ANOVATOR

BODY COMPOSITION ANALYSIS AND HEALTH MANAGEMENT TRAINING MANUAL

BODY COMPOSITION · EXERCISE & FITNESS · HEALTH & MEDICAL KNOWLEDGE
TECHNIQUES, ANALYSIS, AND PRACTICAL APPLICATIONS
PREPARED BY ANOVATOR

2026

BRAND PUBLICATION · NOT FOR SALE

Body Composition Analysis and Health Management Training Manual

---

Principal Author & Chief Reviewer: Stone

Editorial Director: Zoe Zhou

Lead Content Editor: Fiona Long

Illustration Editor: Etain Huu

Contact

Website: www.anovator.com

Email: info@anovator.com

Brand Publication · Not for Sale

CONTENTS

Body Composition Analysis and Health Management Training Manual

Chapter 1
Industry Background

The development of body composition research marks an important shift in modern health science — from a "weight-centered" perspective to a "structure-centered" scientific understanding. For a long time, body weight was regarded as the main indicator of health, physical fitness, and even disease risk. However, as research has deepened, it has become clear that body weight alone only shows the surface. What truly determines health is the proportion and interaction among fat, muscle, bone, and water in the body. This "structural perspective" has replaced the simple "weight perspective" redefining the meaning of health and establishing the theoretical foundation of body composition science.

1. Origin Stage:
Medical and Nutritional Needs
Late 19th – Early 20th Century:
The Birth of the Body Composition Concept

The concept of Body Composition originated in the late 19th century. At that time, anatomists and physiologists used dissection and chemical analysis to study the proportional relationships among different human tissues. They gradually realized that fat was not merely an energy reserve, but also closely related to health status, metabolic efficiency, and disease risk.

In 1906, U.S. Navy physiologist Albert R. Behnke proposed the two-compartment model of the human body (fat mass vs. fat-free mass), dividing it into fat tissue and fat-free tissue. This framework changed the way people understood "health" — body weight was no longer seen as a single measure but as a structured combination of functional components.

While serving in the Navy, Behnke noticed that some divers with higher body weight performed better underwater. This observation led him to question the idea that "being overweight" necessarily meant poor fitness. His insight inspired him to study the human body from the perspective of density and buoyancy, laying the theoretical groundwork for future body composition research.

Albert R. Behnke

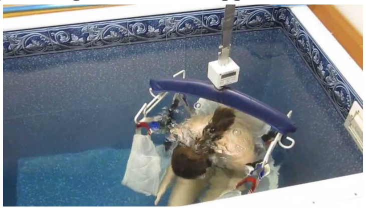
Early studies of body composition mainly relied on dissection and chemical analysis, which could not be applied to living humans. As a result, this field remained largely theoretical in its early stages.

1940s–1960s:
The Rise of Scientific Measurement

The outbreak of World War II made nutrition and physical fitness national strategic priorities. Soldiers' physical conditions were directly linked to combat performance, so the military began to support systematic research on body composition. After the war, these findings were gradually applied to nutritional assessments for athletes and clinical patients.

During this period, the hydrodensitometry method (underwater weighing) was considered the most accurate way to measure body composition. Based on Archimedes' principle, it calculates body density by comparing a person's weight in air and in water, and then estimates the body fat percentage from that density. Researchers also developed the dilution method and the potassium-40 isotope method to measure body water and mineral content.

In the 1950s, NASA first used body composition measurement to assess astronauts' health. Space missions required extremely precise physical monitoring, and scientists used these measurements to track astronauts' muscle mass, body fluid balance, and bone calcium loss. This marked the transition of body composition analysis from laboratory research to advanced engineering and medical applications.



Hydrodensitometry

2. Development Stage:
From Laboratory to Clinical and Civil Applications

1970s–1990s:
Multidisciplinary Integration

The emergence of Bioelectrical Impedance Analysis (BIA) was a major breakthrough. This technology estimates body water by measuring the electrical resistance within the body, and then calculates fat and muscle content from that data. BIA is non-invasive, convenient, and low-cost, giving it strong commercial potential.

Dual-energy X-ray Absorptiometry (DEXA) was originally developed for bone density measurement and later expanded to whole-body composition analysis. DEXA can precisely distinguish fat, lean tissue, and bone minerals, and is recognized as the gold standard in clinical assessment.

Other techniques, such as skinfold thickness measurement and isotope dilution methods (D_2O, tritiated water), were also used in research to provide validation data or serve as reference standards.

1990s–2000s:
Rise of Commercialization

In the 1980s, a research team from **Waseda University in Japan** was the first to apply BIA technology to human studies and developed a portable body composition analyzer. This marked a turning point — body composition measurement devices began shifting from research tools to commercial products used in fitness centers, hospitals, and health checkups.

Athletes started using body composition data to monitor training progress, nutritionists used it to assess metabolic conditions, and hospitals used it to track patient recovery. From then on, body composition measurement truly became a *window into one's health status*.

3. 2010s to Present:
Integration of Medical and Sports Health

Since the 21st century, the integration of **artificial intelligence (AI)** and **big data** has transformed body composition analysis from a simple measurement method into a comprehensive health management tool. Modern analyzers not only measure basic metrics such as body fat percentage, muscle mass, and bone mass, but also use algorithms to estimate metabolic status, nutritional balance, and visceral fat risk.

Public health systems around the world have begun incorporating body composition analysis into **chronic disease management**, tracking long-term trends in obesity, diabetes, and osteoporosis. In fields such as fitness, rehabilitation, elderly care, and occupational health, body composition data are used for personalized assessment and intervention.

By the **2004 Athens Olympics**, many national teams had already integrated body composition analysis into their training strategies, using real-time monitoring to adjust nutrition and recovery plans. Around the same period, large-scale research by the **U.S. National Institutes of Health (NIH)** found a strong correlation between age-related muscle loss (*sarcopenia*) and the incidence of chronic diseases. Since then, "body composition health" has gradually replaced "weight management" as the new focus of the global health industry.

Body composition measurement technology has evolved from **academic research** to **social application**. It has not only changed how doctors and scientists understand the human body, but also enabled ordinary people to view their health through the lens of data.

From precise laboratory instruments to clinical diagnostic tools and now to personal health companions, body composition measurement has become a vital bridge connecting **medicine, technology, and daily life**.

Chapter 2
Industry Status and Trends

1. Current Status: Mainstream Technologies and Diverse Applications

1.1 Technical Routes: Dual-Track System of BIA and DEXA

At present, the body composition analysis industry mainly follows two technical paths:

BIA (Bioelectrical Impedance Analysis)

Estimates body water, fat, and muscle mass based on changes in electrical impedance.

Its advantages include low cost, high portability, and fast measurement, making it widely used in gyms, health checkup centers, and smart home scales.

DEXA (Dual-energy X-ray Absorptiometry)

Originally developed for bone density measurement, later extended to full-body composition analysis.

It offers high accuracy and repeatability and is considered the gold standard in medical research. However, due to its high cost and complex operation, it is mainly used in hospitals and research institutions.

1.2 Application Scenarios: Bridging Medicine and Public Health

Body composition analysis has moved beyond laboratories and into everyday life, now covering multiple sectors:

Medical and Healthcare:

Clinical nutrition assessment, pre- and post-surgery nutritional monitoring, and metabolic management for kidney and diabetes patients.

Sports and Fitness:

Athletic performance evaluation, training cycle monitoring, and posture management.

Research and Education:

Universities and research institutes in sports, medicine, and nutrition use body composition data to build reference models.

Nutritional Intervention and Chronic Disease Follow-Up:

Provides data support for personalized nutrition programs and interventions for obesity and metabolic syndrome.

Across different settings, **data interpretation** is becoming more valuable than **data measurement**. The true competitive edge of the industry is shifting from *"measuring accurately"* to *"understanding deeply."*

2. Industry Trends: Smart, Medical, and Localized

2.1 Portability and Home Use: From Professional Instruments to Smart Scales

In recent years, with improved sensor accuracy and algorithms, home-use smart body fat scales have become a new entry point in consumer electronics.

Brands like Xiaomi, Huawei, Fitbit, and Withings have made "body fat percentage" a widely recognized health metric.

However, most of these devices use single-frequency BIA technology, which has a short measurement path and is easily affected by hydration and temperature.

Therefore, professional multi-frequency or segmental analyzers are still required for research and clinical applications.

2.2 Medical-Grade Applications: The "Third Eye" for Clinical Decisions

In hospital nutrition and rehabilitation departments, body composition analysis is gradually becoming part of standard clinical procedures:

Cancer patients:

Monitoring fat-free mass and intracellular water helps assess malnutrition and sarcopenia risk.

Diabetes and metabolic disease patients:

Changes in body fat and visceral fat guide adjustments in medication and diet.

Dialysis patients:

Segmental water assessment helps optimize fluid balance during dialysis.

This trend has also promoted standardization research worldwide. For example, the American Society for Parenteral and Enteral Nutrition (ASPEN) has included BIA data as one of the malnutrition screening indicators.

2.3 AI and Cloud Data: From Measurement to Prediction

Currently, the industry is experiencing a second wave of innovation driven by artificial intelligence and big data:

Models trained on large population databases can predict health risks and provide personalized intervention suggestions.

Integration with wearable devices and cloud analytics enables real-time monitoring and long-term trend tracking.

At the enterprise level, accumulated data is becoming a key asset, shifting the competition from hardware to data.

Chapter 3 Core Technology of Anovator and Interpretation of Indicators

1. Overview of Technical Principles

Body composition analysis uses **BIA (Bioelectrical Impedance Analysis)** to measure the electrical conductivity of different tissues in the body, allowing estimation of the proportions of fat, muscle, water, and bone.

During measurement, the device sends weak alternating currents at multiple frequencies through electrodes on the body:

Fat tissue: Low water content, high resistance, poor conductivity;

Muscle tissue: Rich in water and electrolytes, high conductivity;

Different frequencies: Can reflect the distribution of intracellular and extracellular fluids separately.

By calculating the impedance (Z) at different frequencies and applying algorithmic models, the device can determine the composition of various body tissues.

2. Interpretation of Indicators

2.1 Health Score

Meaning

The health score quantifies an individual's overall health based on body composition measurements.
To avoid interference from other dynamic indicators such as blood pressure, heart rate, and blood oxygen (which can fluctuate under different conditions), the health score is calculated using only **body fat percentage** and **BMI**. The score is derived by comparing the deviation of these two metrics from their standard values: the greater the deviation, the lower the score.

Different ages and genders have different standard values. For example, for adult males, the ideal body fat percentage is **15%** and the ideal BMI is **22**. Deviations above or below these standards will reduce the health score. Ideal value ranges for each metric by age and population group can be found in the report.

Gender	Age Range	Ideal Body Fat	Ideal BMI	Scoring Reference
Male	18–60	15%	22	±10% deviation considered good
Female	18–60	22%	21	±10% deviation considered good

The health score is not a label of "good" or "bad," but indicates how far the body is from the ideal range.

Application

The health score helps quickly assess individual health risk trends. Examples:

Low BMI but high body fat → risk of "hidden obesity"
High BMI but low body fat → indicates good physical fitness.

2.2 Weight

Meaning

Weight is a direct indicator of total body mass, but on its own, it does not fully reflect health status.

For example, two people with the same weight may differ significantly—one may have well-developed muscles while the other has higher fat content.

Therefore, weight should be evaluated together with BMI, body fat percentage, and muscle mass for a comprehensive assessment.

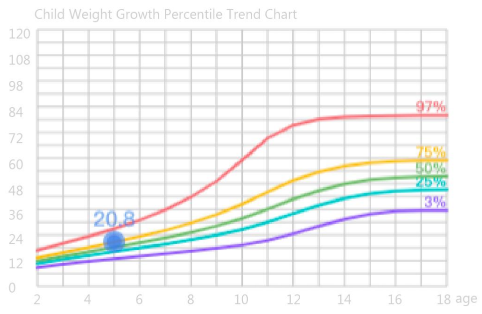
Children's Weight Assessment

For children, healthy weight is assessed using **percentile curves**, which show an individual's relative position among peers rather than absolute values.

Example

A 5-year-old girl weighs 20.8 kg, which is above the 75th percentile for girls of the same age, indicating her weight is higher than most peers.
However, higher weight does not necessarily mean obesity; it must be analyzed together with body fat percentage, height, and muscle mass.

The core of children's healthy weight lies not in being "heavy or light" but in whether body proportions are balanced.



Weight 20.8kg, higher than 75% of girls at age 5. Each colored curve in the chart shows the weight percentile distribution for girls as they grow.

2.3 Height

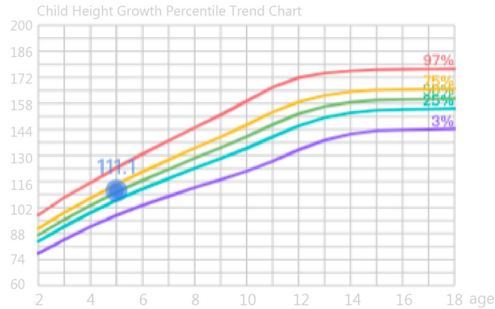
Meaning

Height is the vertical measurement from the top of the head to the ground and is an important indicator of growth and development.

The growth rate of children's height is influenced by **genetics, nutrition, and physical activity**, with genetics accounting for about 60% and nutrition and exercise about 40%.

Percentile Growth Curve Interpretation

Similar to weight distribution curves, the chart shows five percentile curves representing height growth for children aged 0–18. For example, a 5-year-old girl whose height is 111.1 cm exceeds 55% of her peers, placing her within the 50%–75% percentile range. If she maintains her current diet and exercise habits, her predicted adult height at 18 years old would likely be between 158 cm and 165 cm.



Height: 111.1cm, higher than 55% of girls at age 5. Each colored curve in the chart shows the height percentile distribution for girls as they grow.

Improvement Recommendations

Increase nutrition intake: consume more protein, calcium, and vitamins D, A, and C (e.g., milk, lean meat, fresh fruits, and vegetables).

Sunlight and routine: moderate sun exposure promotes vitamin D synthesis.

Exercise stimulation: vertical stretching activities such as high jump, basketball, volleyball, and climbing can help promote bone growth.

Chapter 4
Key Body Composition Indicators

1. Overview

Body composition analysis measures parameters such as fat, muscle, water, protein, and bone mass to help assess an individual's health status, nutritional level, and metabolic capacity.

Reference ranges for these indicators vary across different populations, including children, adolescents, adults, and the elderly.

Understanding these indicators is essential for accurately interpreting body composition reports and developing effective health intervention plans.

2.Basic Body Composition Indicators

2.1 Body Mass Index (BMI)

Definition

BMI (Body Mass Index) is an internationally recognized standard for assessing body shape, reflecting the ratio of weight to height.

Calculation Formula

BMI = Weight (kg) ÷ Height² (m)

Reference Ranges

Region	Ideal BMI	Standard Range
Asia	21.2	18.2 – 23.9
Europe/America	22	19 – 24

Both high and low BMI are significantly associated with metabolic disease risk and should be evaluated together with body fat percentage for a comprehensive assessment.

2.2 Body Fat Percentage (BFP)

Definition

Body fat percentage represents the proportion of fat in total body weight and is a core indicator for assessing obesity.

Gender	Normal Range	Underfat	Overfat
Male	11% – 20%	<11%	>20%
Female	20% – 27%	<20%	>27%

Application

High body weight does not necessarily indicate obesity; the key is the proportion of body fat. For children, assessment should be combined with muscle and bone mass.

Example

In adolescent health monitoring, a situation where weight is low but body fat percentage is high usually indicates insufficient physical activity and underdeveloped muscles, which should be addressed through exercise interventions.

Children

Children's body fat percentage varies with age and gender, so adult standards cannot be directly applied.
The following ranges can serve as general reference values (may vary slightly by region and institution):

Age	Gender	Underfat	Normal Range	Overfat
5–12 years	Boys	<10%	10% – 20%	>20%
5–12 years	Girls	<14%	14% – 25%	>25%

Notes

The assessment of children's body fat focuses not on whether they are "heavy or light," but on:
• Whether the body fat level matches their age and gender
• Whether body fat, height, weight, and muscle mass are in balance
• Whether signs of "hidden obesity" appear (normal weight but high body fat) or low muscle mass

A comprehensive evaluation combining body fat percentage, BMI, weight-for-age percentile, and muscle mass provides a more accurate picture of a child's growth and health status.

2.3 Subcutaneous Fat

Definition

Subcutaneous fat is the fat stored beneath the dermis and above the fascia, commonly concentrated in the waist, abdomen, and thighs.

Gender	Normal Range
Male	8.6% – 17.7%
Female	18% – 26%

Subcutaneous fat has the most direct impact on body appearance. Excessive subcutaneous fat can lead to visible obesity, but its metabolic risk is lower than that of visceral fat.

2.4 Visceral Fat

Definition

Visceral fat refers to the fat located inside the abdominal cavity, surrounding vital organs such as the liver, pancreas, and intestines.

Unit Explanation

The unit of visceral fat is cm^2, representing the visceral fat area (VFA).

The commonly used visceral fat index is calculated by dividing the visceral fat area by 10, resulting in a simplified score for easier interpretation.

Reference Standards

• Medical standard: 0–10
• General health/fitness industry standard: 0–5 (stricter threshold to encourage early risk management)
• A value >5 typically indicates elevated metabolic health risks, including fatty liver and insulin resistance.

Health Significance

Visceral fat poses greater health risks than subcutaneous fat because it is metabolically active and closely linked to chronic diseases.
Excess visceral fat can silently drive the development of:
• Fatty liver
• Type 2 diabetes
• Hypertension
• Cardiovascular diseases
• Systemic inflammation

2.5 Muscle Rate

Definition

Muscle rate refers to the percentage of total body weight made up of muscle mass.
Higher muscle rate is associated with higher basal metabolic rate, greater calorie expenditure, and lower risk of fat accumulation. It is important to distinguish muscle rate from skeletal muscle: skeletal muscles are attached to bones and are a type of striated muscle, forming part of total body muscle. Generally, males have higher muscle rates than females.

For children, muscle rate differs from adults and varies significantly across developmental stages. From 0–6 years, boys and girls show similar slow muscle growth. From 6–12 years, girls tend to develop muscle slightly faster than boys, reflecting higher physical performance and strength in everyday activities. Between 12–18 years, boys' muscle growth accelerates, surpassing girls. Ensuring adequate protein and calcium intake during ages 6–18 is essential for healthy growth.

Gender	Normal Range
Male	42.9% – 52.4%
Female	37.8% – 46.2%

Development Differences

• 0–6 years: slow muscle development for both genders
• 6–12 years: girls slightly ahead of boys
• 12–18 years: boys' muscle growth accelerates

Application Example (Educational Context)

Children who meet weight standards but have insufficient muscle in school physical assessments should focus on protein intake and physical training.

2.6 Protein

Definition

Protein is a vital component of body cells and tissues, accounting for about 18% of body weight and closely related to muscle rate. It is essential for all major bodily functions and is a key driver of life activities. Protein content generally correlates with muscle rate, with males typically having higher levels than females.

Gender	Normal Range
Male	15% – 19%
Female	11% – 19%

Insufficient protein can lead to muscle loss and decreased immunity, so adequate daily intake is necessary.

2.7 Total Body Water (TBW)

Definition

Total body water refers to the percentage of body weight that is water, serving as an important indicator of fluid balance and metabolism. Adequate hydration supports metabolic processes and helps maintain firm, elastic, and youthful skin.

Males generally have higher body water content than females because muscles, which are primarily composed of water, protein, and carbohydrates, contain over 70% water.

Gender	Normal Range
Male	55% – 65%
Female	45% – 60%

Note

• The total body water value presented here does not include water content in the head segment.
This differs from many physiology textbooks, which state that the human body contains 80%–90% water.
The main reason for this difference is that segmental bioelectrical impedance analysis (BIA) does not measure the head, leading to a lower TBW percentage compared with whole-body physiological descriptions.
• Due to higher muscle water content, males typically have a higher overall body water percentage than females.

2.8 Bone Mass

Definition

Bone mass reflects the health and density of the skeletal structure. It represents the weight of bone tissue in the body and indicates overall bone health. Bone tissue is composed of cells, fibers (mainly collagen), and a matrix rich in inorganic minerals.

Population	Normal Range
Adults	2.75 – 7.75 kg
Minors	2 – 6 kg

Application Recommendation

Long-term low bone mass should be addressed with adequate calcium intake and resistance training.

2.9 Basal Metabolic Rate (BMR)

Definition:

Basal Metabolic Rate refers to the minimum amount of energy the body needs to maintain essential life functions while at rest. It represents the energy the body consumes when awake but completely calm — without muscle movement, environmental influence, or mental stress.

In general, people with higher muscle mass have a higher BMR. Men usually have a higher BMR than women, and individuals with greater body weight also tend to have higher BMR.

Patterns:

• Higher muscle mass → higher BMR
• Greater body weight → higher BMR
•Males generally have higher BMR than females

How to Use BMR for Exercise and Diet Planning

Step 1: Calculate Total Daily Energy Expenditure (TDEE)

TDEE = BMR × Activity Factor

Common activity factors:

• Sedentary (little exercise): ×1.2
• Light activity (1–3 days/week): ×1.375
• Moderate activity (3–5 days/week): ×1.55
• High activity (6–7 days/week): ×1.725

Example:

If your BMR is 1200 kcal and you exercise moderately:
TDEE = 1200 × 1.55 = 1860 kcal/day

Step 2: Set Calorie Intake Based on Your Goal

• For fat loss

Recommended intake = TDEE − 300 to 500 kcal
(Moderate deficit avoids metabolic slowdown)
Using the example above:
1860 − 300 = 1560 kcal/day (ideal target)

• For muscle gain

Recommended intake = TDEE + 200 to 300 kcal
To support muscle growth and training recovery.

Step 3: Set Macro Ratios Based on BMR and Body Composition

Fat-loss macro recommendation

• Protein: 1.2–1.6 g per kg body weight
• Fat: 20%–30% of total calories
• Carbohydrates: remaining percentage

Muscle-gain macro recommendation

• Protein: 1.6–2.0 g per kg
• Carbohydrates: higher proportion to support training intensity
• Fat: 20%–25% of total calories

Example (fat loss target = 1560 kcal/day):

• Protein 90 g → 360 kcal
• Fat 50 g → 450 kcal
• Carbs 190 g → 760 kcal

Step 4: Adjust Exercise Strategy Based on BMR

If BMR is low

• Prioritize strength training 3–4 times/week
• Add moderate cardio (20–30 min)
• Increase daily activity (steps, light movement)

If BMR is high

• Combine strength + cardio flexibly
• Maintain enough protein and calories to avoid muscle loss

Step 5: Re-evaluate Every 2–4 Weeks

As muscle increases or weight changes, BMR may change slightly.
Update your TDEE and calorie target regularly for accurate control.

The key to losing weight is not strict dieting, but improving your metabolism.

2.10 Waist-to-Hip Ratio (WHR)

Definition:

Waist-to-Hip Ratio (WHR) is the ratio of waist circumference to hip circumference. It is an important indicator for assessing central (abdominal) obesity.

Normal Range:

Gender	Normal Range
Male	0.80 – 0.95
Female	0.67 – 0.80

Explanation:

WHR is a key predictor of cardiovascular and metabolic risks. A ratio higher than the normal range indicates possible visceral fat accumulation, which increases the risk of chronic diseases.

2.11 Body Age

Definition:

Body age is a “functional age” calculated based on multiple body composition indicators. It reflects the degree of physiological aging.

• If **Body Age > Actual Age**, it suggests faster functional decline.
• If **Body Age < Actual Age**, it indicates good physical condition and active metabolism.

Notes on the Relationship Between Body Age and the Health Score

Body age is directly linked to the Health Score, forming a unified evaluation system:

• Health Score 80–85 → Body age generally aligns with actual age.
• For adults:
When the Health Score is below 80, body age will appear older than actual age, with a maximum difference of up to 5 years.
• For minors:
The logic is the opposite of adults — a lower Health Score corresponds to a younger body age, reflecting developmental characteristics rather than aging patterns.

Body age is not an absolute value, but rather a reflection of overall health and metabolic vitality.

2.12 Lean Body Mass (LBM)

Definition:

Lean Body Mass refers to the total body weight excluding fat.

Formula:

LBM = (1 - Body Fat Percentage) × Body Weight

Function:

It represents the combined weight of muscles, bones, and body water. LBM is a key parameter for assessing body composition and overall physical health.

2.13 Fat Mass

Definition:

Fat Mass refers to the total weight of fat tissue in the body.

Formula:

Fat Mass = Body Fat Percentage × Body Weight

2.14 Ideal Weight

Definition:

Ideal Weight is derived from a large-scale Asian body database, representing the median weight percentile that reflects the most optimal physiological and health status.

It corresponds to the best metabolic level, the lowest risk of chronic disease, and the highest movement efficiency.

Formula:

Ideal Weight (kg) = 21.2 × Height^2 (m^2)

(For Asian populations; non-Asian populations may use BMI = 22 for calculation.)

Notes:

• Ideal weight is not the “thinnest” weight, but a balanced range that optimizes both body function and appearance.
• For individuals who regularly exercise, such as athletes or those engaged in strength training, the actual weight may be slightly higher than the ideal weight and still be considered healthy.

2.15 Weight Control

Definition:

Weight Control refers to the projected weight adjustment goal that an individual can achieve after a period of reasonable training and dietary intervention (e.g., one month), based on the difference between their current and ideal weight.

It is **not** a simple subtraction of current weight minus ideal weight, but a calculated target considering metabolism, fat distribution, and muscle mass.

Example:

If the report shows “Weight Control: -3.0 kg,” it suggests reducing 3.0 kg through balanced training and nutrition to approach the ideal weight.

If it shows “+2.5 kg,” it indicates a need to gain weight — commonly seen in individuals with low muscle mass, poor nutrition, or adolescents in growth phases.

Interpretation:

Weight control is **not a command to lose weight**, but a **direction for healthy body restructuring**.

The key is understanding **what to reduce** and **what to increase**, rather than simply focusing on the number.

2.16 Fat Control

Definition:

Fat Control refers to the amount of fat mass that should be reduced or increased as part of a body weight adjustment plan.

It indicates the **direction and magnitude** of fat changes needed to achieve an ideal body composition.

Example:

• If the report shows "Fat Control: -2.5 kg," it means the goal is to reduce 2.5 kg of body fat.

• If it shows "+1.0 kg," it suggests the individual has insufficient fat reserves (such as from excessive dieting) and needs to restore fat moderately to maintain hormonal balance.

Additional Note:

Fat Control is closely related to Weight Control, but they are **not equivalent**.

In healthy body reshaping, "no change in weight but lower fat" is often **better** than "lower weight but muscle loss."

Sidebar Quote:

Healthy weight loss is not about being lighter — it's about being leaner.

2.17 Muscle Control

Definition:

Muscle control refers to the amount of muscle mass that should be increased or decreased during body weight adjustment.

It is often shown as "Target Muscle Gain" or "Muscle Recovery Needed," serving as an important indicator of the effectiveness of an individual's exercise and training outcomes.

Interpretation:

"Muscle Control: +2.0kg" → Indicates that approximately 2 kg of muscle should be gained to improve metabolism and body composition.

"Muscle Control: -0.5kg" → May suggest overdeveloped muscles in certain areas or an imbalance in training.

Practical Value:

• In fitness and rehabilitation programs, the muscle control value helps guide precise muscle gain strategies.

• In weight management and nutrition counseling, when combined with fat control, it helps differentiate between "weight-gain" and "body-shaping" approaches.

Muscle growth is not a short-term process. A realistic goal is to increase 0.5–1.0 kg per month, supported by a high-protein diet and resistance training.

2.18 Body Type Classification Logic

Principle:

Body type classification is based on BMI (Body Mass Index) and Body Fat Percentage, using a two-dimensional cross-analysis to determine an individual's overall body type.

The core idea is to transform "weight quantity" into an assessment of "body composition quality," identifying whether a person falls into categories such as healthy, hidden obesity, or muscular.

• BMI reflects whether "body weight exceeds the reasonable range for height."

• Body Fat Percentage reveals the "proportion of fat versus non-fat mass in the body."

Combining these two indicators helps avoid misjudgment based on a single metric. For example, a person with a normal BMI but high body fat is classified as "hidden obesity," while someone with slightly elevated BMI but low body fat is considered "muscular" rather than truly overweight.

Classification Logic

The table below shows the standard logic model for body type classification based on the combination of BMI and Body Fat Percentage (using Asian adult standards as an example):

Body Fat % \ BMI	Low BMI	Normal BMI	High BMI
Low Body Fat	Thin-Muscular	Standard-Muscular	Very Muscular
Normal Body Fat	Thin	Standard	Very Muscular
High Body Fat	Hidden Obesity	Overweight	Obese

Notes:

• "Hidden Obesity" refers to a body type that appears slim but has high body fat and low muscle mass.

• "Very Muscular" or "Athletic" types are often seen in athletes or long-term resistance trainers; BMI may be high but health risk is low.

• Children, adolescents, and older adults should adjust the standard values according to age and gende

Body Type Interpretation and Health Guidance

Body Type	Characteristics	Health Advice
Thin	Both fat and muscle are low; underweight	Increase nutritional intake and combine with strength training
Thin-Muscular	Low body weight but high muscle rate	Maintain training habits and ensure balanced nutrition
Standard	All indicators within ideal range	Maintain current diet and activity level
Standard-Muscular	Low body fat, ideal muscle mass	Exemplary healthy type; pay attention to recovery and nutrition
Hidden Obesity	Normal weight but high body fat	Increase physical activity, especially a mix of resistance and aerobic training
Overweight	Slightly high fat, insufficient muscle	Control calorie intake and strengthen muscle training
Obese	Excessive fat, elevated metabolic risk	Implement a structured fat-loss program
Very Muscular	High BMI but low fat and high muscle mass	Healthy athletic type; monitor joint and cardiovascular load

Chapter 5
Exercise Safety and Risk Assessment

With a clear understanding of exercise safety hazards and the necessity of risk assessment, trainers—who directly serve members—must focus on balancing safety and effectiveness in daily practice. For high-risk individuals, the initial stage of an exercise program should emphasize fat loss and aerobic training. Once blood pressure risks are reduced, the program can gradually progress to cardiovascular endurance training, ensuring a safe and effective exercise process.

Reference Blood Pressure Ranges:

Blood Pressure Category	Systolic / Diastolic (mmHg)
Ideal	120 / 80
High-Normal	130–139 / 85–89
Hypertension Stage 1 (Mild)	140–159 / 90–99
Hypertension Stage 2 (Moderate)	160–179 / 100–109
Hypertension Stage 3 (Severe)	≥180 / ≥110

Recommended Training Intensity Limits by Risk Level:

• **High-Risk (Stage 3):**
Training intensity must not exceed 70% to avoid safety risks.

• **Moderate-Risk (Stage 2):**
Training intensity should stay below 75% to prevent potential exercise hazards.

• **Mild-Risk (Stage 1):**
Training intensity should be controlled under 85%.

• **General Population:**
Training intensity recommended not to exceed 90%.

Note:
Training intensity should be determined in combination with individual exercise capacity assessment results.

Chapter 6
Exercise Capacity Assessment

1. Definition and Significance of Exercise Capacity

Exercise Capacity (E.C) refers to an individual's overall ability to participate in physical activity and training.

It is determined by multiple factors, including body composition, physical fitness, physiological functions, motor skills, and psychological state. From a biochemical perspective, exercise capacity largely depends on the efficiency of energy supply, transfer, and utilization during physical activity.

Exercise capacity not only affects the level of fatigue experienced during exercise but also influences the speed and quality of post-exercise recovery.

Therefore, it serves as a fundamental basis for determining exercise intensity, evaluating training outcomes, and designing effective training programs.

2. Importance of Exercise Capacity Assessment

After understanding the significance, principles, and methods of exercise capacity assessment, we need to consider: What can we do for members once we know their exercise capacity?

• **Members with lower exercise capacity**

a. If training intensity exceeds their physical tolerance, they are prone to excessive fatigue and exercise burnout.

b. Movements may lose proper form or stability due to fatigue, which in severe cases can lead to injury or sudden health events.

c. Media reports of issues such as hematuria or fainting after gym workouts are often caused by these factors.

• **Members with higher exercise capacity**

d. If the training intensity is too low, the stimulus is insufficient, making it difficult to achieve expected results.

e. This can negatively impact member experience and the visible outcomes of training, which may affect follow-up services and membership renewal.

3. Determining Exercise Intensity and Training Zones

Appropriate exercise intensity is key to ensuring both safety and effectiveness.

Heart rate is commonly used as the primary monitoring indicator, with different training goals corresponding to specific heart rate zones:

Training Goal	Recommended Heart Rate Zone (as % of Maximum Heart Rate, MHR)
Fat Loss / Aerobic Training	70% – 83% MHR
Cardiopulmonary Fitness / Endurance Training	84% – 90% MHR

4. Maximum Heart Rate (MHR) Calculation

Maximum Heart Rate (MHR) refers to the highest heart rate an individual can reach during maximal exercise, beyond which it will not increase.

It can be estimated using the medical formula:

$$\text{MHR} = 205.8 - 0.685 \times \text{Age}$$

Important Note:

When assessing MHR, blood pressure conditions must also be considered.

Individuals with hypertension should use a lower adjusted MHR to ensure exercise safety and avoid excessive cardiovascular load.

Example:
A 30-year-old member with a resting heart rate of 70 bpm:
MHR = 205.8 − 0.685 × 30 = 185 bpm

Based on this, the training zones can be calculated:

Training Goal	Formula	Heart Rate Zone(bpm)
Fat Burn / Aerobic Zone	(MHR − Resting HR) × 70%–83% + Resting HR	151 – 165
Cardiopulmonary / Endurance Zone	(MHR − Resting HR) × 84%–90% + Resting HR	166 – 173
Warning Zone	> 173	Reduce exercise intensity

Using real-time heart rate monitoring devices allows dynamic adjustment of training intensity, improving safety and the professionalism of personal training sessions.

5. Resting Heart Rate and Training Effect Evaluation

Body composition analyzers can use resting heart rate (RHR) to help evaluate training outcomes:

- **Initial training stage:** RHR = 75 bpm
- **After a period of training:**

RHR drops to 63 bpm → indicates significant improvement in cardiopulmonary function and oxygen utilization.

Conversely, an increase in RHR may suggest a decline in fitness, signaling the need to adjust the training plan.

6. Importance of Blood Oxygen (SpO_2)

Blood oxygen saturation (SpO_2) reflects the body's oxygen supply status.

- **Normal range:** above 95%
- **Below 90%:** may indicate hypoxia or respiratory issues

Reference Blood Pressure Ranges:

- **Too high (near 100%):** not necessarily better; long-term high saturation may accelerate cellular oxidative stress and aging

Monitoring SpO_2 helps assess an individual's exercise load and recovery status.

In summary, exercise capacity evaluation is more than just data collection—it is the foundation of scientific training. By analyzing heart rate, blood oxygen, and resting indicators together, trainers can create personalized programs for members, achieving safe, efficient, and sustainable exercise goals.

Chapter 7
Posture Risk Assessment

Poor posture is not only an aesthetic issue but also a "hidden health risk." In modern lifestyles, maintaining incorrect posture for prolonged periods can have long-term impacts on the skeletal system, muscular balance, and overall health.

To ensure accurate and reliable posture evaluation, our system is built on an advanced three-in-one technical framework:

- AI Skeletal Point Recognition

Accurately identifies key skeletal landmarks to analyze structural alignment and posture deviations.

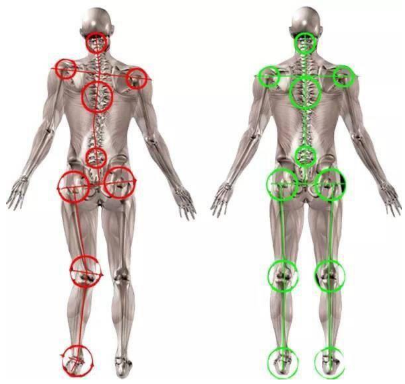
- Segmental Body Composition Analysis

Evaluates muscle and fat distribution across different body regions to uncover imbalances that may contribute to poor posture.

- Human Image Segmentation Technology

Separates the body from complex backgrounds for precise posture extraction.

Through the integration of these three technologies, the system ensures stable and accurate measurement even when clothing styles, lighting conditions, or surrounding environments vary, delivering professional-grade posture assessment in real-world settings.



Special Focus: Posture in Adolescents

The impact of poor posture is particularly significant in adolescents. Studies show that up to 80% of teenagers exhibit postural problems. Abnormal posture can also increase the risk of myopia in adolescents. Parents and schools need to work together to ensure adequate physical activity and to timely remind and correct improper sitting and standing postures.

Posture risk assessment using the device must be performed with a stable network connection. Without connection to the cloud-based posture big data platform, comparative analysis cannot be conducted. The main risk assessments include:

1. Uneven Shoulders

Uneven shoulders refer to a posture issue where the two shoulders are clearly not at the same horizontal level. This condition is mainly caused by poor posture habits, muscle imbalances, spinal scoliosis, congenital skeletal abnormalities, or injuries. Long-term unilateral loading, spinal deformities, or nerve damage can disrupt shoulder balance, and corrective measures should be tailored according to the underlying cause.

1.1 Common Causes Analysis

• Poor Posture Habits

Long-term behaviors such as carrying a one-sided backpack, crossing legs habitually, or leaning to one side while writing can cause continuous tension in the muscles on one side of the shoulder and neck, while passively stretching the muscles on the other side. For example, students or office workers who habitually support their head with one arm are prone to developing uneven shoulders.

• Muscle Strength Imbalance

Unilateral sports (e.g., badminton, tennis) or uneven exertion during workouts can lead to one side of the shoulder and neck muscles, such as the sternocleidomastoid and trapezius, becoming more developed while the other side remains weaker. This strength imbalance can directly shift the position of the scapula.

• Spinal Scoliosis

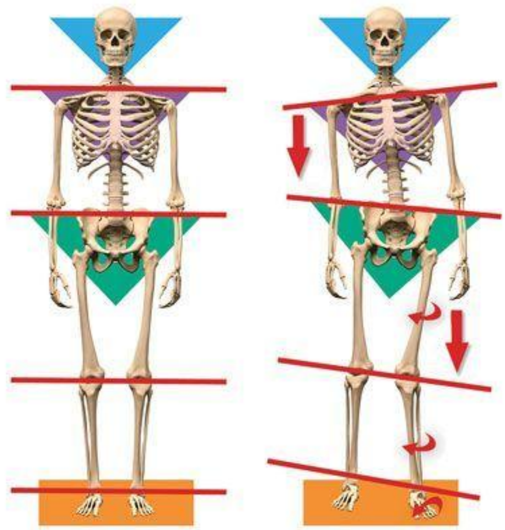
Structural spinal scoliosis (C-shaped or S-shaped curvature) affects the alignment of the ribs and scapula. Lateral curvature in the thoracic spine often causes one scapula to protrude while the opposite shoulder compensates by dropping, creating a noticeable height difference.

• Congenital or Pathological Factors

Congenital skeletal abnormalities, such as unequal clavicle lengths or high scapula (Sprengel’s deformity)

Postural compensation due to pelvic tilt or leg length discrepancy.

Muscle atrophy caused by neurological conditions (e.g., polio sequelae) or injuries.



1.2 Correction and Prevention Recommendations

• Posture Adjustment

Avoid carrying weight on one side for prolonged periods. Use a double-strap backpack adjusted to fit snugly against the back. While working at a desk, keep the computer screen at eye level and take breaks every 30 minutes to move and stretch the shoulders and neck.

• Muscle Balance Training

Strengthen the weaker side: Perform unilateral dumbbell lateral raises or resistance band exercises.

Release tight muscles: Use a foam roller to relax the upper trapezius and stretch the pectoralis minor.

Symmetrical exercises: Engage in full-body coordination workouts such as swimming or Pilates.

• Medical Intervention Timing

If the shoulder height difference exceeds 2 cm, or if there is pain or limited mobility, seek medical attention promptly. For spinal scoliosis over 10°, custom orthotic braces may be required; severe cases could need surgical correction.

• Special Attention for Children and Adolescents

During growth, bones are highly plastic, but this is also a high-risk period for scoliosis. It is recommended to perform posture screenings every six months, keep backpack weight under 10% of body weight, and avoid high pillows during sleep.

Important Note:

Short-term postural shoulder imbalance may improve with behavioral correction, but long-standing uneven shoulders often involve deeper skeletal and muscular issues. Blindly massaging or stretching may worsen the imbalance. It is recommended to develop a correction plan under professional guidance.

2. Risk of X/O-Leg Deformity

The formation of X-shaped (knock-knee) or O-shaped (bow-leg) deformities is generally associated with congenital skeletal development abnormalities, habitual posture issues, muscle strength imbalances, and nutritional deficiencies. It is mainly characterized by outward or inward curvature of the thighs and lower legs, with knees tilting inward (X-leg) or outward (O-leg). This condition is commonly seen in children and adolescents, and some adults may develop it due to long-term postural habits or underlying medical conditions.

2.1 Skeletal Development Abnormalities or Congenital Factors

• **Genetic factors**: A family history of similar leg shapes may increase the risk of developing X- or O-shaped legs through hereditary influence.

• **Fetal development issues**: Inadequate maternal nutrition during pregnancy or pressure on the fetus in the womb can affect the normal growth of lower limb bones.

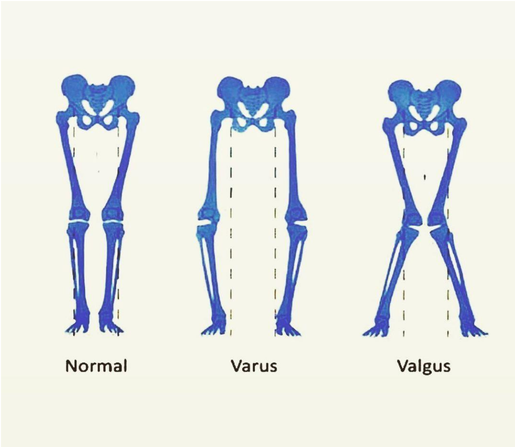
•**Rickets**: Vitamin D deficiency in infancy and early childhood can lead to insufficient calcium absorption, causing bone softening and deformation, which may result in X- or O-shaped legs.

2.2 Muscle Imbalance

• **Tight lateral muscles**: Prolonged sitting, lack of exercise, or poor posture may cause tightness in the outer thigh muscles (e.g., tensor fasciae latae), pulling the knees inward.

• **Weak medial muscles**: Insufficient strength in the inner thigh muscles (e.g., adductor group) cannot counteract the lateral pull, worsening leg alignment.

• **Collapsed arches**: Flat feet or weak arch support can shift lower limb alignment, indirectly contributing to knee inward rotation.



2.3 Acquired Habits and Posture Effects

• **Incorrect sitting posture**: Prolonged kneeling or W-sitting (knees inward, calves outward) increases stress on the knee joints and may affect bone development.

• **Faulty movement patterns**: Running or jumping with knees collapsing inward, or wearing improper footwear (e.g., high heels) over time, can worsen leg deformities.

• **Prolonged standing or improper loading**: Early standing in children, obesity, or carrying heavy loads (e.g., backpacks) for extended periods can place excessive pressure on the lower limb bones.

2.4 Other Factors

• **Injuries or surgery**: Poor recovery after knee or lower limb fractures may alter bone alignment.

• **Arthritis or skeletal disorders**:
Conditions such as rheumatoid arthritis or bone tumors can damage joint structures, leading to leg deformities.

• **Hormonal imbalances**:
Endocrine disorders (e.g., thyroid dysfunction) may affect bone metabolism.

2.5 Age-Related Differences

• **Childhood**: Often physiological genu varum (bowlegs, before age 2) or genu valgum (knock-knees, ages 3–7). Persistence beyond age 8 may indicate pathological factors.

• **Adolescence**: Rapid skeletal growth may not match muscle development, and poor posture can exacerbate leg alignment issues.

• **Adulthood**: Usually related to long-term postural habits, muscle imbalance, or joint degeneration, making correction more difficult.

2.6 Prevention and Improvement Strategies

• **Posture Adjustment**: Avoid W-sitting; distribute weight evenly while standing and reduce unilateral load.

• **Targeted Exercise**: Strengthen inner thigh muscles (e.g., wall sits, clamshell exercises) and stretch outer muscles (e.g., iliotibial band relaxation).

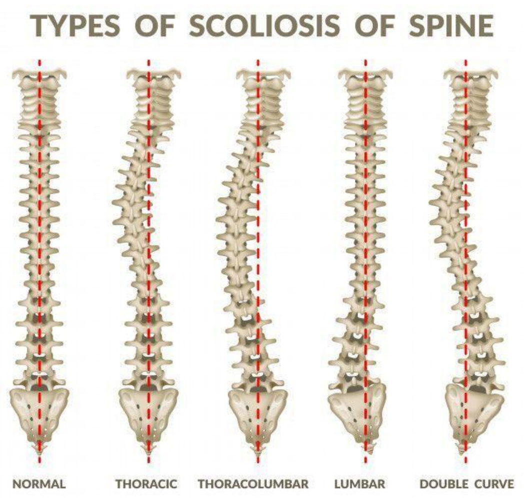
• **Nutritional Support**: Children should ensure adequate calcium and vitamin D intake; adults can use diet or supplements to prevent osteoporosis.

• **Medical Intervention**: Severe cases require professional evaluation and may involve braces, corrective insoles, or surgery (e.g., osteotomy) to improve skeletal alignment.

Note: If XO-type legs are accompanied by pain, limited mobility, or rapid progression, seek medical attention to rule out skeletal disorders or neuromuscular conditions. Mild leg alignment issues can improve with consistent exercise and posture correction, but require long-term adherence.

3. Scoliosis

Scoliosis (lateral curvature of the spine) has complex causes, usually resulting from a combination of factors. Major contributors include congenital spinal malformations, neuromuscular dysfunction, degenerative skeletal changes, and long-term poor posture habits. In some cases, the cause is unknown (idiopathic). Genetics, hormone levels, injuries, or diseases may also play a role, and the specific cause should be analyzed on an individual basis.



3.1 Congenital Factors

Abnormal spinal development during the embryonic stage is a common cause of scoliosis. Examples include vertebral segmentation failure (adjacent vertebrae not fully separated) or vertebral formation defects (such as hemivertebrae or wedge-shaped vertebrae). These types of scoliosis can be detected at birth or in early childhood and may be associated with genetic mutations, though the exact mechanisms remain unclear.

3.2 Neuromuscular Factors

Abnormalities in the muscles or nerves that control spinal balance can lead to asymmetrical muscle strength on either side of the spine, resulting in scoliosis. Examples include:

• **Cerebral palsy or spinal cord injury**: impaired nerve signaling causes muscle spasticity or atrophy.

• **Muscular dystrophy**: muscles gradually lose their ability to support the spine.

• **Post-polio syndrome**: unilateral muscle paralysis creates uneven spinal load.

3.3 Idiopathic Scoliosis

Approximately 80% of scoliosis cases are classified as idiopathic, with causes not yet fully understood. Research suggests potential contributing factors:

• **Genetic predisposition**: individuals with a family history of scoliosis have a significantly higher risk.
• **Hormonal imbalances**: irregular secretion of growth hormone or melatonin may affect spinal development.
• **Asynchronous skeletal growth**: during adolescent growth spurts, differences in the growth rate of vertebrae and intervertebral discs can lead to spinal twisting.

3.4 Degenerative Factors

In middle-aged and older adults, spinal aging may lead to degenerative scoliosis. Key contributing factors include:

• **Intervertebral discdegeneration**: loss of disc elasticity causes collapse of disc spaces and reduces spinal stability.
• **Osteoporosis**: vertebral compression fractures result in spinal deformity.
• **Facet joint degeneration**: hypertrophy of small joints or ligament laxity exacerbates lateral deviation of the spine.

3.5 Other Contributing Factors

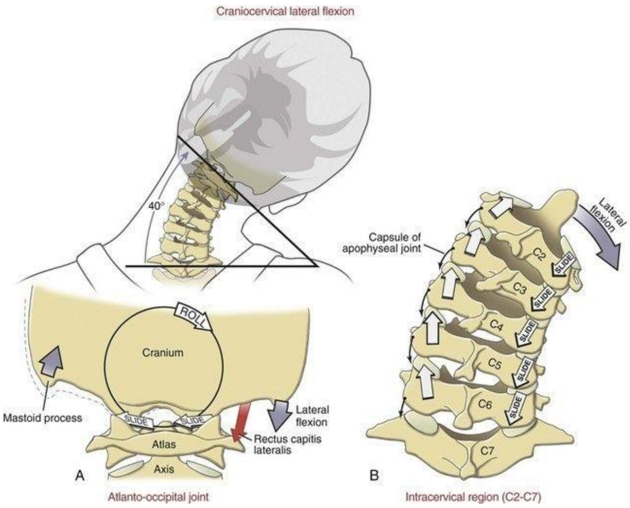
• **Poor posture habits**:
prolonged unilateral loading or slouched sitting can worsen scoliosis, though they rarely cause it alone.
• **Trauma or surgery**:
spinal fractures or vertebral resection can alter spinal mechanics.
• **Disease impact**:
tumors or infections (e.g., spinal tuberculosis) can compromise spinal stability.

3.6 Special Types and Secondary Factors

• **Syndrome-related scoliosis**:
e.g., Marfan syndrome (connective tissue disorder), neurofibromatosis (tumor invasion).
• **Functional compensation**:
leg length discrepancy, pelvic tilt, or other skeletal imbalances that force compensatory spinal curvature.

4. Head Tilt Risk

Head tilt can result from multiple factors, commonly including muscle tension, skeletal abnormalities, nerve injuries, habitual posture, or pathological conditions (e.g., torticollis, cervical spondylosis). It may present as a temporary postural issue or be related to congenital development, trauma, or disease. Assessment should consider symptoms to determine whether medical evaluation is needed.



4.1 Common Causes

• **Musculoskeletal Issues**

a. **Congenital muscular torticollis**: Common in infants and young children, caused by shortening of the sternocleidomastoid muscle, leading to the head being fixed to one side; may be accompanied by a neck lump.

b. **Muscle strain or spasm**: Prolonged one-sided activity (e.g., tilting the head to look at a phone) or sleeping awkwardly can cause neck muscle stiffness and pain, resulting in compensatory head tilt.

c. **Cervical spine abnormalities**: Herniated discs or bone spurs may compress nerves or blood vessels, limiting head movement or causing tilt.

d. **Nervous system injuries**: Stroke or brain injury can impair coordination, manifesting as involuntary head tilt. Peripheral nerve issues, such as facial nerve palsy or cervical nerve damage, may also cause associated numbness or muscle weakness.

• **Habitual or psychological factors**
Long-term one-sided sleeping, improper visual habits (e.g., compensatory head tilt due to strabismus), or unconscious head tilting under stress can form habitual postures.
• **Other pathological factors**

a. **Eye or ear disorders**: Strabismus, amblyopia, or inner ear balance disorders (e.g., Ménière's disease) may lead to head tilt to relieve discomfort.

b. **Infections or tumors**: Cervical lymphadenitis or compressive neck tumors can also cause head tilt.

4.2 Possible Associated Symptoms

• **Pain or limited mobility**: Neck muscle tenderness, difficulty turning the head.

• **Facial asymmetry**: Long-term torticollis may affect facial development.

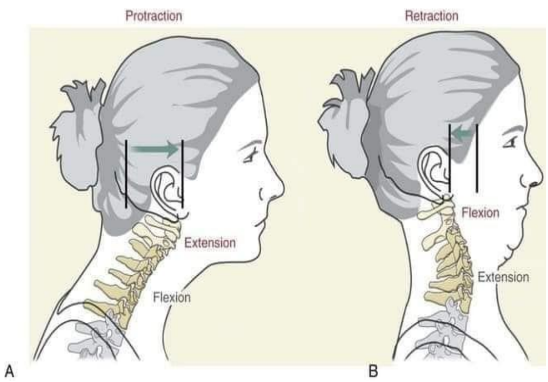
• **Dizziness or blurred vision**: Often related to inner ear or eye disorders.

• **Limb numbness or weakness**: May indicate nerve compression or cervical spine issues.

5. Forward Head Posture Risk

Forward head posture (FHP), also called "anterior head carriage" or "text neck," is a common postural deviation where the head protrudes forward relative to the body's midline.

From a side view, the vertical line from the earlobe falls in front of the acromion (the highest point of the shoulder), failing to align vertically with the ground. FHP often occurs together with rounded shoulders and thoracic kyphosis, collectively referred to as "Upper Crossed Syndrome."



5.1 Common Causes

Forward head posture (FHP) usually results from multiple contributing factors rather than a single cause:

• **Prolonged poor posture:** This is the most common reason. Extended periods of looking down at phones or computers, or excessive forward lean during desk work, keep the anterior neck muscles chronically tight while the posterior muscles are passively lengthened, leading to muscular imbalance.

• **Incorrect movement patterns:** During strength training or lifting, over-reliance on neck and shoulder muscles for compensation can exacerbate forward head posture.

• **Abnormal breathing patterns:** Shallow, chest-dominant breathing frequently engages the accessory neck muscles, which can pull the head forward over time.

• **Physiological and developmental factors:** In children and adolescents, incomplete musculoskeletal development, or structural issues such as flat feet affecting body alignment, may contribute to unconscious forward head positioning to maintain balance.

5.2 Possible Associated Symptoms

If forward head posture (FHP) is not corrected over time, it may lead to a range of discomforts and functional issues, from localized pain to systemic effects:

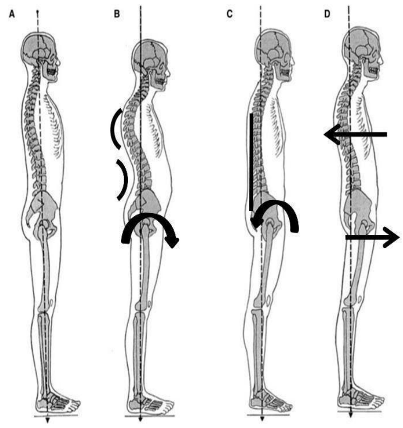
• **Musculoskeletal discomfort:** The most common symptoms are stiffness and soreness in the neck and shoulders, which may extend to the upper back, causing thoracic or dorsal pain.

• **Neurological and vascular symptoms:** Changes in cervical spine curvature can compress nerves or blood vessels, leading to headaches, dizziness, numbness in the hands, or reduced cerebral blood flow, which may cause difficulty concentrating and fatigue.

• **Other impacts:** Severe FHP can limit cervical mobility and interfere with normal breathing patterns, resulting in shallower respiration.

6. Kyphosis Risk

Kyphosis (excessive thoracic spine curvature) commonly results from poor posture, skeletal development abnormalities, neuromuscular disorders, age-related degeneration, or psychological factors. It is characterized by a rounded back and may be accompanied by pain or limited mobility. Intervention should target the underlying cause for effective correction or treatment.



6.1 Poor Posture and Muscle Imbalance

Prolonged forward head posture, slouching, or hunching are the most common causes of kyphosis. Examples include:

• **Electronic device habits:** Long periods of looking down at phones or computers can lead to forward head posture and thoracic spine rounding.

• **Weak back muscles:** Sedentary lifestyles with limited exercise can result in tight chest and anterior neck muscles, while the back and scapular muscles become weak, contributing to rounded shoulders and kyphosis.

• **Adolescent habitual posture:** During skeletal development, failure to correct sitting habits or carrying overly heavy backpacks may accelerate spinal curvature.

6.2 Skeletal Structural Abnormalities

Developmental issues or pathological changes in the skeleton can alter spinal mechanics:

• **Scheuermann's disease (juvenile kyphosis):**
Wedge-shaped deformities of the thoracic vertebrae during adolescence lead to progressive kyphosis.

• **Osteoporosis:**
Reduced vertebral bone density in older adults increases the risk of compression fractures, resulting in forward spinal curvature.

• **Congenital spinal deformities:**
Conditions such as spina bifida or hemivertebrae present at birth with abnormal spinal curvatures.

6.3 Neuromuscular Disorders

Abnormalities in the nerves or muscles that control the spine can lead to kyphosis:

• **Cerebral palsy or muscular dystrophy:**
Muscle tone abnormalities or weakness prevent maintenance of normal spinal curvature.

• **Parkinson's disease:**
Rigidity of trunk muscles and reduced postural control cause forward-leaning posture.

• **Spinal cord injury or infections:**
Compromise spinal stability, potentially resulting in secondary structural kyphosis.

6.4 Age-Related Degenerative Changes

Degeneration of intervertebral discs and ligaments is a primary cause of kyphosis in older adults:

• **Disc dehydration and thinning:**
Reduced disc height increases thoracic curvature.

• **Ligament laxity:**
Decreased elasticity of posterior thoracic ligaments (e.g., ligamentum flavum) makes it harder to maintain upright posture.

• **Thoracic joint degeneration:**
Osteoarthritis limits mobility, resulting in a compensatory forward-flexed posture.

6.5 Psychological Factors

Emotional states or behavioral habits can indirectly affect posture:

• **Low self-esteem or depression:**
Prolonged slouching or shoulder- hunching as a "protective posture" can reinforce kyphotic curvature.

• **Abnormal breathing patterns:**
Anxiety-induced shallow breathing may limit thoracic expansion, exacerbating rounded shoulders.

6.6 Prevention and Improvement Recommendations

• **Posture adjustment:**
Keep the ear, acromion (shoulder peak), and hip aligned vertically; ensure the computer screen is at eye level.

• **Targeted exercises:**
Strengthen rhomboids and middle/lower trapezius (e.g., YTWL exercises), and stretch pectoralis major and sternocleidomastoid muscles.

• **Timely medical consultation:**

Adolescents with sudden kyphosis or pain should be evaluated for Scheuermann's disease; older adults should monitor bone density regularly.

• **Assistive tools:**

Severe cases may use corrective braces short-term, combined with muscle training to avoid dependency.

• **Red flags:**

Rapid progression of kyphosis or accompanying neurological symptoms (e.g., limb numbness) requires prompt medical evaluation to rule out conditions such as ankylosing spondylitis or tumors.

7. Anterior and Posterior Pelvic Tilt

The relative severity of anterior versus posterior pelvic tilt cannot be directly compared, as both can lead to pain, postural abnormalities, or functional impairments. The specific impact should be assessed based on individual factors, such as tilt angle, duration, and degree of muscular imbalance. The key concern is whether the pelvic deviation from the neutral position triggers compensatory postural adaptations or affects organ function, rather than simply determining which type is "more dangerous."

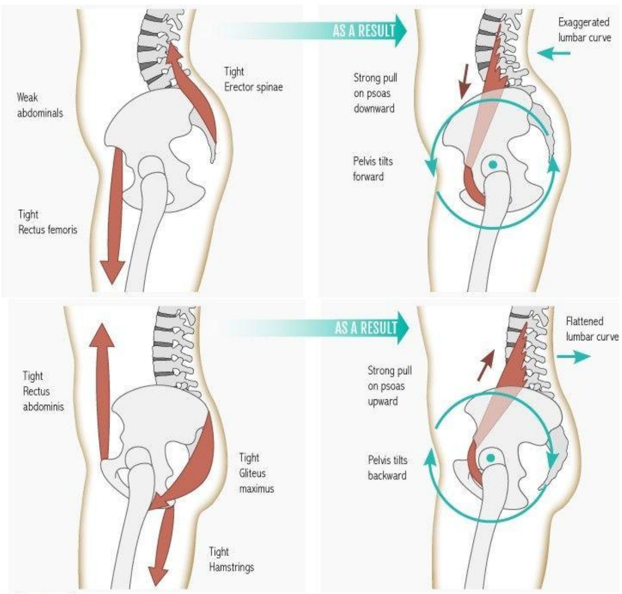


Photo Credit: sequencewiz.org

7.1 Manifestations and Causes of Anterior and Posterior Pelvic Tilt

• **Anterior Pelvic Tilt**

a. **Manifestation:** Excessive lumbar lordosis (arched lower back), protruding buttocks, forward-tilted abdomen, sometimes presenting a "pseudo-buttocks" appearance.

b. **Causes:** Prolonged sitting leading to tight iliopsoas muscles and weak gluteal and abdominal muscles; other contributing factors include long-term high-heel use or obesity.

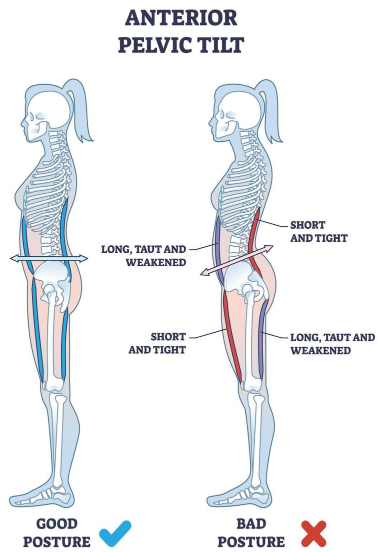
• **Posterior Pelvic Tilt**

a. **Manifestation:**

Flattened or reversed lumbar curve (kyphotic posture), flattened buttocks, posterior-shifted center of gravity, often accompanied by rounded shoulders or forward head posture.

b. **Causes:**

Chronic poor sitting posture (e.g., slouching), weak core muscles, tight hamstrings, and other muscular imbalances.



7.2 Potential Risks Comparison of Pelvic Tilt

• **Anterior Pelvic Tilt – Common Impacts:**

a. **Increased lumbar stress:**

Excessive lumbar lordosis increases posterior intervertebral disc pressure, potentially causing chronic low back pain or disc herniation.

b. **Knee joint compensation:**

Forward-shifted center of gravity may lead to knee hyperextension, increasing joint wear.

c. **Risk of visceral prolapse:**

Weak abdominal muscles can contribute to organ displacement or reduced pelvic floor function.

• **Posterior Pelvic Tilt – Common Impacts:**

a. **Impaired lumbar function:** Flattened lumbar curve reduces spinal shock absorption, predisposing to lumbar muscle strain or sciatica.
b. **Thoracic compensation:** Rounded back may limit respiratory function and cause shoulder/neck discomfort.

7.3 Assessing the Severity of Pelvic Tilt Risks

To evaluate how seriously pelvic tilt affects an individual, pay attention to the following indicators:

• **Pain frequency and location:** Monitor if low back, knee, or shoulder/neck pain is persistent or worsening.

• **Movement limitations:** Check for discomfort during bending, prolonged sitting, or walking.

• **Postural compensations:** Observe if other postural issues appear, such as scoliosis or XO-shaped legs.

• **Organ function changes:** Note signs like constipation, urinary frequency (from weakened pelvic floor), or shortness of breath (due to restricted thoracic mobility).

7.4 Adjustment and Prevention Recommendations

• Targeted Exercises

a. **Pelvic anterior tilt:**

Stretch the iliopsoas, strengthen glutes and abdominal muscles.

b. **Pelvic posterior tilt:**

Stretch the hamstrings, activate core and back muscles.

c. **Recommended movements:**

Dead bug, glute bridge, cat-cow stretch, and other core/hip mobility exercises.

• Daily Habit Improvements

a. Avoid prolonged sitting; stand up and move every 30 minutes.
b. Use ergonomically designed chairs.
c. Minimize high-heel use; choose supportive flat shoes.

• Professional Intervention

a. If pain or limited mobility occurs, consult a rehabilitation physician or physical therapist.
b. Professional guidance may include manual correction or equipment-assisted training to restore neutral pelvic alignment.

8. Knee Hyperextension

Knee hyperextension refers to the condition where the knee joint extends beyond its neutral position by more than 5 degrees during standing or movement. It is mainly caused by muscle imbalance, ligament laxity, postural abnormalities, or incorrect movement patterns. The following analyzes common causes from different perspectives.

8.1 Muscle Imbalance and Weakness

• Tight or Overactive Quadriceps

Prolonged tension in the front thigh muscles (quadriceps) can pull the tibia forward, causing the knee to “lock” backward. This is common among people who sit for long periods or engage in exercise without proper stretching.

• Weak Hamstrings and Gluteal Muscles

Insufficient strength in the hamstrings (back thigh) and gluteal muscles cannot counterbalance the pull of the quadriceps, leading to decreased knee stability.

• Compensation by Calf Muscles

Overactivation of the gastrocnemius may force the knee joint backward, resulting in a hyperextension compensation gait.

8.2 Joint Structure Issues

• Ligament Laxity

Congenital or acquired laxity (e.g., due to injury) of the joint capsule or anterior cruciate ligament can increase the risk of knee hyperextension.

• Abnormal Bone Alignment

Issues such as anterior pelvic tilt, femur forward shift, or posterior tibial tilt can alter knee joint loading, potentially triggering hyperextension.

8.3 Posture and Movement Pattern Errors

• Prolonged Poor Posture

Habitually “locking” the knees when standing (pushing the knees backward), shifting weight to the heels, or wearing high heels that move the center of gravity forward can all contribute to hyperextension.

• Compensatory Movements During Exercise

Activities such as overextending the leg during running, or deliberately straightening the knees in dance or yoga, may overload the joint.

• Foot Issues

Flat feet, high arches, or limited ankle mobility can cause lower limb alignment deviations, forcing the knee into hyperextension to maintain balance.

8.4 Neuromuscular Control and Proprioception Abnormalities

• **Reduced Proprioception**
When the nervous feedback around the knee joint is impaired, the body cannot accurately sense joint position, leading to insufficient control.

• **Poor Motor Coordination**
During movements such as jumping or deep squats, incorrect muscle activation sequence (e.g., knee flexion occurs before the glutes engage) can increase stress on the knee joint.

8.5 Other Potential Factors

• **Excess Body Weight**
Increases load on the knee joint, accelerating compensatory hyperextension.

• **Post-Injury or Surgical Sequelae**
Incomplete recovery of tissues around the knee may leave residual stability issues.

• **Genetic Factors**
Some individuals are naturally more flexible in their joints, making them more prone to hyperextension.

Chapter 8
Body Circumference Measurement

Traditional body circumference measurement methods often rely on **optical 3D scanning**, which has a major limitation—**clothing significantly affects accuracy**. When the subject wears thick or layered clothing, the measurement results become largely unreliable.

To address this issue, **Anovator Medical** has developed an **innovative multi-technology fusion approach** for human body circumference measurement.z

First, we use **binocular optical cameras** to capture **3D body data** through multi-frame data accumulation. Then, we apply **AI-based human skeleton point detection** and **image segmentation** to perform initial data correction.

Next, we combine these results with **five-segment body composition analysis**—including **fat and muscle distribution** across different body regions—to further refine the circumference data. Finally, **AI algorithms** perform **deep correction** of body circumference values, minimizing interference from factors such as **strong lighting** and **clothing** that typically affect conventional measurements.

In summary, our advanced body circumference system integrates **binocular 3D vision**, **AI image segmentation**, **AI skeletal point detection**, and **multi-segment body composition analysis**. Compared to single-technology solutions currently available on the market, this approach offers **greater stability, higher reliability, and improved accuracy**, while requiring **fewer environmental constraints**.

The **measurement accuracy** of our system is guaranteed to be within **±2 cm**.

Measurement Sites and Verification Methods

To ensure the accuracy and consistency of body circumference measurements, each measurement site follows specific anatomical positioning and standardized procedures:

• **Chest Circumference (Bust)**

Positioning: Place the measuring tape horizontally under the armpits, passing over the fullest part of the chest.

Technique: The tape should fit snugly without compressing the skin. Maintain a level line parallel to the ground around the torso.

• **Waist Circumference**

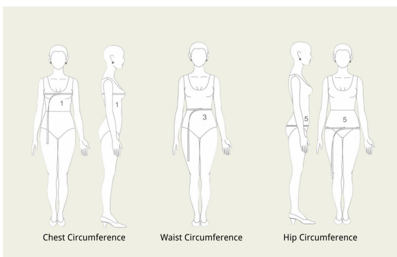
Positioning: Approximately **2–3 cm above the navel**, around the midpoint between the **lowest rib** and the **iliac crest** (top of the hip bone).

Technique: Measure at the end of a **normal exhalation**, with the tape in light contact with the skin (not tight). Record the value at the end of exhalation.

• **Hip Circumference**

Positioning: With feet together and body upright, measure around the **most prominent point of the buttocks**.

Technique: Keep the tape horizontal, passing through the **highest point of the gluteal contour**.



• **Other Circumference Measurements**

Thigh Circumference:
Stand with feet shoulder-width apart and measure around the **thickest part of the upper thigh** near the groin.
Calf Circumference:
Measure horizontally around the **widest part of the calf**.
Arm Circumference:
With the arm relaxed and hanging naturally, measure around the **peak of the biceps** at its most prominent point.

• **Measurement Precautions**

The body should remain **relaxed and natural** during all measurements.

Keep an **upright posture**, with arms hanging naturally and eyes looking forward.

Ensure the measuring tape is **level, snug but not tight**, and parallel to the ground at each site.

Chapter 9
Balance Ability Assessment

Balance ability is essential for maintaining posture and controlling body movements. It plays a vital role in daily life and is particularly important in **fall prevention for older adults**, **athletic training**, and **rehabilitation therapy**.

It is important to note that the current assessment focuses on **static balance ability**—the body's capacity to maintain stability in a fixed position without movement. This evaluation primarily reflects the following three physiological aspects:

• **Sensory systems:**
visual adjustment system, proprioceptive system, and vestibular system
• **Central nervous system integration:**
coordination and processing of balance-related information
• **Motor control:**
static balance depends on **isometric muscle contractions**, while dynamic balance requires **isotonic muscle contractions**

The **measurement principle** involves recording the **magnitude of the body's center-of-gravity sway over a 10-second period**. The greater the degree of sway, the **poorer the balance ability**.

Relevant References:

Validity and Reliability of Dynamic and Functional Balance Tests in People Aged 19-54: A Systematic Review

Review of the Upright Balance Assessment Based on the Force Plate

Basic Measurement Procedure:

During the test, the participant should **remove their shoes and stand barefoot** on the weight measurement area. The **hands are clasped together**, and **one leg is lifted** so that the lower leg is **parallel to the ground**. The participant should **close their eyes and maintain the posture**, while ensuring safety—an assistant should be present nearby to **prevent falls**.

If the participant shows significant body sway with eyes closed, the test can be **repeated with eyes open** to compare results and assess the **compensatory role of vision** in maintaining balance.

Individuals with **arthritis** or **lower limb injuries** are **not suitable** for this test; instead, they may perform the test **with eyes open** or for a **shorter duration**.

For **children under six years old**, whose neural and muscular control systems are still developing, balance should be assessed **in the eyes-open condition** for more accurate and safer results.

Chapter 10
Agility and Reaction Ability Assessment

Agility and reaction ability are evaluated from two key dimensions—**agility** and **reaction speed**.**Agility** refers to the body's comprehensive ability to perform movements **quickly, accurately, and in a coordinated manner** when responding to sudden or changing conditions. **Reaction speed**, in contrast, describes the brain's ability to **rapidly process external stimuli** and **transmit neural commands** to the body. The essential difference between the two lies in their focus: agility emphasizes **the overall coordination of movement execution**, while reaction speed highlights **the responsiveness of the nervous system**. The measurement of agility and reaction ability is primarily applied in the following areas:

• **Assessing Athletic Performance**
By testing indicators such as **reaction speed** and **body coordination**, agility assessments provide a comprehensive understanding of an individual's physical performance. These

results help in designing **personalized training programs** to enhance movement skills and overall fitness.

• **Predicting Health Risks**

Research indicates a link between **reaction speed and life expectancy**. Individuals with slower reaction times may face up to a **25% higher risk of premature mortality**, primarily related to **cognitive decline**, **reduced balance ability**, and **increased risk of accidental injuries**.

• **Supporting Medical Diagnosis**

Reaction time testing can assist in diagnosing **neurological disorders** such as **Alzheimer's disease**, and is also applied in **occupational assessments** for professionals like pilots and athletes, where rapid response capability is critical.

• **Optimizing Training Effectiveness**

Data from agility and reaction measurements can guide **targeted training improvements**—for example, using **interval sprint drills** or **finger-tapping exercises** to enhance **muscle coordination** and **movement precision**.

In the system, **agility and reaction standards** vary by **age group**—adults are generally expected to perform at higher levels than children.For **adults**, a **reaction time under 550 milliseconds** is considered normal.A **reaction time below 500 milliseconds** indicates **good reaction ability**.**Elite athletes** typically achieve reaction times of **450 milliseconds or faster**.

Relevant References:

Reliability of the Dynavision™ D2 for Assessing Reaction Time Performance

The Effect of Using Reactive Agility Exercises with the FITLIGHT Training System on the Speed of Visual Reaction Time and Dribbling Skill of Basketball Players

Chapter 11
Lung Capacity Assessment

Lung capacity is a key indicator of **respiratory system function** and **cardiopulmonary endurance**, measuring the maximum volume of air that can be exhaled after a full inhalation. It is closely linked to **cardiopulmonary health**, **metabolic efficiency**, and **exercise performance**, and is often used to evaluate an individual's overall physiological condition and potential health risks.

Lung capacity standards vary across age groups in children. For healthy adults, the typical ranges are:

• **Men:** approximately **3,500–4,500 mL**

• **Women:** approximately **2,500–3,500 mL**

These values fluctuate based on **age, sex, height, weight**, and **general health status**.

1.Core Significance of Lung Capacity

1.1 Reflects Respiratory System Function

Lung capacity directly represents the ventilatory ability of the lungs. A higher value indicates a greater capacity to **inhale oxygen** and **exhale carbon dioxide**, supporting stronger metabolic function.

1.2 Assesses Cardiopulmonary Endurance

Individuals with stronger cardiopulmonary function—such as athletes—tend to have higher lung capacity, allowing for **more efficient oxygen delivery to muscles** during exercise and **delayed fatigue onset**.

1.3 Warns of Potential Health Issues

A significant decline in lung capacity may be associated with **pulmonary diseases** (e.g., asthma, pulmonary fibrosis), **cardiac disorders**, or **muscle weakness**. It serves as an important reference for **early screening of chronic conditions**.

2. Key Factors Affecting Lung Capacity

2.1 Physiological Factors

As people age, the **elasticity of lung tissue decreases**, leading to a natural decline in lung capacity. Taller individuals generally have **larger thoracic volumes**, which often correspond to greater lung capacity.

2.2 Lifestyle Habits

Smoking, **physical inactivity**, and **obesity** can significantly reduce lung capacity, while **regular exercise**—especially **aerobic activities**—can greatly enhance it.

2.3 Diseases or Injuries

Conditions such as **lung infections**, **thoracic deformities**, and **respiratory muscle weakness** can directly impair lung function and reduce lung capacity.

3.Practical Applications of Lung Capacity

3.1 Health Examinations

As a standard part of routine medical checkups, lung capacity testing helps detect early signs of respiratory diseases or abnormalities in cardiopulmonary function.

3.2 Fitness and Athletic Assessment

In athlete selection or fitness program design, lung capacity serves as a key indicator of overall physical endurance and aerobic performance.

3.3 Disease Monitoring

Patients with **Chronic Obstructive Pulmonary Disease (COPD)** should undergo regular lung capacity testing to evaluate disease progression and the effectiveness of treatment interventions.

4.How to Improve Lung Capacity Scientifically

4.1 Aerobic Exercise

Activities such as **running**, **swimming**, and **cycling** help strengthen cardiovascular and respiratory function. With consistent practice over time, these exercises can gradually increase lung capacity.

4.2 Breathing Training

• Diaphragmatic (Abdominal) Breathing:
Engage the diaphragm to expand lung volume and improve breathing efficiency.

• Deep Breathing Exercises:
Inhale slowly, hold your breath for a few seconds, and then exhale gently. Repeat several times a day to enhance lung control and endurance.

4.3 Avoid Unhealthy Habits

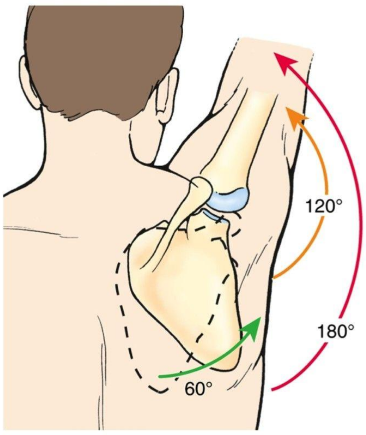
Quit smoking, minimize exposure to air pollution, and maintain respiratory health through clean air and healthy lifestyle choices.

Chapter 12
Shoulder Joint Range of Motion

Shoulder joint range of motion (ROM) assessment is commonly used to evaluate the functional condition and mobility of the shoulder. This examination helps clinicians determine whether a patient has shoulder pain, stiffness, or other functional impairments.

In our system, **AI-based 3D motion capture technology** is used to track the movement trajectory of the shoulder, allowing for an accurate assessment of whether the range of motion is within the normal range.

Shoulder ROM evaluation is an important diagnostic method that assists healthcare professionals in understanding the patient’s shoulder condition and developing appropriate treatment or rehabilitation plans.



Practical Tips for Improving Posture

• Strengthen Core Muscles:
The core serves as the body’s natural “belt” for maintaining proper posture. Exercises such as **planks** and **glute bridges** can effectively enhance core stability and strength.

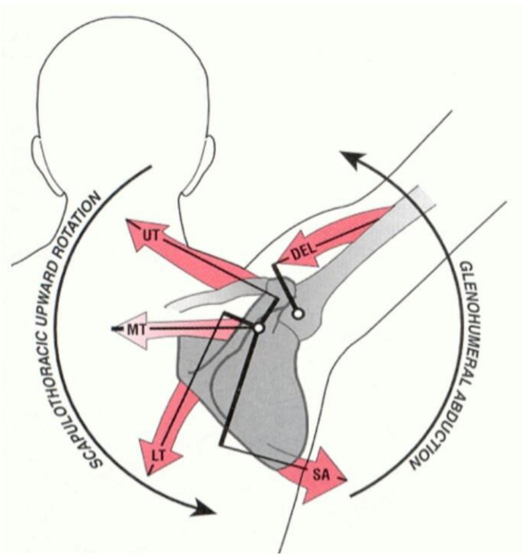
• Stretch Tight Muscles:
Regularly stretch muscles that tend to stay tense—such as the **pectoralis major** and **posterior neck muscles**—to help restore joint balance and improve alignment.

• Optimize Daily Habits:

a. **Sitting posture:** Keep your back straight and your thighs at a 90° angle to your torso. The top of your computer screen should be at or slightly below eye level. You may place a cushion behind your lower back for support.

b. **Standing posture:** When viewed from the side, the **ear, shoulder, hip, knee, and ankle** should align in a nearly straight line.

c. **Avoid prolonged sitting:** Stand up and move around every **30–45 minutes**, stretching your neck and shoulders to relieve tension.



• **Seek Professional Guidance:**

If poor posture has led to persistent pain or self-correction efforts prove ineffective, consult a **physical therapist** or a **qualified fitness trainer**. They can provide targeted assessments and personalized corrective training programs.

Chapter 13
The Science Behind BIA

This chapter is designed to help readers gain a deeper understanding of the core principle behind body composition analysis—**Bioelectrical Impedance**

Analysis (BIA).

Mastering this principle enables more accurate interpretation of test results, better evaluation of data reliability, and clearer communication of the technology's advantages to clients.

1.Operating Conditions

During bioelectrical impedance testing, **environmental conditions** and **power supply parameters** directly affect measurement accuracy and stability.

The **ANOVATOR** device is designed and manufactured in strict compliance with **national medical device standards**, with the following optimal operating conditions:

a) **Ambient Temperature:** 10°C–40°C

- Low temperatures increase skin resistance; excessively high temperatures affect the linear response of the sensors.

b) **Relative Humidity:** Below 80% (non-condensing)

- Avoid moisture condensation on the electrode surface to prevent current leakage.

c) **Atmospheric Pressure:** 70–106 kPa

- Ensures stable electrode contact pressure and uniform current distribution.

d) **Rated Voltage and Frequency:** 100–240 VAC, 50/60 Hz, 1.3–0.6 A

- Compatible with global power standards, featuring built-in **power filtering** and **voltage stabilization** technology.

2.ANOVATOR Frequency Overview

The ANOVATOR Body Composition Analyzer uses advanced multi-frequency bioelectrical impedance analysis (BIA) to deliver highly accurate body composition measurements.

Frequency Bands by Model

Earlier models (before 2025): Dual-frequency
20 kHz, 100 kHz

Current multi-frequency models:
All-series: Three-frequency
20 kHz, 100 kHz, 250 kHz

M7: Six-frequency
1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, 1000 kHz

M9: Eight-frequency
1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, 1000 kHz, 2000 kHz, 3000 kHz

The higher the frequency band, the deeper and more precise the current penetration, allowing richer analysis of intracellular and extracellular fluid distribution.

Why Multi-Frequency Matters

There is a direct relationship between ion concentration and electrical conductivity, and an inverse relationship between ion concentration and impedance.

BIA works by sending a small, constant alternating current through the excitation electrodes and measuring voltage via the sensing electrodes, generating impedance data used to estimate water distribution, fat mass, and muscle status.

Different frequencies penetrate the body differently:

• Low Frequency (1 kHz, 5 kHz, 20 kHz)
The current does not effectively penetrate cell membranes.
Reflects: Extracellular water (ECW) impedance
Application:
Edema detection
Extracellular fluid balance

• Mid Frequency (50 kHz, 100 kHz)
The current partially penetrates cell membranes.
Reflects: ECW + partial intracellular water (ICW)
Application:
Aligns with traditional industry standard
Useful for general body composition estimation with improved accuracy

• High Frequency (250 kHz, 500 kHz, 1000 kHz)
The current fully or almost fully penetrates cell membranes.
Reflects: Total Body Water (TBW = ECW + ICW)
Application:
Differentiating ECW and ICW
Accurate muscle mass and metabolic assessments

• Ultra-High Frequency (2000 kHz, 3000 kHz) – M9 Exclusive
Provides deep penetration and higher sensitivity to intracellular components.
Application:
More precise ICW estimation
Higher accuracy in athletes or individuals with high muscle mass
Improved modeling for metabolic rate and cellular health indicators

3.Impedance Ranges for Different Body Segments

BIA measurements provide not only total body impedance but also **segmental analysis**, which evaluates the electrical impedance characteristics of the **trunk, upper limbs, and lower limbs** separately.

Differences in impedance values among body segments are determined by variations in **muscle mass, water distribution, and cross-sectional are.**

3.1 Allowable Error Standards for Segmental Impedance Measurements

Item	Measurement Range	Reference Points	Maximum Allowable Error
Trunk Impedance	10–68 Ω	10Ω, 20Ω, 30Ω, 43Ω, 56Ω, 68Ω	±1% or ±1Ω (whichever is greater)
Left Arm Impedance	100–680 Ω	150Ω, 200Ω, 330Ω, 390Ω, 510Ω, 680Ω	±1%
Right Arm Impedance	100–680 Ω	150Ω, 200Ω, 330Ω, 390Ω, 510Ω, 680Ω	±1%
Left Leg Impedance	100–680 Ω	150Ω, 200Ω, 330Ω, 390Ω, 510Ω, 680Ω	±1%
Right Leg Impedance	100–680 Ω	150Ω, 200Ω, 330Ω, 390Ω, 510Ω, 680Ω	±1%

3.2 Physiological Patterns of Segmental Impedance

• **Arm impedance** is typically higher than **leg impedance** due to smaller cross-sectional area and lower muscle mass.

• **Trunk impedance** is the lowest, generally ranging between **10–40 Ω**.

• Under the same body weight, a **higher muscle mass** corresponds to **lower impedance**.

• Segmental impedance is **inversely proportional to cross-sectional area** and **directly proportional to tissue conductivity**.

4.Systematic Errors and Calibration in Impedance Measurement

To ensure data consistency, **ANOVATOR** has established an **automatic calibration system** that includes the following mechanisms:

• **Automatic channel impedance drift detection** each time the device is powered on;
• **Regular software self-checks** and comparison with standard resistance modules;
• **Quarterly manual verification** is recommended to maintain measurement accuracy within **±1%**.

5.Case Study: From Impedance to Health Insights

In a longitudinal study involving 500 fitness club members, researchers observed that:

When the ratio of intracellular water to extracellular water (ICW/ECW) drops below **0.75**, it often indicates impaired cellular function or a state of chronic fatigue. Conversely, individuals with a ratio above **0.8** tend to exhibit better muscle activity and higher metabolic levels.

This finding demonstrates that multi-frequency BIA not only reflects body composition but also serves as an early indicator of overall health status.

Final Chapter
Key Training Points

Throughout the entire training process, agents should focus on mastering the following three areas:

1.Understanding the Health Implications Behind the Data

Each measurement is more than just a number—it serves as a reference for assessing an individual's health status and potential intervention strategies. By comprehensively analyzing data such as body fat percentage, muscle mass rate, basal metabolic rate, and waist-to-hip ratio, agents can provide clients with scientific and actionable health guidance.

2.Mastering the Technical Principles

Become familiar with BIA multi-frequency measurement, segmental analysis, and instrument error ranges. Understand how different frequencies and segmental impedance contribute to body composition analysis. A solid grasp of these principles enables professional and confident data interpretation for clients, enhancing trust and credibility.

3.Keeping Up with Industry Trends and Applications

Gain insight into the development of body composition analysis, market dynamics, and emerging technologies—including portable devices, smart systems, medical-grade applications, and AI-driven health data management. Understanding industry trends supports business expansion, client education, and the continuous improvement of professional services.

ANOVATOR | Human Composition Analysis Handbook

Note: This handbook is intended for educational and training purposes only. Reproduction or excerpting without authorization is prohibited.

REFERENCES

1. Norkin, C. C., & White, D. J. (2016).

Measurement of Joint Motion: A Guide to Goniometry. F.A. Davis.

2. Kendall, F. P., McCreary, E. K., Provance, P. G., Rodgers, M. M., & Romani, W. A. (2005).

Muscles: Testing and Function, with Posture and Pain. Lippincott Williams & Wilkins.

3. Schamberger, W. (2012).

The Malalignment Syndrome: Implications for Medicine and Sports. Elsevier Health Sciences.

4. Kritz, M., Cronin, J., & Hume, P. (2009).

The bodyweight squat: A movement screen for the squat pattern. Strength and Conditioning Journal, 31(1), 76–85.

5. Cook, G., Burton, L., & Hoogenboom, B. (2006).

Pre-participation screening: The use of fundamental movements as an assessment of function–Part 1 & 2. North American Journal of Sports Physical Therapy, 1(2), 62–72.

6. Lee, J., Hong, Y., Kim, J., Kim, J., & Koo, C. (2021).

A review on posture analysis technology for physical human health. Sustainability, 13(3), 1479.

7. Xu, Y., et al. (2022).

Human posture recognition and risk assessment using deep learning: A systematic review. Computers in Biology and Medicine, 146, 105576.

8. Lesch KJ, Tuomisto S, Tikkanen HO, Venojärvi M. Validity and Reliability of Dynamic and Functional Balance Tests in People Aged 19-54: A Systematic Review. Int J Sports Phys Ther. 2024 Apr 1;19(4):381-393. doi: 10.26603/001c.94612. PMID: 38699672; PMCID: PMC11065456.

9. Chen B, Liu P, Xiao F, Liu Z, Wang Y. Review of the Upright Balance Assessment Based on the Force Plate. Int J Environ Res Public Health. 2021 Mar 8;18(5):2696. doi: 10.3390/ijerph18052696. PMID: 33800119; PMCID: PMC7967421.

10. Wells AJ, Hoffman JR, Beyer KS, Jajtner AR, Gonzalez AM, Townsend JR, Mangine GT, Robinson EH 4th, McCormack WP, Fragala MS, Stout JR. Reliability of the dynavision™ d2 for assessing reaction time performance. J Sports Sci Med. 2014 Jan 20;13(1):145-50. PMID: 24570618; PMCID: PMC3918550.

11. Hassan AK, Alhumaid MM, Hamad BE. The Effect of Using Reactive Agility Exercises with the FITLIGHT Training System on the Speed of Visual Reaction Time and Dribbling Skill of Basketball Players. Sports (Basel). 2022 Nov 14;10(11):176. doi: 10.3390/sports10110176. PMID: 36422946; PMCID: PMC9695455.

12. American Thoracic Society / European Respiratory Society (ATS/ERS) Task Force. Standardisation of spirometry. Eur Respir J. 2005;26(2):319-338

13. Graham BL, et al. Standardization of Spirometry 2019 Update. An Official ATS/ERS Technical Statement. Am J Respir Crit Care Med. 2019;200(8):e70-e88.

14. Quanjer PH, et al. Multi-ethnic reference values for spirometry for the 3–95 yr age range: the Global Lung Function 2012 equations. Eur Respir J. 2012;40(6):1324-1343.

15. Norkin CC, White DJ. Measurement of Joint Motion: A Guide to Goniometry. 5th ed. Philadelphia: F.A. Davis; 2016.

16. American Academy of Orthopaedic Surgeons (AAOS). Joint Motion: Method of Measuring and Recording. 1965.

ANOVATOR

Founded in 2013, ANOVATOR is a global leader in human medical data services. We are dedicated to delivering precise, scientific, comprehensive, and accessible human data solutions for the healthcare sector and related industries.

Integrating R&D, manufacturing, brand promotion, and global sales, ANOVATOR is a specialized enterprise in the medical device sector. We remain committed to independent innovation in core technologies and hold dozens of patents and software copyrights. Several of our products have reached internationally recognized medical standards.

ADDRESS: **WB2-7F,CLP Information Port,Wuhan,Hubei,China**

OFFICIAL WEBSITE: **WWW.ANOVATOR.COM**

EMAIL: **info@anovator.com**

ANOVATOR APP