

December 2, 2022

Stable isotope study

“Variation in human water turnover associated with environmental and lifestyle factors” was published in the American scientific journal “Science”

Taiyo Nippon Sanso Corporation (“TNSC”, President: Kenji Nagata) hereby announces that the results of an international project (IAEA Doubly Labeled Water Database), which TNSC has been cooperating with for many years were published in the journal “Science” by the American Association for the Advancement of Science (November 25, 2022 edition).

This study is the second consecutive report utilizing the doubly labeled water method database to be published in “Science,” following on from “Daily energy expenditure through the human life course,”^{*1} by Herman Pontzer, Yosuke Yamada, Hiroyuki Sagayama, et al, which was published in the “Science” August 13, 2021 edition.

(TNSC issued a news release on August 20, 2021, titled: “Stable Isotope study ‘Changes in daily energy expenditure with aging in humans’ was published in the American scientific journal ‘Science’.”)

1. Background

Water is always needed for human life support, temperature regulation, blood circulation and physical activity. It has long been known how much water is contained in the human body (body water content), but it has been difficult to accurately ascertain how much water enters and exits the human body (water metabolic turnover). Against that backdrop, in 2014, the National Institutes of Biomedical Innovation, Health and Nutrition (President: Yusuke Nakamura, located in Ibaraki, Osaka Prefecture) (NIBIOHN) and TNSC jointly organized an international workshop in Tokyo and a tour of the Water-¹⁸O^{(*)2} production plant.

This was an opportunity for researchers from around the world to work together to develop a single measurement of total energy expenditure using the doubly labeled water method^{(*)3}, the gold standard for measuring human body water content and total energy expenditure. The outcome of this workshop led to the start of an international project organizing the doubly labeled water database. (Chaired by Dr. John Speakman, University of Aberdeen/ Chinese Academy of Sciences).

Recently, Dr. Yosuke Yamada, Head of Section of Exercise Guideline, Department of Physical Activity Research, NIBIOHN, and researchers from research institutes around the world jointly conducted a study using stable isotopes on a total of 5,604 people, comprising men and women from 23 countries and ages ranging from infants 8 days old to senior citizens aged 96. They studied the factors behind fluctuations in the human body’s metabolic turnover of water, and for the first time in the world, clarified a method to predict the volume of body water lost in one day.

The study found that on average, in a single day infants lost approximately 25% of their body water content and adults lost approximately 10% of their body water content outside of the body. Due to the extremely rapid metabolic turnover of water in the body, humans face a life-threatening situation if water is not replenished for three days. The study also made clear that various factors have an impact on the metabolic turnover of water, including such as hot and humid environments, or geographical environments like high altitude, etc., as well as the type of person, such as if they are an athlete, pregnant, have high muscle mass or high levels of physical activity.

Please refer to the following press release (dated November 25, 2022) jointly issued by NIBIOHN, Waseda University, Kyoto University of Advanced Science and the University of Tsukuba related to study result ^(*).

(Joint press release announced November 25, 2022: “Discovery of World’s First Method to Predict Metabolic Turnover of Water in the Human Body: Results of Joint International Study of 5,604 People in 23 Countries.”)

(Only in Japanese)

2. Our role

In this project, we have provided heavy water and the stable isotope of oxygen-18 (Water-¹⁸O) to many of the study participants, which is required for the doubly labeled water method and stable isotope analysis in biological samples such as blood, urine and saliva. In addition, we have provided support for the promotion of this project, including lectures and workshops on stable isotope analysis using this technique, both in Japan and abroad.

3. Our future development

The results of this study raise expectations of being able to approximate the volume of fluid intake needed to prevent dehydration or heat stroke under various environments, and also to prevent damage to the kidneys or heart associated with dehydration. Furthermore, at a time when the United Nations estimates that about one-third of the global population lacks safe drinking water in the home and the problem of water shortages is particularly severe in developing countries, the prediction method devised through this study is believed to be useful for developing strategies to secure drinking water and food in the event of disaster or emergency in various countries, and for building a model to project water shortages due to the increase in global population or climate change.

TNSC will continue to provide innovative solutions to various problems in a wide range of fields through our stable isotope production and analysis technology, and enhance human well-being and contribute to a more sustainable future.

[Terms]

***1 Total energy expenditure**

The amount of energy (in kcal or MJ) consumed in a day, comprising basal metabolism (BMR), diet-induced thermogenesis (DIT) and energy expenditure from physical activity (AEE).

***2 TNSC's Oxygen-18 Stable Isotope Labeled Water (Water-¹⁸O)**

A water molecule is composed of two hydrogen atoms and one oxygen atom. Water-¹⁸O is an isotope of oxygen with a mass of 18 instead of the more common mass of 16.

There are three isotopes of oxygen in air, with mass numbers 16, 17 and 18. Their ratios are 99.76%, 0.04% and 0.2% for each. The isotopes have almost identical physico-chemical properties and are therefore extremely difficult to enrich and separate. We have developed an oxygen-18 enrichment method using oxygen (O₂) cryogenic separation technology, and have achieved the world's highest enrichment of over 98atom% and started its production from 2004, and stably supply high quality products to customers around the world.

***3 Doubly labeled water method**

Doubly labeled water method is used to determine the rate of rise and subsequent decay of stable isotope in biological samples such as blood, urine and saliva by orally taking doubly labeled water, labeled with stable isotopes of hydrogen and oxygen (non-radioactive molecules). From the difference in decay rates of stable isotopes of hydrogen and oxygen, the CO₂ emission rate in exhaled air can be calculated. And also from the accurate body water content and CO₂ emission rate, the total daily energy consumption can be estimated.

***4 Joint Press Release**

Based on a joint press release related to the study results by NIBIOHN, Waseda University, Kyoto University of Advanced Science and the University of Tsukuba jointly. Please inquire with the respective research institutes for details.

[Title] Variation in human water turnover associated with environmental and lifestyle factors

[Journal] Science

[Published date] November 25, 2022

[DOI] DOI: 10.1126/science.abm8668

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