Condition Support Guide for Girls in School-Based Sport Club Activities

To all those who teach and support girls in school-based sport club activities

The middle and high school age (adolescence) is an important time when young girls' bodies transition into adulthood

The adolescent stage of middle and high school students is in a process of "growth" in which the body grows and "maturity" in which the body is enhanced in accordance with one's purpose. For student girls who are involved in athletic club activities at school (hereinafter referred to as "girls in school-based sport club activities"), this is a time when they must simultaneously improve their athletic anabolism. During this period, the strength of the "muscles" that move the body and the "bones" that support the body must be enhanced, otherwise the body will not be able to withstand the load it receives through sport. However, in addition to the enhancement of internal organ function, "body fat gain," which is intended to protect internal organs and retain energy, occurs at the same time, **creating a major misconception among girls in school-based sport club activities that they "have gained weight even though they are exercising."**

Don't think about it as "gaining weight," think about it as "gaining Lean Body Mass (LBM)!"

Girls in school-based sport club activities are under the misconception that "I have to lose weight, or my body will become heavier and I will not be able to move well!" They are so concerned about their weight that they try to reduce the amount of food they eat, but they do not reduce the amount of "protein" that builds the body, and they try to reduce the energy sources of "carbohydrates" and "lipids." This means that the "engine" (muscles) working through exercise needs fuel like a sort of "gasoline" (carbohydrates), but this "gasoline" is in short supply.

Since "weight gain does not equal body fat gain," we recommend measuring LBM, which is body weight minus body fat, to determine the weight of "muscles, bones, organs, and blood," which increase with maturity. For girls in school-based sport club activities, it is important to determine by LBM measurement how much "muscle" weight they have gained, which increases when they play sport.

Energy deficiency causes "amenorrhea" and "iron deficiency"

Normal menstruation is a state in which energy is sufficient to build muscles and strengthen bones, and an increase in LBM is seen, which leads to improved athletic performance, but a prolonged menstrual cycle and **"amenorrhea"** are **"signs of energy deficiency."**

Similarly, symptoms of suspected **"iron deficiency"** are also "a sign of energy deficiency." It is now known that iron absorption is impaired when energy deficiency occurs due to lack of carbohydrates. First of all, ask yourself, "Is my body not getting enough carbohydrates?"

Don't let them get a "red card" so that they can continue to play sport

Until now, the problem of energy deficiency has been viewed as part of the "Female Athlete Triad (FAT)." However, the International Olympic Committee (IOC) has proposed the concept of **"Relative Energy Deficiencies (REDs)"** (revised in 2023), which indicates that this is a problem common to both men and women in sport, not just women.

In particular, REDs conditions are common among girls in school-based sport club activities. The **"yellow card"** conditions can be solved by increasing **carbohydrate** intake. In order to prevent **"red card"** (=REDs) (i.e., amenorrhea, iron deficiency, stress fractures, etc.), which cannot be solved, the support of club activity advisors and school nurses, who are in closest contact with girls in school-based sport club activities, is necessary. We ask for **your support so that girls in school-based sport club activities can continue to play sport in good health for a long time.**

How to use the "Condition Support Guide for Girls in School-Based Sport Club Activities"

This guide is a commentary and supplemental guide to help advisors, health and physical education teachers, and school nurse teachers of athletic club activities in schools to provide supplementary explanations of correct knowledge to girls in school-based sport club activities when they hold seminars, classes, study groups for each club activity, and so on. The "guide" is designed to be used in conjunction with the "Support Videos for Girls in School-Based Sport Club Activities," so please use it in conjunction with watching the videos.

We hope that this guide will be useful for improving the knowledge and awareness of not only girls in school-based sport club activities, but also advisors of athletic club activities, health and physical education teachers, and school nurse-teachers.

Contents

To all those who teach and support girls in school-based sport club activities

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Publication Date February 29th, 2024

Publisher Japanese Center for Research on Women in Sport
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Design Dyunamis Co., Ltd.

This guide was created as part of the "Problem-Solving Practical Program for Girls in School-Based Sport Club Activities," a project to develop and support female athletes commissioned by the Japan Sports Agency in FY2023.

The Ideal Body is Made of Muscles and Bones!
- How to self-evaluate relative energy deficiency -

1-1 Opportunities to Increase Muscles and Bones - Video Supplement

POINT **The middle and high school years are the best time to increase "muscles" and "bone strength"**

80% of female middle and high school students are reported to be "at risk of amenorrhea due to energy deficiency" (see the description on the right). Although this risk is often thought to occur only in those who deliberately restrict their weight to an unreasonable level, it also occurs in those who are not concerned about their weight at all.
It is important that students correctly understand the mechanism by which weight gain occurs during this period, as energy deficiency may prevent them from engaging in sport in a vigorous and enjoyable manner.

Results of a Survey: Weight Loss of Middle and High School Girls

A total of 1,214 middle and high school students, including those who belong to sport club or had no exercise habits, were asked, "Have you ever restricted or carefully controlled what you eat?". Percentage of those who answered "yes."

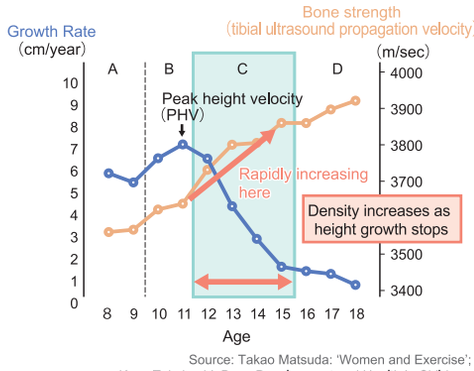
Students who exercise... 81.1%.
Students who do not exercise regularly... 80.7%.

*"Women's Sport Medicine Awareness Program" a project to develop and support female athletes commissioned by the Japan Sports Agency in FY2009.

Weight gain during growth and adolescence

Reason #1: Growth in Height

As height increases, bones become proportionally longer and muscles increase, so weight naturally increases. The effect of this weight is to increase bone mineral density, so that the bones become stronger after height growth.
The girls in school-based sport club activities' age group is the golden age when women can strengthen their bones (see Figure 1). Women have the highest annual rate of increase in bone mineral density between the ages of 11 and 14, and reach their peak of bone mass (peak bone mass; maximum bone mass) around the age of 19.
However, if they suffer from "energy deficiency," they become "amenorrheic," which, if left untreated, leads to "osteoporosis" and makes them more prone to stress fractures and other problems. This is the "Female Athlete Triad (FAT)."

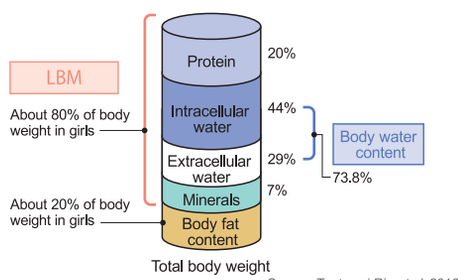


Source: Takao Matsuda: 'Women and Exercise'; Kayo Takahashi, Bone Development and Health in Children, Osteoporosis Japan 2002

Figure 1. Growth spurt and bone strength

Reason #2: Continued increase in skeletal muscles

At adolescence, the secretion of sex hormones increases. Sex hormones promote muscle protein synthesis, which increases muscle mass.
Three-fourths of muscle is made up of water, and the increase in muscle mass is thought to be due to the increase in water content and therefore weight gain.
Muscle is composed of body water, protein, and minerals. For a girl with a body fat percentage of 20%, 80% is LBM (Figure 2), and three-quarters of that is water, so about 60% of her body weight is water weight.



Source: Tsutsumi Rie *et al.* 2016

Figure 2. Weight Breakdown

Key Point! **Weight gain during growth and adolescence primarily consists of muscles and bones. Sex hormones, which begin to be secreted to mature the body, work to increase muscle and bone, and weight gain during this period is very natural and healthy.**

Relationship Between Growth Peak/Menarche/LBM

- Menarche is a sign that LBM has increased after their growth peak.
- The confirmation of growth peak is a sign that there was no energy deficiency. (menarche occurs on average 1.3 years after the growth peak)
- After menarche, height growth stops (about 1 year after menarche). In the past, weight gain after the height growth stopped was thought to be due to an increase in body fat. However, as shown in the graph on p. 3, Figure 6 "Change in LBM with age," weight gains due to an increase in LBM (skeletal muscle) for about two years after height growth stops.
- Menstruation is evidence of the production of sex hormones. The more sex hormones are secreted, the easier it is to build up skeletal muscle through training.

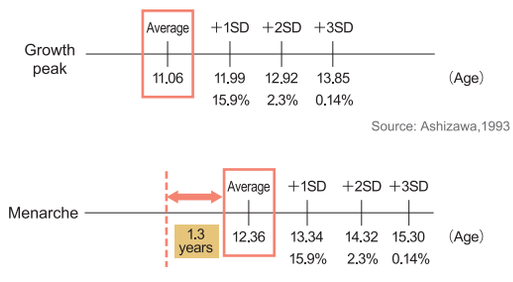


Figure 3. Growth peak and timing of menarche

The Ideal Body is Made of Muscles and Bones!
- How to self-evaluate relative energy deficiency -

Key Point!

It is important to know the contents of weight gain. It is essential to look at LBM to confirm that it is not "fat" but "muscle" and "bone" mass that has increased. It is necessary to switch the way of thinking from "losing weight" to "increasing LBM."

What is LBM?

LBM is "the weight of muscles, bones, internal organs, and blood," excluding the weight of fat from body weight.

Current LBM formula:

LBM (kg) = body weigh (kg) × (100 − body fat percentage (%)) / 100

Formula for calculating ideal LBM based on height (for females)

LBM (kg) = 0.5 × height (cm) − 40

*LBM (kg) = 0.8 × height (cm) -80 for boys
Boys have higher sex hormones, so the increase is greater.

Useful tools for LBM management

- Surari Muscle

(Refer to "Girls in School-Based Sport Club Activities FAT Screening Sheet" p.10)

- Surari-chan's Growth and Muscle Graph

This chart shows the balance between height and LBM and necessary daily energy intake at a glance.

https://research-center.juntendo.ac.jp/jcrws/research-products/support/surari_nobi_muscle/

Why LBM?

We used to believe that weight gain after height growth stops was due to an increase in body fat, but in fact it is an increase in skeletal muscle due to an increase in sex hormone levels. Managing only weight and body fat percentage does not capture the increase or decrease in important skeletal muscle mass, and may lead to poor choices in diet and meal restriction. It is imperative to measure LBM regularly using a body composition analyzer.

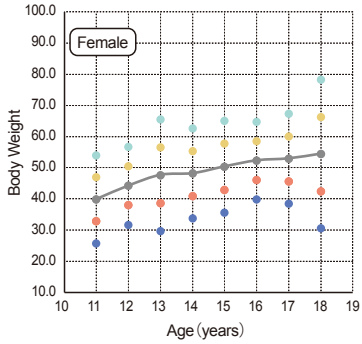


Figure 4. Weight change with age

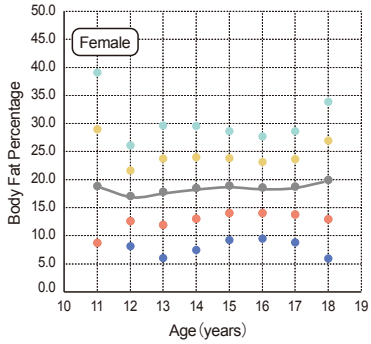


Figure 5. Change in body fat percentage with age

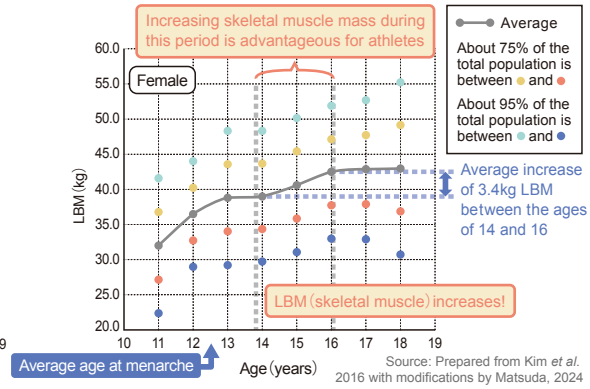


Figure 6. Change in LBM with age

LBM increases in this age group!

Girls in school-based sport club activities who play sport continue to increase their LBM and thus require more energy than the general girl students due to increased basal metabolic rate and skeletal muscle mass.

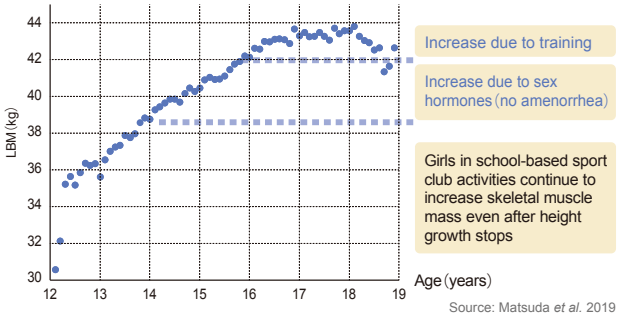


Figure 7. LBM changes in girls from the Japan Football Association Academy Fukushima

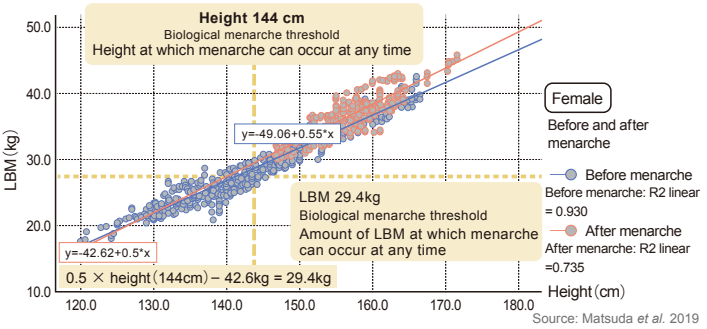


Figure 8. Correlation between height and LBM before and after menarche

Increased LBM has many positive effects!

Key Point!

An increase in LBM is evidence of an increase in muscles, bones, and blood.

The ideal virtuous cycle is: **work hard at sports** → **eat well** → **increase LBM and bone mineral density**.

What an increase in LBM brings

(1) Strong muscles and bones
(2) Instantaneous power to move quickly
(3) Increased endurance
(4) Increased basal metabolism, making one less likely to gain weight

▶ **Leads to improved performance!**

If LBM is not increased

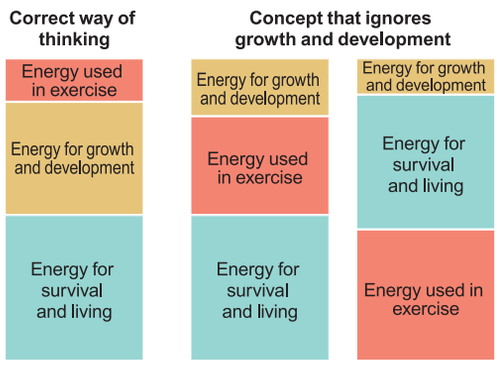
(1) Muscles, tendons and bones are easily damaged
(2) Decrease in speed and instantaneous power
(3) Decreased endurance
(4) In addition to not being able to increase the amount of food you eat, you are more likely to gain weight.

▶ **Rather than improving performance, it will threaten your athletic career.**

1-2 LBM Review - Video Supplement

POINT

Since girls in school-based sport club activities are in an important period of growth and adolescence, they need energy "for growth and development" (see Figure 9), so special attention should be paid to avoid a shortage of available energy.
To prevent energy deficiency, it is important to measure LBM regularly to determine the total daily energy expenditure (TDEE).

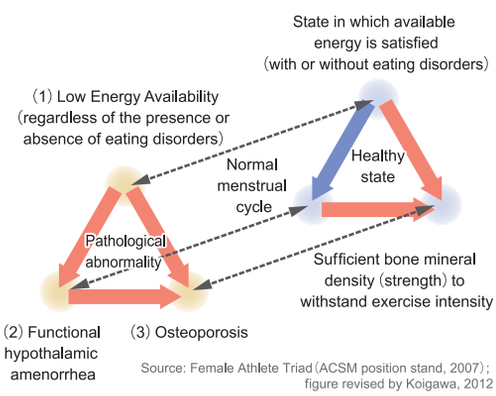


Source: Shihoko Suzuki, 2018

Figure 9. Way of thinking about energy intake for middle athletes

Be careful of the FAT!

The American College of Spors Medicine (ACSM) defines the Female Athlete Triad (FAT) as three concerning disorders that female athletes are prone to.
The root of FAT is Low Energy Availability (LEA).
When female athletes compete, if training and nutrition (energy intake) are balanced, they can continue to exercise in a "healthy" state without menstrual abnormalities or injury.
However, if the quantity and quality of training is increased but the athlete continues without a well-balanced diet, she may suffer from energy deficiency, which may lead to irregular menstruation or complete stop of menstruation, stress fractures, ligament damage, poor healing from injuries, and other problems that may affect her performance (see p. 5 for details).
Since girls in school-based sport club activities may consume more energy by starting club activities after entering middle school or practicing harder in high school, it is imperative to regularly check that the available energy is sufficient.



Source: Female Athlete Triad (ACSM position stand, 2007); figure revised by Koigawa, 2012

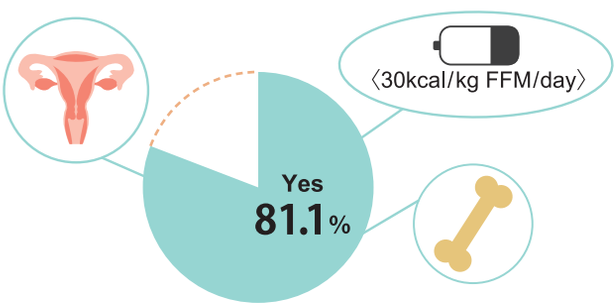
Figure 10. Three disorders that female athletes are prone to (the Female Athlete Triad)

Key Point!

If too much energy is used for exercise, even the energy needed for "daily life" will be reduced. In addition to common symptoms such as a drop in body temperature and a weakened immune system that makes it easier to catch colds, the menstrual cycle in women is also affected (see Video 2 for details), so it is useful to check the menstrual cycle as the most obvious sign of energy deficiency.

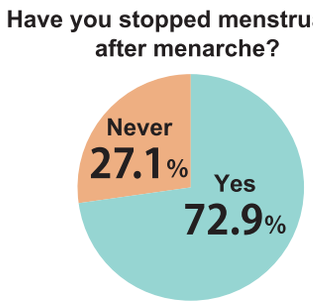
FAT Current Status

It is known that 81.1% of Japanese girls in school-based sport club activities are at risk for FAT (Figure 11).
In a survey of 314 Japanese college female *ekiden* runners, 72.9% have stopped menstruating after menarche at least once (Figure 12).
Furthermore, 45.5% of the respondents had ever suffered a stress fractures (Figure 13), with the most common fracture occurring at the age of 17, followed by 16.



Source: Sakurama *et al.* 2019

Figure 11. Middle and high school club-aged girls who may fall into FAT.



Source: Survey of Japanese Collegiate Female *Ekiden* Runners, Japanese Center for Research on Women in Sport, 2015

Figure 12. Experience of stopping menstruation after menarche

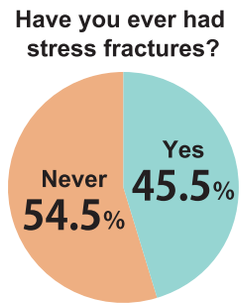


Figure 13. Experience of stress fractures

Video 1

The Ideal Body is Made of Muscles and Bones!
- How to self-evaluate relative energy deficiency -

Girls in Sport
Condition Support Guide for Girls in School-Based Sport Club Activities

1) "Low Energy Availability"

Judging "energy deficiency"

As a way to determine if there is an energy deficiency, the formula on the right can be used, where EA* is the number obtained by subtracting the energy consumed through exercise from the energy ingested through diet and dividing by the LBM. A value of less than 30 is determined to be Low Energy Availability (LEA). A value of at least 45 is needed to remain healthy.
However, it is difficult to accurately calculate EA because energy intake requires a dietary survey by a registered dietitian and energy consumption requires measurement using a wearable device.

***EA (Energy Availability): The amount of energy required**

$$EA = \frac{\text{"energy intake"} - \text{"energy consumed through exercise" (kcal)}}{\text{LBM (= body weight − body fat mass) (kg)}}$$

〈Low molecular weight〉
Low energy intake≒ Low amount of food consumed
Energy consumed by exercise is high≒ A lot of exercise, exercising too much

〈Denominator is large〉
LBM is high

More LBM is more likely to cause energy deficiency

In REDs*, energy deficiency should be determined by "symptoms caused by energy deficiency."

Symptoms caused by energy deficiency

Health effects of REDs

(1) Decreased reproductive function
(2) Bone health problems
(3) Decreased digestive function
(4) Impairment of energy metabolism/ regulation
(5) Dysfunction of hematopoietic function
(6) Urinary incontinence
(7) Disorders of glucose and lipid metabolism
(8) Mental health problems
(9) Neurocognitive dysfunction
(10) Sleep disorder
(11) Cardiovascular dysfunction
(12) Deficiency of skeletal muscle function
(13) Growth and developmental disorders
(14) Lower immune function

Effects of REDs on performance

(1) Decreased opportunities to compete due to illness or injury
(2) Decreased response to training
(3) Decreased recovery
(4) Decreased cognitive ability and skills
(5) Decreased motivation
(6) Decreased muscle strength
(7) Decreased endurance
(8) Decreased power performance

*What is "REDs (Relative Energy Deficiency in sport)"?

It is a syndrome of physiological or psychological impairment of function caused by exposure to a "Low Energy Availability" (LEA) when an athlete's energy intake is not commensurate with the amount of energy consumed through exercise.
REDs is believed to cause a variety of health problems not only in female athletes but also in male athletes, leading to increased risk of injury and decreased sport performance.

For more information, see "Preventing Energy Deficiency in Middle and High School Students," a nutritional guidance manual for girls in school-based sport club activities.

2) "(Athletic) Functional hypothalamic amenorrhea"

Those caused by energy deficiency due to sport are called functional hypothalamic amenorrhea (for details, see Video 2).

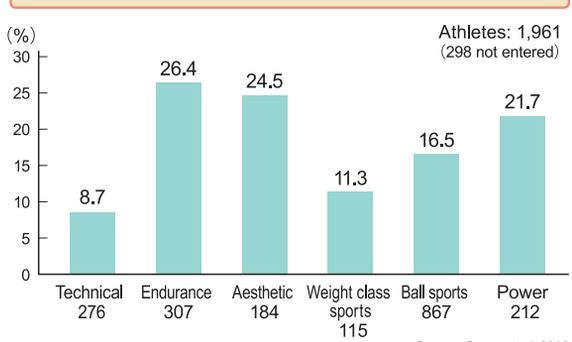
3) "Osteoporosis (stress fractures)"

The figure on the right shows the types of sport in which athletes who developed stress fractures belong.
The common conception is that it is common among thin people, but it is also common among power athletes and other athletes with a good physique.

What the growth curve reveals

A tool that can help us notice LEA in girls in school-based sport club activities is the growth curve. This growth curve allows us to understand the energy status of the athlete to date.
Case 1 and Case 2 are both athletes who have not had their first menstruation in high school. Case 1 had no weight gain since about age 11, and stress fractures occurred here and there in high school. The athlete in case 2 did not develop stress fractures despite not menstruating at all during her three years of high school.
The difference between the two athletes can be seen by creating a growth rate curve. For the athlete in case 2, a growth peak is observed. Although it is possible that there is not enough information about maturation after the growth peak, there was at least an increase in height, which suggests that some bone mineral density was acquired due to the load on the bones.

Although the percentage is higher in endurance and aesthetic sports, the actual number of patients in ball game sports is 1.7times higher than that in endurance sports. In addition, because of the large number of ballgame athletes in middle and high school students, it is highly likely that the actual number of ballgame athletes that the school nurse will come into contact with will be larger.



Source: Osuga *et al.* 2016

Figure 14. Percentage of previous stress fractures by sport

〈Case 1〉16years old (*ekiden*), multiple stress fractures (menstruation started after treatment)

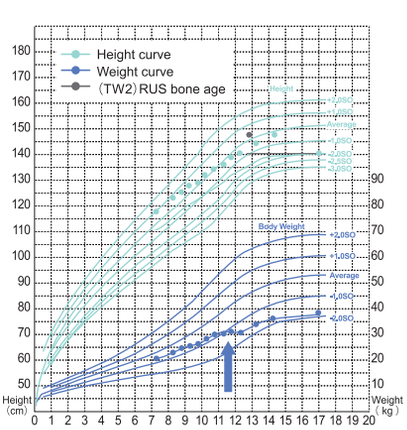


Figure 15. Height and weight curves of Case 1.

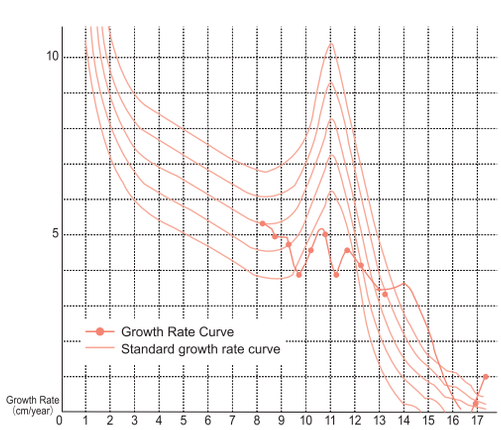
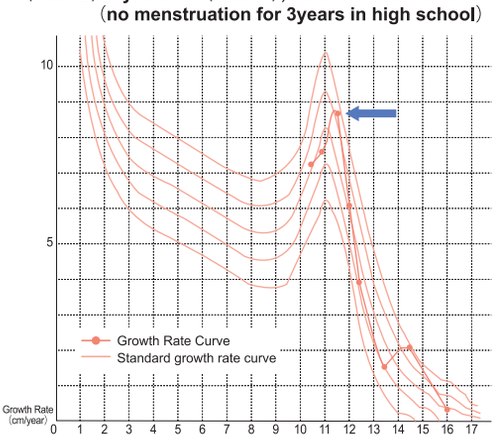


Figure 16. Growth rate curve for Case 1

〈Case 2〉16years old (*ekiden*), no stress fractures (no menstruation for 3years in high school)



Source: Matsumoto *et al.* 2018

Figure 17. Growth rate curve of Case 2 athlete

1-3 Preventing Energy Deficiency - Video Supplement

POINT It is very important to understand the TDEE (Total Daily Energy Expenditure).
Since sport activities increase energy consumption for various reasons, we must be careful to take in energy commensurate with the increase and avoid energy deficiency.

Let's calculate basal metabolic rate with LBM

In the JISS formula, LBM is multiplied by 28.5kcal as shown on the right, but when urging girls in school-based sport club activities to know their approximate basal metabolic rate, the following formula, it is multiplied by 30kcal.

Basal metabolic rate = LBM (kg) × 28.5 kcal/day
(Japan Institute of Sports Sciences (JISS) formula)

Concept of basal metabolic rate for girls in school-based sport club activities

Basal metabolic rate ≒ LBM (kg) × 30kcal/day

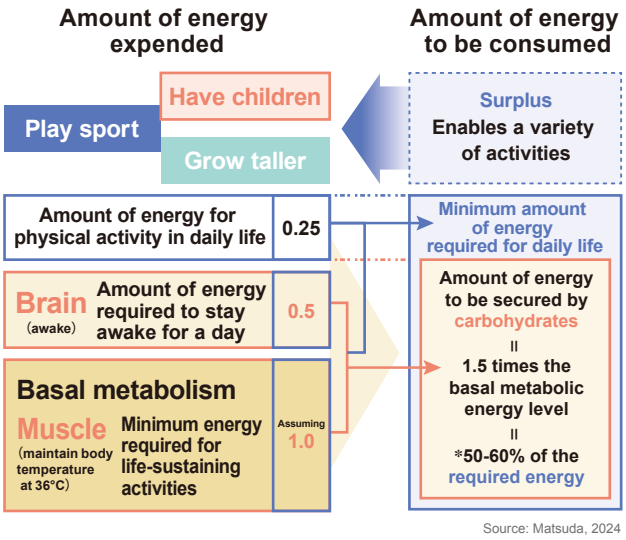
Basal metabolic rate ≒ body water content (kg) × 40kcal/day

40kcal of calorific value is required to bring 1mL of water to 40°C from 0°C.
Since LBM is three quarters of body water content, LBM can be multiplied by 3 kcal to obtain the basal metabolic rate (BMR).

Example: Body weight 50kg, body fat percentage 20%, and LBM 40kg

The figure obtained by multiplying 40kg of LBM by 30kcal ≒ 1200kcal is the approximate amount of energy required for basal metabolism.
At least the same amount of carbohydrate as the basal metabolic rate needs to be taken, but when converted to white rice, one bowl of rice is 240kcal, which means that 5 servings are necessary, which indicates that a considerable amount of carbohydrate intake is required.

Brain and muscles (engine) need carbohydrates (gasoline)



Source: Matsuda, 2024

Figure 18. Amount of energy desired to be consumed by carbohydrates, based on basal metabolic rate

If the basal metabolic rate (BMR) is set as the standard (1.0), the TDEE by the brain to stay awake for a day is half of the basal metabolism (0.5), and about a quarter of the basal metabolism (0.25) is needed to move the body in daily life. If the energy intake were higher than this, various activities such as sport would be possible.
Since the energy used by muscles and brain is mainly supplied by carbohydrates, nearly 1.5times the BMR should be provided by energy from carbohydrates if possible (50-60% of the required energy level).

*However, the IOC Consensus Statement in 2023 points out that while protein intake is sufficient worldwide, carbohydrate intake is insufficient.

Example: A person who needs 1200kcal for basal metabolism (body weight 50kg, body fat percentage 20%, LBM 40kg)

Since BMR is ≒ 1200kcal, the amount of energy required to stay awake for a day is 1.5times that ≒ 1800kcal
1.75times the minimum amount of energy required for daily life is ≒ 2100kcal
Energy intake of more than 2100kcal is required for various activities such as sport.

Concept of Energy Consumption by Increase/Decrease of LBM

When LBM increases by 1kg, the additional energy required is 30kcal, which cannot be maintained without increasing carbohydrate by at least 30kcal per day. If LBM were to decrease by 1kg, the energy deficit would occur without an increase of 30kcal.

Concept of energy expenditure for girls in school-based sport club activities in exercise

If she exercises while her LBM has increased by 1kg, her energy expenditure will further increase by that amount. Roughly 10kcal per hour of exercise, for example, a 4-hour exercise session between morning practice and after school would add 40kcal.

This energy expenditure is calculated from the METs*, a unit of intensity for exercise and physical activity.
Although there are differences in the type and intensity of exercise, it is assumed that approximately 8 to 10METs of movement (exercise) is performed for one hour.
- 8METs − 1METs (energy consumption used just to stay alive) = 7METs; 7METs × 1.05 = 7.35kcal
- 10METs − 1METs (energy consumption used just to stay alive) = 9METs 9METs × 1.05 = 9.45kcal
⇒ This means an increase in energy consumption of approximately 10kcal.
The formula is: METs × time (hours) spent performing the exercise × LBM (kg) ×1.05 = energy consumption (kcal)

*A metabolic equivalent of task (MET) is a unit of intensity of exercise or physical activity. It indicates the intensity of an activity by how many times more energy is expended compared to when the resting state (sitting quietly) is set at 1.

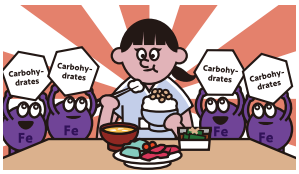
The Ideal Body is Made of Muscles and Bones!
- How to self-evaluate relative energy deficiency -

Two solutions to prevent or improve energy deficiency

☑ Eat proper and adequate amounts of carbohydrates, especially

Why do we need carbohydrates?

- The brain determines the amount of energy it has consumed by the amount of carbohydrates ingested.
- Carbohydrates also prevent dehydration (because when combined with oxygen, they become carbon dioxide and water "metabolic water").
- Lack of carbohydrate causes protein catabolism, in which protein is converted to carbohydrates and used as energy (gluconeogenesis), and muscle mass does not increase.
- Carbohydrate deficiency prevent iron absorption (See "What is iron-blocking hepcidin?" on p. 11.)
- The brain is the most vulnerable organ to lack of carbohydrates and oxygen.



Environment surrounding today's middle and high school students with insufficient carbohydreates intake

Recently, students' ratio of carbohydrates in energy intake has been decreasing. Products claiming to be low in carbohydrates are everywhere, and the reality is that carbohydrates intake is decreasing even in families that are supposed to be eating an appropriate diet.
One of the reasons for this is that parents of middle and high school students are clearly older than in the past, due to an increase in the age of childbearing, and it must be recognized that this, in no small part, has spurred a decrease in carbohydrate intake for middle and high school students.

Key Point!

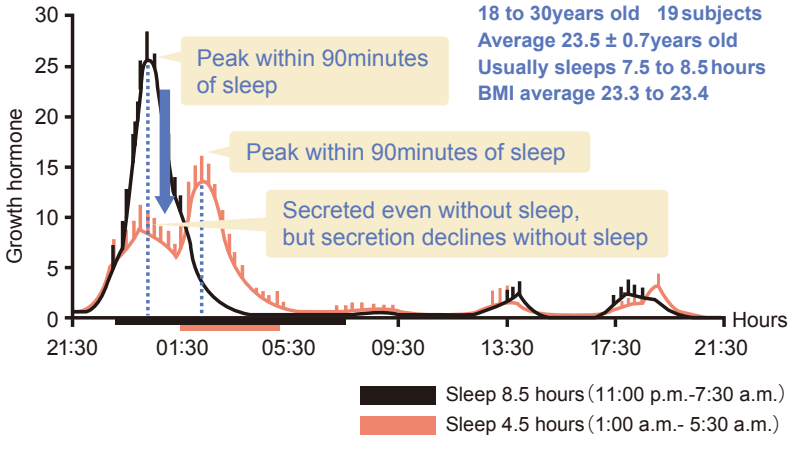
Carbohydrates diets that avoid carbohydrates are also affecting this age group. Therefore, it is important that students understand why carbohydrates are necessary.

☑ Get a good night's sleep

Sleep time = time to repair the body. Inadequate sleep is said to reduce up to 50% of the body's capacity to do so.

The first 90minutes is the "golden time" for growth hormones

The peak of growth hormone secretion is during the first 90minutes immediately after falling asleep (Figure 19), or the first deep non-REM sleep. Growth hormone plays an important role in the body's repair process, regulating the balance of sex hormones and increasing bone mineral density, in addition to promoting growth, such as increasing height.
It is important to refrain from watching television or watching a smartphone at least 30minutes before going to bed in order to promptly fall into a deep sleep after falling asleep.



Source: Broussard *et al.* 2015

Figure 19. Differences in growth hormone secretion according to bedtime and sleep duration

REM and Non-REM Sleep

In REM sleep, the body is in a rested state, but brain activity is similar to the awake state, and memory consolidation and retention are taking place. During REM sleep, the eyes twitch and move actively, and rapid eye movement (REM) accompanies the sleep, hence the name REM sleep.
Non-REM sleep means sleep that is not REM sleep, and is divided into four stages (shallow to deep) according to the depth of sleep. During non-REM sleep, the cerebrum is considered to be at rest and is considered important for recovery from brain and physical fatigue.

Key Point!

The first deep non-REM sleep stimulates the secretion of growth hormone. Growth hormone is useful not only for growth but also for repairing the body fatigued by training.

Dealing with menstruation!
- The relationship between sport and menstruation -

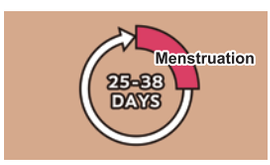
POINT It is important to deal with menstruation well in order to perform at your best in games and practices, and to continue to play sport in good health. Menstruation is a sign from the body saying, "It's okay to gain muscle and bone!" If your menstrual cycle is not normal, if it is long, or if you are amenorrheic, there is a high possibility that you have an energy deficiency, and it is important to correct this energy deficiency. Also, if there are any unpleasant symptoms caused by menstruation, consult a doctor.

2-1 Sport and Menstruation - Video Supplement

What is the menstrual cycle?

Normal menstrual cycle

What is a menstrual cycle?
The menstrual cycle is from the first day of bleeding to the day before the next bleeding, and the average cycle is 25~38days.



Menstruation indicates that a woman has "enough energy" to have a baby. Especially for those who play sport, it is a sign that female hormones are being secreted, which increases body fat, but also makes it easier to build muscle. (See p. 2)

Irregular menstrual cycle

What is an irregular menstrual cycle?
- Irregular menstrual cycle : Cycle fluctuates for more than one week
- Oligomenorrhea : Menstruation rarely occurs in cycles of 39 to 89days **Yellow Card**

Menstrual cycles that are not in the normal range (less than 25days or more than 39days) are a sign of energy deficiency. If menstrual cycles are becoming longer (once a month for those who used to always have them twice a month or twice a month for those who used to always have them once a month), it is important to check for a sudden increase in physical activity or weight loss.

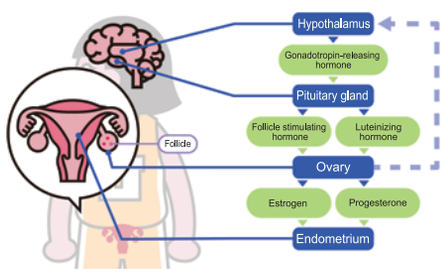
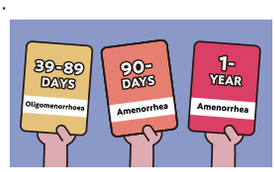


Figure 20. Mechanism of menstruation

Amenorrhea

No menstruation for more than 3months (90days) **Orange Card*** *Newly proposed in the 2023 REDs.
- Functional hypothalamic amenorrhea : Caused by energy deficiency

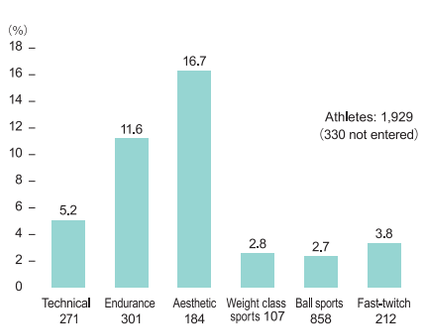


When energy intake decreases and energy consumption increases, the brain determines the priority of functions in the body and suppresses ovulatory function, causing hypothalamic amenorrhea. When competition is interrupted, energy expenditure decreases and menstruation may resume spontaneously.

Severe amenorrhea

- Amenorrhea and delayed menarche for more than 1 year: menstruation does not begin before the age of 15 **Red card**
- Primary amenorrhea: Menstruation does not begin even after reaching the age of 18

*If the patient does not have menarche at the time of entering high school, encourage her to visit a hospital.



Source: Osuga *et al.* 2016

Figure 21. Percentage of previously amenorrheic women by sport

Symptoms (which may be caused)

Oligomenorrhea or functional hypothalamic amenorrhea is a sign of energy deficiency. If the condition persists, the body will not produce enough energy and muscle mass will decrease. In addition, the brain, sensing an energy deficiency, orders the production of female hormones to be reduced, which also weakens the bone-strengthening process, resulting in decreased bone strength.

Key Point! Normal menstruation means that muscles build up easily and bones become stronger, i.e., LBM increases, leading to improved athletic performance. Longer menstrual cycles and functional hypothalamic amenorrhea are signs of energy deficiency, so try to correct the energy deficiency first.

Polycystic ovary syndrome (PCOS)

PCOS is more common in female athletes with greater muscle mass than in the general female population. It refers to a condition in which the ovaries do not ovulate at a rate of approximately one follicle every 28days (irregular menstruation or amenorrhea), and many small follicles grow inside the ovaries, making it difficult for ovulation to occur. In this condition, testosterone (a male hormone), which makes it easier to build muscle, is slightly elevated. The accompanying increase in energy requirements can lead to iron deficiency anemia (see p. 11) or energy deficiency due to increased basal metabolic rate.

Dealing with menstruation!
- The relationship between sport and menstruation -

Symptoms caused by menstruation

Premenstrual syndrome (PMS)

PMS is a general term for the symptoms that appear 7 to 10days before the start of menstruation, including lower abdominal pain, edema, weight gain, breast tenderness, drowsiness, fatigue, irritability, constipation/diarrhea, etc. Symptoms characteristically improve after the onset of menstruation. It is believed to be caused by changes in progesterone and other hormones associated with the menstrual cycle.

Dysmenorrhea

Symptoms such as lower abdominal pain, headache, nausea, back pain, loss of appetite, and fatigue that interfere with daily life during menstruation. Menstruation-Associated Symptoms are a problem that athletes want to resolve as soon as possible, as they clearly impair performance during competition.

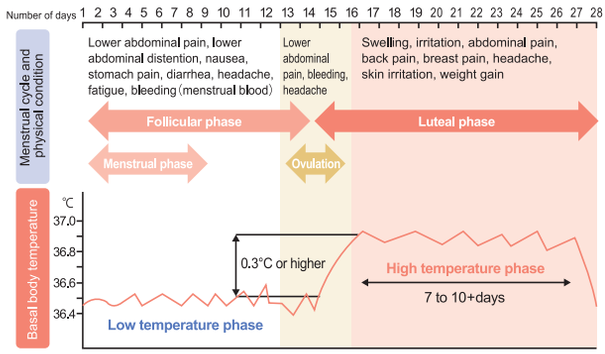


Figure 22. Changes in the menstrual cycle

Dealing with Menstruation

Although there are individual differences, if symptoms of PMS, dysmenorrhea, PCOS, or amenorrhea affect athletic performance, it is effective to consult a hospital. Counseling, nutritional guidance, and medical treatment are options to improve or control menstrual problems as needed. Low-dose oral contraceptives, which suppress fluctuations in female hormones and allow menstrual shifts, are also effective treatments. (Low-dose oral contraceptives are not included in the International Standard of the Prohibited List published by the World Anti-Doping Agency (WADA)*).

* As of February 29, 2024

Key Point! **If you have symptoms before and during menstruation, do not endure them, but consult a hospital for advice, as your performance may be impaired.**

2-2 Self-check - Video Supplement

Let's use tools to support your condition!

Female Athlete Diary*

By recording items that are essential for female athletes to manage their physical condition, they can objectively know whether their physical and mental condition is good or bad.

(Recommended for these people)
Those who want to "write" and record their physical condition and check for changes.
People who want to compare their physical condition with past records.

Pre-participation Physical Evaluation

Pre-participation physical evaluation (PPE) for female athletes is an online tool that allows you to answer 42 questions to assess your risk for concussion, heart, general illness, bone and FAT status on a 3-point scale. This is a great tool to take before the season.

(Recommended for these people)
People who want to assess their physical health objectively.
Athletes who want to make sure they are in perfect physical condition before the season starts.

E-learning for Female Athletes*

An online learning support tool for female athletes to learn what they need to know about sport. The videos are followed by a confirmation test, making learning fun and enjoyable.

(Recommended for these people)
Women who want to learn basic knowledge about body mechanics and nutrition.

FAT Screening Sheet*

People who want to learn about the risks of the FAT with a high degree of accuracy by simply answering simple questions. Make sure to check it regularly.

(Recommended for these people)
Want to know if they are at risk for the FAT. Want to be aware of the causes of poor physical condition.

Surari Muscle*

Enter your height, weight, and body fat percentage, and LBM and energy requirements are calculated. It is also possible to check whether you have acquired sufficient LBM for your height, which is useful to support your physical development during your growth period.

(Recommended for these people)
People who want to check whether their LBM is increasing in accordance with their height growth.
People who want to know how much energy they need to consume.

* Japanese only

Key Point! **It is important to conduct regular screenings by using tools appropriate to the situation and purpose so that one can check one's own health status from various angles. Knowing your body will lead to your best performance.**

Make your body less prone to injury!
- Iron deficiency is a sign of energy deficiency -

3-1 Signs of Iron Deficiency - Video Supplement

POINT Girls in school-based sport club activities who play sport during their growth and adolescence should be aware of iron deficiency!
Anemia is a common symptom in athletes and leads to poor performance. It is also a "sign of energy deficiency," so "avoiding anemia = preventing FAT."

Iron deficiency is likely to occur during growth and adolescence

During adolescence, from upper elementary school to high school, the body needs to increase muscle and blood to grow bigger, which increases the demand for iron. People who are thin in appearance are often thought to be anemic, but it can also be said that a person with good physique is, the more likely he or she is to be anemic. The taller a person is, the more LBM (skeletal muscle) he or she has, so this is especially important for tall people or those who have grown taller rapidly. The risk of anemia in women is said to increase with the onset of menstruation, but increased iron discharge due to menstrual blood is not the only cause of anemia.

Survey of Oita Prefecture high school students at the national level (2020-2023)

A survey of 485 female athletes revealed the following low percentages who met or exceeded the average.

Hemoglobin 13g/dL+ ····· 54.6%
Ferritin 25ng/mL+ ····· 47.8%

The following levels are criteria for anemia and iron deficiency.

Hemoglobin <12g/dL ·····12.0%
Ferritin <12ng/mL ····· 24.3%

Source: Matsuda, 2024

Girls in School-Based Sport Club Activities who play sport need iron!

People who play sport need more iron than those who do not exercise because they have more muscle mass. Especially when training increases muscle mass, there is less iron available for red blood cells because more iron is supplied to the muscles. This results in smaller red blood cells, which carry less oxygen and cause iron deficiency symptoms. During periods of increased LBM, it is very important to be especially conscious of iron intake.

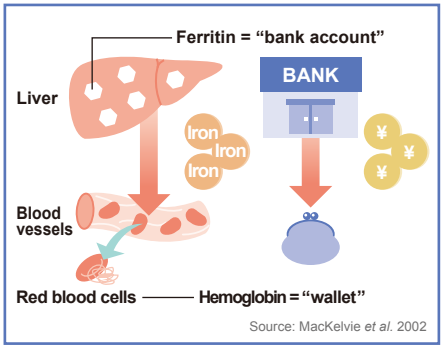
Anemia caused by sport

Originally, anemia caused by sport was thought to be "athletic hemolytic anemia," which is common in long-distance track and field, volleyball, kendo, and other sport that require strong impact to the sole of the foot (which tends to destroy red blood cells). Once it occurs, the iron contained in the broken red blood cells cannot be reused, making it difficult to cure.

The function of Iron

The function of iron in the body

Iron in the body includes hemoglobin, which is found in red blood cells, myoglobin, which stores oxygen in muscles, and ferritin, which is stored in the liver.
Hemoglobin acts as a "wallet" and ferritin as a "bank account," and when hemoglobin is depleted, iron is supplied from ferritin, thus keeping the hemoglobin concentration in the blood constant (Figure 23). Since a large amount of oxygen transported throughout the body leads to improved performance, it is desirable for people who play sport to have a higher hemoglobin concentration than those who do not play sport, but even if there is no decrease in hemoglobin, performance is said to be affected when ferritin decreases, and this condition is called an "iron deficiency" in sport.



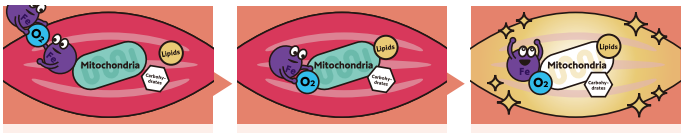
Source: MacKelvie *et al.* 2002

Figure 23. Relationship between hemoglobin and stored iron (ferritin)

The function of iron in muscle

When muscles produce energy, they need oxygen. This is because myoglobin iron, which receives oxygen from hemoglobin iron, supplies oxygen to the mitochondria, which are responsible for energy production, resulting in high-quality muscles that produce a lot of energy.
Therefore, it is important for athletes to train with adequate iron supplementation.

In the muscle cells of a sport person



Many mitochondria need oxygen to produce energy

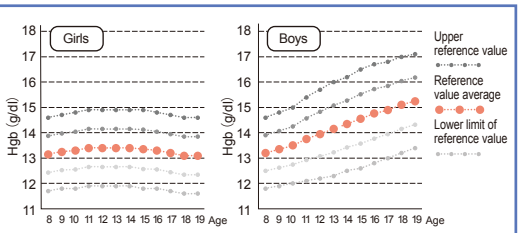
Oxygen carried by iron is supplied to mitochondria

Using oxygen, lipids and carbohydrates are converted into energy. This leads to good quality muscle!

Gender Differences in Anemia

It is generally believed that anemia is more common in women, but in fact, hemoglobin levels (see Figure 24) are the same in boys and girls during childhood. However, differences between the sexes emerge during the process of growth.
The reason for this is that in addition to a rapid increase in the hormone testosterone, which is involved in hematopoiesis, men also increase the synthesis of haptoglobin, which is necessary to re-collect broken iron. Especially, hemoglobin concentration is significantly higher only in adult men, and they are less anemia.

*It is said that a 10% difference in hemoglobin concentration results in a 10% difference in maximum oxygen uptake.



Reference: Hea Lin Oh *et al.*: Reference values for serum ferritin and percentage of transferrin saturation in Korean children and adolescents

Figure 24. Hemoglobin concentration by age of growth

Make your body less prone to injury!
- Iron deficiency is a sign of energy deficiency -

What happens when you are iron deficient?

Symptoms like these can be due to an “iron deficiency”?!

Anemia causes symptoms such as tiredness, lethargy, shortness of breath, and dizziness, and reduces endurance and dynamic vision. In addition, the brain, which consumes the second most oxygen after the muscles, does not receive enough oxygen, resulting in poor judgment and concentration, which can lead to mistakes that one would not normally make.

〈Examples of mistakes〉
Table tennis: Cannot keep up with the speed of the ball, rallies do not continue./Soccer... Missed passes, trapping errors./Team sport... teamwork errors, misreading of signs, etc.

In addition, a decrease in motivation and an increased susceptibility to colds and gastroenteritis can also be attributed to the effects of anemia caused by an energy deficiency.
If you notice any physical changes, first measure your LBM!（See “Key Point!”）

Iron deficiency

Iron deficiency occurs when there is a lack of iron.
Iron deficiency is determined by low ferritin, which represents the amount of iron stored in the body. Iron deficiency occurs even when the hemoglobin, which carries oxygen in red blood cells, is not low.

Iron deficiency anemia

When iron deficiency is combined with energy deficiency, a condition called “iron deficiency anemia” occurs, and symptoms such as tiredness, lethargy, shortness of breath, and dizziness are manifested. In this condition, supplementation with iron alone does not cure the anemia because the energy deficiency is still present. The reason why iron supplementation often causes iron deficiency anemia to return after a temporary improvement is that the energy deficiency has not been corrected.

What is “hepcidin,” the iron inhibitor?

It is an antimicrobial substance（something the prevents bacterial growth）found in the liver that reduces the amount of iron in the body. It makes the skeletal muscles iron-deficient to prevent them from producing any more energy, and prevents the mitochondria of the skeletal muscles from supplying iron. Since the amount of iron in the body increases 2.7-fold when carbohydrates are low, we should not restrict carbohydrates, especially during periods of skeletal muscle growth, but should be sure to consume them aggressively.

Key Point!

The symptoms of iron deficiency are a good indicator to tell you that you are “starting to run out of energy!”
When skeletal muscles are trained, iron distribution is concentrated in the muscles to generate energy, which causes iron deficiency in other parts of the body. If symptoms of iron deficiency are felt, athletes should measure LBM to check for increased skeletal muscle mass!

3-2 Effective Iron Intake - Video Supplement

Points to consider when ingesting iron!

Generally, it has been said that the supply of iron increases as the energy intake from the diet increases, for example, 2000kcal intake will provide 12mg of iron needed per day. However, it is now known that the amount of iron needed by athletes（15-18mg）is insufficient to meet their dietary intake alone.
When a person is said to be anemic, he or she is in a very advanced state of energy deficiency, and often becomes anemic again soon after supplementation with iron alone.
Since energy deficiency due to lack of carbohydrate reduces iron absorption, we ask that you instruct your patients to be mindful of their energy intake, which includes sufficient carbohydrate. For those who play sport, supplements may be effective in replenishing the amount of iron that cannot be supplemented by diet alone.

*If symptoms do not improve, consult a medical professional!

Important notes regarding iron intake
When two minerals are ingested at the same time, one of them will not be absorbed. When taking iron, it should be taken separately from milk, which contains calcium, as absorption may be inhibited if taken together.

The relationship between “collagen” and “iron,” the reason why iron deficiency makes you prone to injury.

Collagen is contained in ligaments and tendons.
When the strength of collagen decreases, you are more prone to injury. And iron is necessary to make collagen strong.
Collagen is made up of three chains, and the secret of its strength is that these chains are firmly attached to each other, but iron is needed for the hydroxyl bonding of “proline hydroxylase,” the glue that holds them together. Without iron, the chains would unravel and lose their strength, which could lead to injury.

Key Point!

If training leads to an anemic state where LBM increases and hemoglobin also decreases, iron administration alone will not improve performance. And you will quickly revert back to anemia. In addition to iron supplementation, performance will not recover without increasing the amount of energy intake with carbohydrates to compensate for the increased LBM.