

# What Does “Chrono-Nutrition” Have to Teach us About When and How to Eat?

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Chrono-nutrition involves timing your nutritional intake to suit the body’s rhythms. There are various biorhythms that control the mind and body and govern biological processes, such as body temperature, blood pressure, sleep, and activity. Scientists now think that timing meals to suit rhythms of the body’s biological clocks allow for more effective nutrient uptake and plays a role in good health. We spoke with Professor Hideo Kato who has established a long history in research of chrononutrition and is a specialist in this field.

Let’s take a look at milk, for example. We all know that milk is a good source of protein and calcium. So “when” is the best time of the day to have a glass of milk?

There are a number of answers to this question. If you consume milk in the morning, it will stimulate gastrointestinal functioning and prevent constipation. For children who take part in physical activities after school or adults who go to the gym on the way home from work, a glass of milk around 3 PM followed by exercise in the late afternoon/early evening allows secretion of growth hormones to develop strong bones and muscles, as well as improve stamina. If you have milk for supper with some fruit that contains a lot of citric acid and malic acid, it will help to strengthen your bones. In other words, the best time to drink milk depends on how you would like to improve your health. You also need to take into account what you will be having with the milk in order to get the most out of the nutrients.

In the past, nutritionists focused on the ingredients contained within the food we eat, but chrononutrition also factors in practical perspectives on what to eat when, and how in order to maximize the health benefits.

The “chrono-nutrition does not simply mean the timing of consuming nutrients from food. Researchers studying chrono-nutrition are interested in the various rhythms cycling within the body.

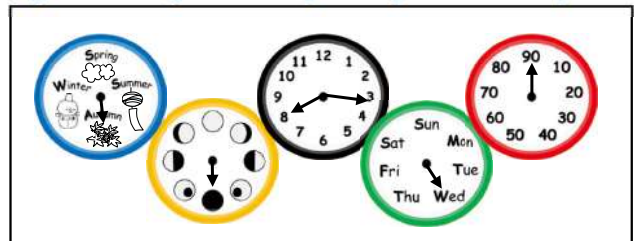
Most people understand the system of homeostasis maintaining things like body temperature and metabolism at appropriate levels, but the body also have various internal body clock that cycle through their own biological rhythms. There are daily rhythms with a period of one day (circadian rhythms), as well as weekly, monthly and seasonal rhythms (Figure 1). We maintain our health because of the rhythms found in the hormones that increase our immune capabilities or in the autonomic nervous system that regulates various physiological functions.

These rhythms within the body play a major role as a control tower for our mental and physical health and the biological processes involved in body temperature, blood pressure, sleep, and activity. Recent research has also shown that diet can affect the development of rhythms within the body.

## Hideo Kato

Born in Osaka in 1947. Graduated from the School of Medical Nutrition of the Faculty of Medicine at Tokushima University. He completed a Master’s degree (Chemical Engineering for Food Staples) at Kyushu University Graduate School and a PhD (Metabolic Nutrition) at Osaka University Graduate School. After a position as an Assistant at the School of Medicine of Ehime University, he embarked on research into sports nutrition, chrono-nutrition, and basic nutritional science at the Prefectural University of Hiroshima (previously Hiroshima Women’s College and Emeritus Professor at the Prefectural University of Hiroshima). Has authored/co-authored a number of books including Food and Nutrition-The Pitfalls of Common Sense (Shodensha) and ChronoNutrition (Kagawa Nutrition Publishing Division).

Figure 1: Biological clock systems gave various rhythms



Biological clock systems have various rhythm, ranging from an annual rhythm timed with the seasons (seasonal rhythm) to a monthly rhythm, daily rhythm (circadian rhythm), weekly rhythm, and even a 90-minute rhythm (ultradian rhythm).

## Regular meals maintain the cycle of the physiological rhythms

One of the physiological rhythms affected by meal times is the daily rhythm of corticosteroid secretion. Corticosteroid is involved in the metabolism of carbohydrates, proteins, and fats, and has various functions, such as acting on the nerves, bones, and muscle tissue. When lab rats were offered nutrient solution or animal feed every day at a certain time to eat by mouth, blood corticosteroid levels developed a daily rhythm that corresponded to the timing of when the nutrient solution was provided. When feeding was suspended the next day, this daily rhythm persisted for several days. However, if the same nutrient solution was given by central venous hyperalimentation instead of oral eating, the rhythm disappeared.

Similar results have been obtained from studies in humans. For example, the corticosteroid rhythm disappears completely in patients given continuous central venous hyperalimentation over a 24-hour period. However, when the method of feeding was switched to three hospital meals a day consumed orally, after one week the patients had redeveloped a rhythm that corresponded to the meal schedule in the morning, afternoon, and evening (Figure 2).

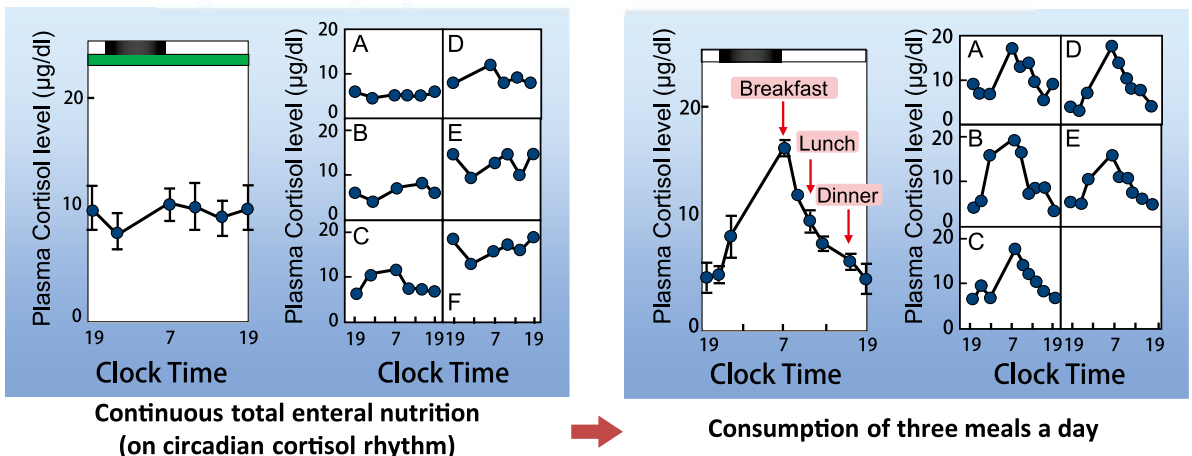
Three meals a day, eaten regularly and orally—allows the body to develop an internal rhythm. Once the rhythm is established, it is not disrupted even by the occasional deviation from this schedule. However, the rhythm does break down in people who often have irregular eating habits. Disruption to

this Physiological rhythm that plays a controlling role in your health can result in abnormalities in the body. Skipping meals is one type of disruption to your eating habits. When you skip breakfast, the body temperature remains at a low and brain activity diminishes. When skipping breakfast becomes the norm, the basal metabolism is lowered and the body becomes less efficient at breaking down fats, which can result in binge eating and a susceptibility to weight gain.

It is often said that our body naturally wakes up in the morning when the sun rises and the light-dark cycle was thought to reset our circadian rhythms. However, my research has turned this concept on its head. My research on rats confirmed that supplying food at a particular time results in the formation of circadian rhythms in corticosteroid levels, regardless of whether the rats were kept 12h – 12h cycle of light and dark. This suggests that the body awakens and starts the new day by eating breakfast.

If you eat at the same time every day over a long period of time, your stomach should be empty just before the next mealtime. In other words, your stomach and small intestines are ready and waiting for the next meal. When we eat under these conditions, the nutrients ingested are absorbed more easily and your body benefits completely from the food. The world is full of healthy foods that are good for the body. However, even if you eat only the healthiest foods, your body will not benefit to the full if you eat at the wrong time for the body to absorb and utilize the nutrients.

**Figure 2: Daily rhythm of blood corticosteroid levels in human**



The circadian rhythm in blood corticosteroid levels is seen in both the group fed meals orally and the group given periodic total enteral nutrition, but this rhythm is lost in the group given continuous total enteral nutrition.

## Prevent metabolic syndrome by timing meals according to the physiological rhythms

We may be able to prevent lifestyle diseases and other conditions if we recognize the importance of matching when and how we eat to the physiological rhythms.

I have researched the impact of dietary patterns on energy metabolism. Study subjects were divided into three groups according to how the total daily calorie intake (1800kcal) was divided across three meals per day: Group 1: Breakfast 2 (400kcal), Lunch 3 (600kcal), and Dinner 4 (800kcal); Group 2: Breakfast 3, Lunch 3, Dinner 3; and Group 3: Breakfast 4, Lunch 3, Dinner 2. When energy consumption was measured, the group with the most active energy metabolism (i.e., diet-induced thermogenesis or DIT) was Group 2 (Breakfast 3, Lunch 3, Dinner 3).

You might have assumed that the best pattern would be Group 3 (Breakfast 4, Lunch 3, Dinner 2) with the smaller dinner. However, the problem with this pattern is that excessive amount of calorie is allocated to breakfast. Eating excessively in the morning when you have just woken up while the digestive system is not ready for action is not good for the efficiency of the energy metabolism. Having that said, breakfast is important. As the word breakfast suggests, it is the first meal of the day when you “break” your “fast” to replenish the body’s energy stores. To feel active and lively each day, it is important to satisfy the body’s need for energy by having an appropriately sized breakfast (so you feel about 80% full) within one hour of waking. Of the three eating patterns, Group 1 is the most common pattern among people today. The problem with this pattern is that even though people consume the same amount of calories as the other patterns, their biggest meal is late in the day. Orexin as neuropeptide plays a central role in the integrated control of feeding behavior and energy homeostasis. Orexin secretion diminishes at night, so eating late at night means surplus nutrients tend to get stored in the adipose tissues, which can lead to obesity. Also the body is less able to process carbohydrates at night, so blood sugar levels tend to rise more.

Obviously, to prevent obesity, diabetes, and other aspects of metabolic syndrome, it is important to avoid overeating, but we also need to avoid eating late at night or eating foods like ramen at night after drinking alcohol. In the evening, it is best to eat four hours before you will go to bed and only eat until you are about 80% full. If you only have time for dinner later in the evening, for example because you have been held up in the office, then you should only eat

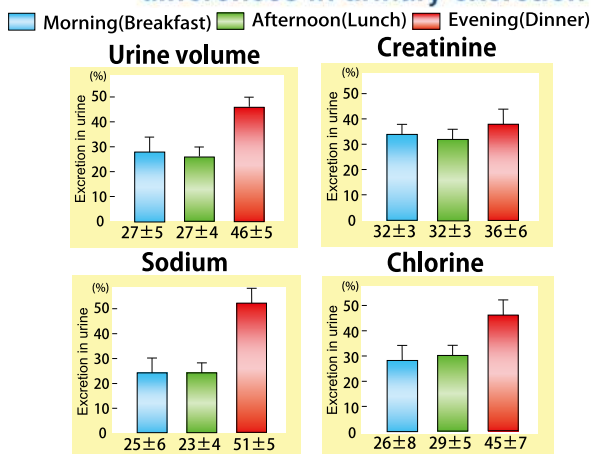
one half the usual amount if it is two hours before bedtime and only one quarter the usual amount if it is one hour before bedtime.

## Chrono-nutrition points the way to practical methods to reduce salt intake

High blood pressure is a lifestyle disease and patients with high blood pressure need to reduce their salt intake. You have probably seen many examples of this type of nutrition guidance. While it is easy to give this advice, it is difficult to actually maintain a low salt intake for all three meals every day. Food can taste bland without salt, so many patients fail in their efforts to maintain a low-salt diet. What if we rethought the advice on a low-salt diet from the perspective of chrono-nutrition?

I investigated whether there was a relationship between the timing of meals and the body’s absorption of the salt and considered whether chrono-nutrition perspectives could provide more useful methods to determine which of the three daily meals was associated with the highest level of salt excretion. One of the three meals was designed to have a high salt content of 10g (rice with peas, salt-grilled salmon, miso-glazed salmon, miso-glazed eggplant, soup, salad)—this meal was given to the study subjects at breakfast on day 1, lunch on day 2, and dinner on day 3. I collected data on urinary excretion of salt (Figure 3). The results showed that urine

Figure 3: Timing of high salt intake and differences in urinary excretion



The amount of salt excreted in the urine has the opposite daily rhythm to that of aldosterone secretion, which is high in the morning and low in the evenings. If hormone rhythms are normal, breakfast and lunch should feature low-salt meals but salt restrictions can be relaxed in the evening.

volume and the level of urinary sodium/chloride excretion were higher after dinner than after breakfast or lunch. This is because blood aldosterone has a rhythm of higher levels in the morning and afternoon. Aldosterone is a hormone that promotes sodium reabsorption in the kidney, so it indirectly raises blood pressure. Therefore, urine volume and urinary sodium/chloride excretion have an opposite rhythm to aldosterone and are higher in the evening.

If people with high blood pressure eat salty foods at breakfast and lunch when blood aldosterone levels are high, the aldosterone will promote reabsorption of the sodium in the kidney and blood pressure will rise. Corticosteroid also increases the body's sensitivity to aldosterone, so blood pressure tends to rise the most in the morning when both these hormones are at their highest levels. For these reasons, it is best to follow a low-salt diet in the morning and afternoon. In the evening, blood aldosterone levels are low, so more salt is excreted even if you eat salty foods. You could say the best advice is to restrict salt intake at breakfast and lunch and relax these restrictions a little at dinner time.

People who are convalescing also need to have food that is tasty and enjoyable. Dietary restrictions cannot be sustained if the food tastes bad. For the three meals a day, you could prepare plain, low-salt food for breakfast and lunch and then food with normal seasonings at perspective, seems like a more practical approach to reducing salt intake.

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## Tailoring exercise and diet to the body's rhythms

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Other important questions are how to combine nutrition with sports and what is the best time of day to exercise. I have heard of a case in Nagano Prefecture where a Junior High School sports club decided under principle to scrap early morning training sessions. This decision actually makes sense.

Previously, I enlisted the help of male high school students who belonged to a sports team club. I measured exercise load and stamina and investigated the impact on exercise physiological functions and endocrine/metabolic systems from the perspective of biological rhythms. The results showed no difference between morning and late afternoon exercise in terms of grip strength or 50m running, but better results in terms of late afternoon training sessions for back muscle strength, vertical

jumps, and 1800m running. A slight improvement was also seen in the late afternoon versus the morning for agility, muscle stamina, balance, and flexibility. Secretion of both noradrenaline and adrenaline increased if exercises were done in the morning. Noradrenaline secretion elevates blood pressure, while adrenaline secretion elevates heart rate. However, growth hormone levels decreased in almost all the boys exercising in the morning, but increased in boy exercising in the late afternoon.

From a chrononutrition perspective, these results suggest that morning training may not be very effective. Many children attending morning training sessions skip breakfast because they are told off if they arrive late. If you miss breakfast in order to attend morning training, your body is unable to reset its internal body clock, your stamina and immune functions decline, and become less able to perform. Parents sending their children to early morning activities have to reduce their sleeping time with early wakeup calls and prioritize providing the children with breakfast and lunches.

These data suggest that it would be more effective for children to participate in sports after school, in the late afternoon, rather than attending morning training. Children who do intense training with their sports team club should make sure they eat a really good lunch. This situation with growing children can be likened to a carpenter building a house. You can not build a house with a carpenter alone—you need cement and other building materials as well. In this analogy, the carpenter translates to growth hormone and the building materials to food. It takes four or five hours for the body to digest and absorb a meal, so children need to eat a good lunch if the nutrients are to be available at the same time as the secretion of growth hormone into the blood. I also recommend eating within two hours after exercising to support recovery from fatigue. You should have a wellbalanced meal of mainly protein and carbohydrates with avoiding excessive fat.

You cannot maintain good health with drugs. A good diet provides the foundations for good health. As well as focusing on the benefits you get from the food you eat, the nutrients it includes, and the flavor, it is also helpful to consider when and how to eat in order to make the most of the health benefits. I believe that chrononutrition by some circadian time-keeping system could be usefully applied to help everyone achieve better health.