian/white populations, the cardiovascular risk is generally higher for American Indian populations and lower for Hispanic/Latino and Asian populations.

The fatal CV events risk model on subjects aged 40 to 65. Therefore, for individuals outside those age ranges, the estimated risk might be artificially higher or lower than their true risk.

Fatal CV events (European SCORE):

- **Coronary death**
- **Fatal stroke**
- **Total cardiovascular mortality (coronary + stroke)**

The estimated risk of a fatal atherosclerotic cardiovascular event in the next 10 years (coronary death or fatal stroke) for someone without CVD. The estimation is based on the Euro SCORE (Systematic COronary Risk Evaluation) derived from a combination of risk factors (age, high systolic blood pressure, high total cholesterol level, and smoking status) examined in 12 European cohort studies.

Resource:
1. Goff Jr DC et al. 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation, 2014;129(25 Suppl 2):S49-73.
2. Conroy RM, Pyörälä K, Fitzgerald AP, et al. for the SCORE Project Group. Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project. Eur Heart J. 2003;24:987–1003.

The Cardiovascular Risk Score

is a point-based measure estimating **the 10-year risk of developing atherosclerotic cardiovascular disease (CVD)**. The higher the score, the higher the estimated risk. The scoring system is based on established cardiovascular risk models, including the Framingham Heart Study, which primarily analyzed the Caucasian white population. Therefore, actual risk levels may vary across different ethnicities.
The total score is calculated as the sum of points assigned to individual cardiovascular risk factors, such as age, systolic blood pressure, cholesterol levels, smoking, and diabetes. Importantly, some factors can contribute negative points if they are at favorable levels, meaning they help reduce overall cardiovascular risk.
By displaying the individual risk factor scores, users can clearly see which factors have the greatest impact on their cardiovascular health and how modifying them—such as lowering cholesterol, improving blood pressure, or quitting smoking—could positively influence their total risk score.
The scales will vary depending on gender and the model used (cholesterol-based or BMI-based).

For example, for women in the main (cholesterol-based) model, the scales are as follows:

Age: 0 - 12

Total cholesterol: 0 - 5

HDL: -2 - 2

SBP: -3 - 5 (if not treated for hypertension) or -1 - 7 (if treated for hypertension)

Smoking: 0 - 3

Diabetes: 0 - 4

Total risk score: -5 - 33

Resource:
1. Framingham Heart Study, D'Agostino RB, et al., Circulation. 2008;117(6):743–753.
2. Framingham Risk Score: https://ccs.ca/app/uploads/2020/12/FRS_eng_2017_fnl1.pdf

Comparison

1. ASCVD (Atherosclerotic Cardiovascular Disease) Risk & Framingham Risk Score:
   a. ASCVD (Atherosclerotic Cardiovascular Disease) Risk – This is an estimated risk of developing cardiovascular diseases (such as heart attack, stroke) over a 10-year period. It is based on algorithms developed from the Framingham Heart Study.
   b. Framingham Risk Score (FRS) – This is a tool that calculates the risk of cardiovascular disease over a 10-year period based on points assigned for various risk factors (such as age, cholesterol, blood pressure, smoking, and diabetes). These points are then converted into a percentage risk (e.g., 5% risk of developing CVD in the next 10 years) using a table like this: https://ccs.ca/app/uploads/2020/12/FRS_eng_2017_fnl1.pdf.
2. Summary: ASCVD and Framingham Risk Score are two different computational models, although both are based on data from the Framingham Heart Study. This means their calculations may differ depending on the algorithms used.

Hypertension Risk

the Framingham Hypertension Risk Score estimates the likelihood of developing hypertension over 1, 2, and 4 years. This model evaluates key factors such as age, blood pressure, BMI, smoking status, and family history of hypertension. A higher score signifies an increased risk, which, if unmanaged, can lead to serious conditions like heart disease and stroke.

Data needed to compute Hypertension Risk:

- Age
- Gender
- Blood Pressure (Systolic and Diastolic)
- BMI (Body Mass Index)
- Parental Hypertension
- Smoking Status

Low Risk:
Less than 5% chance of developing hypertension in the next 4 years.

Medium Risk:
5% to 10% chance of developing hypertension in the next 4 years.

High Risk:
Greater than 10% chance of developing hypertension in the next 4 years, indicating the need for early intervention and regular monitoring.

Resource:
1. Parikh NI, Pencina MJ, Wang TJ, Benjamin EJ, Lanier KJ, Levy D, D'Agostino RB, Kannel WB, Vasan RS. A risk score for predicting near-term incidence of hypertension: the Framingham Heart Study. Annals of Internal Medicine. 2008 Jan 15;148(2):102-10. PMID:18195335

Diabetes Risk

is assessed using two methods: the **Framingham Diabetes Risk Score** and **the Finnish Diabetes Risk Score** (FINDRISC).

Framingham Diabetes Risk Score

The **Framingham Diabetes Risk Score** calculates the **8-year risk** of developing type 2 diabetes using data from the **Framingham Offspring Study**. The model incorporates factors like fasting glucose levels, BMI, HDL cholesterol, triglycerides, blood pressure, and family history of diabetes. It is designed to help identify individuals at higher risk and support preventive healthcare decisions.

Outcome: Type 2 Diabetes Mellitus (T2DM)

Ranges for Diabetes Risk (Framingham Diabetes Risk Score)::
There isn't a single, direct source explicitly defining the classification of diabetes risk in terms of specific percentages. However, based on general guidelines and risk assessments used in various studies, such as the Framingham Heart Study and others, it is reasonable to adopt the following classification for the risk of developing type 2 diabetes:

- Low risk: <5%
- Medium risk: 5% to 10%
- High risk: >10%

The personal model variables, except sex, were statistically significant predictors of T2DM (AROC, 0.72). In the simple clinical model, parental history of diabetes and obesity remained significant predictors, along with hypertension, low levels of high-density lipoprotein cholesterol, elevated triglyceride levels, and impaired fasting glucose findings but not a large waist circumference (AROC, 0.85).

Finnish Diabetes Risk Score (FINDRISC)

The Finnish Diabetes Risk Score (FINDRISC) estimates the 10-year risk of type 2 diabetes using factors like age, BMI, waist circumference, physical activity, diet, blood pressure, and family history. It is a non-invasive tool for early risk detection and prevention.

FINDRISC is a prediction tool to identify patients at risk of developing diabetes. It requires no laboratory testing and has been validated in multiple populations. FINDRISC uses age, BMI, physical activity, vegetable & fruit intake, medical treatment of hypertension, history of hyperglycemia and family history to determine risk of developing diabetes.

By using FINDRISC to identify high-risk people and applying an educational intervention, it has been shown possible to reduce the incidence of diabetes.

Ranges for Diabetes Risk (FINDRISC):

- **Very Low Risk (0-7 points):**
  Indicates a very low likelihood of developing type 2 diabetes in the next 10 years. Regular monitoring and healthy lifestyle habits are still important for maintaining health.
- **Low Risk (7-11 points):**
  Suggests a low chance of developing diabetes. Maintaining a balanced diet
- and regular physical activity can further reduce the risk.
- **Moderate Risk (12-14 points):**
  Indicates a moderate risk of developing diabetes. Lifestyle changes such
- as improved diet and increased physical activity are recommended to reduce risk.
- **High Risk (15-20 points):**
  Suggests a high risk of developing type 2 diabetes. Early intervention, such
- as regular monitoring of blood glucose levels, is crucial.
- **Very High Risk (21-30 points):**
  Indicates a very high likelihood of developing type 2 diabetes. Immediate action, including lifestyle modifications and possibly medical interventions, is strongly recommended to prevent the disease.

Resources:

1. Atayoğlu, Ali & İnanç, Neriman & başmısırlı, Eda & Çapar, Aslı. (2020). Evaluation of the Finnish Diabetes Risk Score (FINDRISC) for diabetes screening in Kayseri, Turkey. Primary Care Diabetes. 14. 10.1016/j.pcd.2020.01.002.
2. Jin, Shenyi & Chen, Qingguang & Han, Xu & Liu, Yahua & Cai, Mengjie & Yao, Zheng & Lu, Hao. (2022). Comparison of the Finnish Diabetes Risk Score Model With the Metabolic Syndrome in a Shanghai Population. Frontiers in Endocrinology. 13. 10.3389/fendo.2022.725314.

Fatty Liver Disease Risk

the risk of developing Non-Alcoholic Fatty Liver Disease (NAFLD) is strongly associated with two key indices: Body Roundness Index (BRI) and Waist-to-Height Ratio (WHtR). Research indicates that higher values of BRI and WHtR correlate with an increased risk of fat accumulation in the liver, which can lead to serious liver complications if left unmanaged. By evaluating these indices, individuals can better understand their risk of developing NAFLD and take preventive actions.

Based on our results, BRI (OR = 5.484 for men and OR = 3.482 for women) and WHtR (OR = 5.309 for men and OR = 3.854 for women) **showed a higher association with NAFLD** than ABSI (OR = 1.363 for men and OR = 1.003 for women) and WHR (OR = 3.123 for men and OR = 1.628 for women).

Our calculated cut-off points for BRI (4.00 for men and 5.00 for women) and WHtR (0.533 in men and 0.58 in women) were greater for women than for men.

Risk Interpretation:

Low Risk:
Men: WHtR < 0.533 and BRI < 4.00
Women: WHtR < 0.58 and BRI < 5.00

Moderate Risk:
WHtR and BRI are approaching the risk thresholds but have not exceeded them yet.

High Risk:
Men: WHtR ≥ 0.533 and/or BRI ≥ 4.00
Women: WHtR ≥ 0.58 and/or BRI ≥ 5.00

Resources:

1. Body Roundness Index and Waist-to-Height Ratio are Strongly Associated With Non-Alcoholic Fatty Liver Disease: A Population-Based Study.
2. Wang, J., et al. (2021). Relationship Between Body Roundness Index, Waist-to-Height Ratio, and Non-Alcoholic Fatty Liver Disease: A Population-Based Study.

Waist-to-Height Ratio (WHtR)

is a metric that estimates the risk of obesity-related conditions, such as cardiovascular diseases, diabetes, and metabolic syndrome, by assessing abdominal fat distribution through the ratio of waist circumference to height. Higher WHtR values indicate greater abdominal fat, which is associated with increased health risks
Depending on the available data, WHtR may either be directly calculated from waist circumference (WC) and height or estimated using regression models based on

demographic data. Research indicates that higher WHtR values correlate with increased risks of cardiovascular diseases, metabolic syndrome, and type 2 diabetes. It serves as a better indicator of central obesity compared to BMI, offering insights into fat distribution.

Accuracy for WC:
For men, the predicted WC is reasonably close to the actual WC, and for women it is somewhat less close than for men. The median difference (actual WC minus predicted WC) for men is − 0.07 cm, and the middle half of the differences extends from − 3.14 cm to + 3.00 cm. For women the median difference is 0.11 cm, and the quartiles are at − 3.84 cm and + 3.81 cm.

Ranges for WHtR:
Normal Range:

- For both men and women, a WHtR of less than 0.5 is generally considered healthy.

Increased Risk:

- A WHtR of 0.5 or higher suggests an increased risk of health issues related to obesity and should be taken seriously.

Resources:
1. Gibson, Sigrid & Ashwell, Margaret. (2019). A simple cut-off for waist-to-height ratio (0·5) can act as an indicator for cardiometabolic risk: Recent data from adults in the Health Survey for England. British Journal of Nutrition. 123. 1-26. 10.1017/S0007114519003301.
2. Eslami M, Pourghazi F, Khazdouz M, Tian J, Pourrostami K, Esmaeili-Abdar Z, Ejtahed HS, Qorbani M. Optimal cut-off value of waist circumference-to-height ratio to predict central obesity in children and adolescents: A systematic review and meta-analysis of diagnostic studies. Front Nutr. 2023 Jan 4;9:985319. doi: 10.3389/fnut.2022.985319. PMID: 36687719; PMCID: PMC9846615.

Body Fat Percentage (BFP)

estimates the proportion of fat in the body relative to total body weight. It is an important indicator of overall health and fitness, helping to assess the risk of obesity-related conditions such as heart disease, diabetes, and metabolic syndrome. A higher body fat percentage is associated with an increased risk of cardiovascular disease. Understanding BFP helps users monitor their health status and encourages lifestyle changes to reduce fat levels.

Standard Error of Estimate (SEE): ±4% body fat compared to reference methods like Dual-Energy X-ray Absorptiometry (DXA).

Ranges for BFP:

Essential Fat:
Men: 2-5%
Women: 10-13%

Athletes:
Men: 6-13%
Women: 14-20%

Fitness:
Men: 14-17%
Women: 21-24%

Acceptable:
Men: 18-24%
Women: 25-31%

Obese:
Men: 25% and higher
Women: 32% and higher

Resource:
1. Ideal Body Fat Percentage chart (American Council on Exercise)

The Body Roundness Index (BRI)

estimates the distribution of body fat, emphasizing abdominal fat, by considering waist circumference and height. Unlike body mass index (BMI), BRI provides a more detailed understanding of fat distribution and its implications for cardiovascular risk and metabolic health. BRI is a practical and accurate metric for identifying individuals at risk of obesity-related conditions such as heart disease and type 2 diabetes.
By focusing on the proportion of abdominal fat, BRI offers valuable insights into an individual's health profile, making it a useful tool for monitoring and encouraging lifestyle changes.

Ranges for BRI:

BRI values range from 1 to 16, with higher values indicating rounder body shapes (higher abdominal fat) and lower values representing leaner individuals.

Research supports BRI as a reliable predictor of health risks:

Optimal cutoff points:

Men: BRI = 3.85 (Sensitivity: 76.5%, Specificity: 82.1%)
Women: BRI = 4.05 (Sensitivity: 76.4%, Specificity: 70.3%)

Resources:

1. Endukuru CK, Gaur GS, Dhanalakshmi Y, Sahoo J, Vairappan B. Cut-off values and clinical efficacy of body roundness index and other novel anthropometric indices in identifying metabolic syndrome and its components among Southern-Indian adults. Diabetol Int. 2021 Jul 18;13(1):188-200. doi: 10.1007/s13340-021-00522-5. PMID: 35059255; PMCID: PMC8733072.
2. Liu B, Liu B, Wu G, Yin F. Relationship between body-roundness index and metabolic syndrome in type 2 diabetes. Diabetes Metab Syndr Obes. 2019 Jun 19;12:931-935. doi: 10.2147/DMSO.S209964. PMID: 31354325; PMCID: PMC6590402.

A Body Shape Index (ABSI)

the A Body Shape Index (ABSI) estimates obesity-related health risks by considering waist circumference, weight, height, and body fat distribution. Unlike BMI, ABSI specifically emphasizes abdominal fat and its association with health risks, providing a clearer picture of cardiovascular and metabolic health. It is particularly useful for identifying risks in individuals with high abdominal fat, which is strongly correlated with adverse health outcomes like heart disease and type
2 diabetes.

Ranges for ABSI:

If the ABSI is above **0.083**, an increased risk is assumed;
A value of **0.091** is said to represent a doubling of the relative risk, so:

Normal Range: ABSI < 0.083

Increased Risk: ABSI > 0.083 but < 0.091

High Risk: ABSI > 0.091 (doubling of relative risk)

Resource:
1. Krakauer NY, Krakauer JC. A new body shape index predicts mortality hazard independently of body mass index. PLoS One. 2012;7(7):e39504. doi: 10.1371/journal.pone.0039504. Epub 2012 Jul 18. PMID: 22815707; PMCID: PMC3399847.

The Conicity Index (CI)

estimates the distribution of body fat, focusing specifically on abdominal obesity. By using waist circumference, weight, and height, CI provides valuable insights into visceral fat levels, which are strongly linked to metabolic conditions such as diabetes, hypertension, and cardiovascular diseases. It is particularly effective for identifying individuals at risk of high coronary and cardiovascular issues. Studies demonstrate the strong correlation of the conicity index with the detection of visceral fat using computed tomography.

Ranges for CI:

CI values range between 1.0 (a perfect cylinder) and 1.73 (a perfect double cone), with higher values reflecting greater abdominal fat accumulation:

- Normal Range: CI < 1.275 for men, CI < 1.285 for women
- High Risk: CI ≥ 1.275 for men, CI ≥ 1.285 for women

The closer the CI value is to 1.73, the greater the accumulation of abdominal fat, indicating a higher risk of metabolic and cardiovascular complications.

Resource:
1. Martins CA, do Prado CB, Santos Ferreira JR, Cattafesta M, Dos Santos Neto ET, Haraguchi FK, Marques-Rocha JL, Salaroli LB. Conicity index as an indicator of abdominal obesity in individuals with chronic kidney disease on hemodialysis. PLoS One. 2023 Apr 19;18(4):e0284059. doi: 10.1371/journal.pone.0284059. PMID: 37075008; PMCID: PMC10115262.

Basal Metabolic Rate (BMR)

is the number of calories your body requires at rest to maintain basic physiological functions, such as breathing, circulation, and cell production. BMR accounts for a significant portion of total daily energy expenditure (TDEE) and is influenced by factors such as age, gender, weight, height, and body composition. Of the four predictive equations for basal metabolic rate most commonly used in clinical practice (Harris-Benedict, Mifflin-St Jeor, Owen, and WHO/FAO/UNU), the Mifflin-St Jeor equation appears to be the most reliable. It predicts resting metabolic rate at 10% of that measured by indirect calorimetry in more non-obese and obese subjects, higher than any other equation, and also had the lowest error rate. BMR doesn't have strict "normal ranges" like some other health metrics (e.g., blood pressure or cholesterol levels) because it is highly individual. However, understanding your BMR helps assess whether your energy needs are typical for your age, gender, and body composition.

The Total Daily Energy Expenditure (TDEE)

represents the total number of calories your body uses in a day to perform all activities, including basic physiological functions (measured by the Basal Metabolic Rate or BMR), physical activity, digestion, and other bodily processes. TDEE is a crucial metric for understanding calorie requirements and planning dietary and fitness goals, whether for weight loss, maintenance, or muscle gain.

Resources:
1. Mifflin MD, St Jeor ST, Hill LA, Scott BJ, Daugherty SA, Koh YO. A new predictive equation for resting energy expenditure in healthy individuals. Am J Clin Nutr. 1990;51(2):241-7. doi: 10.1093/ajcn/51.2.241.
2. Frankenfield D, Roth-Yousey L, Compher C. Comparison of predictive equations for resting metabolic rate in healthy nonobese and obese adults: a systematic review. J Am Diet Assoc. 2005;105(5):775-89. doi: 10.1016/j.jada.2005.02.005.

Parameter	NORMAL	CAUTION
Heart rate [bpm]	[60 100]	[50 60) or (100 110]
Breathing rate [bpm]	adults: [12 20] 65+: [12 28]	adults: [10 12) or (20 22] 65+: none (they have a much wider normal range)
Blood pressure The **2024 ESC guidelines** have updated the BP classification to support more accurate diagnosis and management:		
Systolic Blood pressure [mmHg]	[90 120]	[85 90) or [121 135)("**Elevated**" according to 2024 ESC guidelines)
Diastolic Blood pressure [mmHg]	[60 70]	[55 60) or [71, 85) (**"Elevated"** according to 2024 ESC guidelines)
Cardiac workload [mmHg/s]	[90 216.67]	[70.83 90) or [216.67 256.67)
Heart rate variability	not known (depends on age, gender, time of day, ethnic origin, lifestyle, fitness level)	
Parasympathetic activity	based on HRV; not known (depends on age, gender)	
Cardiac stress	[0 - 4]	equals 0 or (4 8]
BMI [kg/m2]	[18.5 24.9]	[17.5 18.5) or [25.0 27.0]

Note

In SDK version 2.6.3, the defined ranges are still based on the previous version of the ESC guidelines:

SBP [mmHg]

- **NORMAL:** [90, 130)
- **CAUTION:** [85, 90) or [130, 139] ("high-normal")

DBP [mmHg]

- **NORMAL:** [60, 85) mmHg
- **CAUTION:** [55, 60) or [85, 89] ("high-normal")

In 2.7.0 version we introduced an update to ensure alignment with the latest 2024 ESC Guidelines.

Blood pressure
The **2024 ESC guidelines** have updated the BP classification to support more accurate diagnosis and management:

Systolic Blood pressure [mmHg]	[90 120]	[85 90) or [121 135)("**Elevated**" according to 2024 ESC guidelines)
Diastolic Blood pressure [mmHg]	[60 70]	[55 60) or [71, 85) **("Elevated"** according to 2024 ESC guidelines)
Cardiac workload [mmHg/s]	[90 216.67]	[70.83 90) or [216.67 256.67)
Heart rate variability	not known (depends on age, gender, time of day, ethnic origin, lifestyle, fitness level)	
Parasympathetic activity	based on HRV; not known (depends on age, gender)	
Cardiac stress	[0 - 4]	equals 0 or (4 8]
BMI [kg/m2]	[18.5 24.9]	[17.5 18.5) or [25.0 27.0]

Note

In SDK version 2.6.3, the defined ranges are still based on the previous version of the ESC guidelines:

SBP [mmHg]
- **NORMAL:** [90, 130)
- **CAUTION:** [85, 90) or [130, 139] ("high-normal")

DBP [mmHg]
- **NORMAL:** [60, 85) mmHg
- **CAUTION:** [55, 60) or [85, 89] ("high-normal")

In 2.7.0 version we introduced an update to ensure alignment with the latest 2024 ESC Guidelines.

Health Indices

Parameter	GENDER	NORMAL	CAUTION	HIGH
Atherosclerotic cardiovascular disease Risk	Male & Female	**Low risk:** <5%	Borderline & Intermediate: 5% to 20%	**High risk:** ≥ 20%
>Hypertension Risk	Male & Female	**Low risk:** <5%	Medium risk: 5% to 10%	**High risk:** ≥ 10%
Diabetes Risk - Framingham Diabetes Risk Score	Male & Female	**Low risk:** <5%	Medium risk: 5% to 10%	**High risk:** ≥ 10%
Diabetes Risk - FINDRISC	Male & Female	**Low risk:** <11 points	Medium risk: 12-14 points	**High risk:** ≥ 15 points
Fatty Liver Disease Risk	Male	**Low: WHtR < 0.533 and BRI < 4.00**	WHtR and BRI are approaching the risk thresholds but have not exceeded them	**WHtR ≥ 0.533 and/ or BRI ≥ 4.00**
	Female	**WHtR < 0.58 and BRI < 5.00**	WHtR and BRI are approaching the risk thresholds but have not exceeded them	**WHtR ≥ 0.58 and/or BRI ≥ 5.00**
Waist-to-Height Ratio (WHtR)	Male & Female	**[0.0, 0.49)**	[0.49, 0.6]	**>0.6**
Body Fat Percentage (BFP)	Male	**[7.0, 23.0]**	[6.0 7.0) or (23.0 24.0]	**<6.0 & >24.0**
	Female	**[15.0, 30.0]**	[14.0 15.0) or (30.0 31.0]	**<14.0 & >31.0**
Body Roundness Index (BRI)	Male	**[0.0, 3.85)**	[3.85, 4.5]	**>4.5**
	Female	**[0.0, 4.05)**	[4.05, 4.5]	**>4.5**
Conicity Index (CI)	Male	**[0.0, 1.275)**	[1.275, 1.4]	**>1.4**
	Female	**[0.0, 1.285)**	[1.285, 1.4]	**>1.4**
A Body Shape Index	Male & Female	**[0.0, 0.083)**	[0.083, 0.091]	**>0.091**

Interpretation notes

The metrics provided by Shen AI are intended for informational and monitoring purposes. They may support clinical workflows when integrated into regulated healthcare applications but are not intended as standalone diagnostic tools.

Definitions and reference values used in this document follow established clinical guidelines, including those from the European Society of Cardiology (ESC), European Society of Hypertension (ESH), and other peer-reviewed sources.

Measurement accuracy can be influenced by user behavior, lighting conditions, device quality, and signal stability. Shen AI includes built-in signal quality checks to determine whether conditions are sufficient for valid output.

All outputs are delivered in real time and processed locally on the user's device to ensure performance consistency and data privacy.

To learn more about how these metrics can support your product or research, explore the Shen AI SDK or request more information at shen.ai.