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Original article

Results of the Minamiminowa Next-Generation Aid: Maternity Support Project

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Abstract

***Objective*:** This study was conducted under a comprehensive partnership agreement with Minamiminowa Village in Nagano Prefecture. Its objective was to examine the effects of processed brown rice intake during pregnancy on both maternal and neonatal health, with a particular focus on neonatal birth weight.

***Methods*:** Participants were asked to complete a self-administered symptom questionnaire at two time points: during pregnancy (upon application) and after childbirth. The questionnaires included the Edinburgh Postnatal Depression Scale (EPDS) and the Anti-Aging QOL Common Questionnaire. Processed brown rice was provided continuously throughout pregnancy based on individual participant requests to ensure uninterrupted intake. A total of 22 cases were analyzed, accounting for approximately one-sixth of the average annual births in Minamiminowa Village.

***Results*:** Among pregnant participants, improvements were observed in physical symptoms such as skin condition and Early satiety. Notably, significant improvements were also seen in psychological symptoms, including reductions in "Scared", "Mentally irritated", "Short-tempered", "Unhappiness", "Not livable" and "Anxious without reasons". Furthermore, a trend was noted in which participants who felt they consumed a larger amount of processed brown rice tended to give birth to infants with higher birth weights. Although a certain number of low birth weight infants (< 2,500 g) were observed, there were no cases of very low birth weight (< 2,000 g).

***Conclusion*:** Consumption of processed brown rice may have a positive effect on the mental health of pregnant women. There was a trend toward increased newborn birth weight in participants who felt they consumed a larger quantity of processed brown rice. Participation in the first year of the study was limited, so efforts will be made to increase participation in the next year.

***KEY WORDS*:** Sub-aleurone layer residual wash-free rice (SARFR), low birth weight infants (LBW), pregnant and postpartum women, neonates, Minamiminowa Village

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Introduction

In recent years, the number of low birth weight (LBW) infants in Japan has shown an increasing trend since 1990 (Ministry of Health, Labour and Welfare: Survey Report on Infant Physical Growth). Specifically, neonates weighing less than 2,500 grams are classified as LBW infants. The proportion of LBW infants has been increasing since 1980, and since 2005, it has consistently remained around 9.5%[1]. LBW infants often require medical care after birth, and are at higher risk for developmental delays as well as health issues extending into adulthood[2]. Particularly in Japan, LBW infants have been reported to be at increased risk of chronic liver disease[3]. Causes attributed to LBW include maternal weight loss during pregnancy[4], increased stress[4], late marriage[4], alcohol consumption[5,6], and smoking[7,8].

Therefore, research has advanced on how to achieve ideal birth weights in neonates. The EcoChild Study, which involved 100,000 pairs of mothers and infants, reported domestically that insufficient weight gain during pregnancy increases the incidence of LBW or macrosomia[9]. Conversely, excessive weight gain during pregnancy has been associated with higher risks of pregnancy-induced hypertension and gestational diabetes mellitus after delivery (Ministry of Health, Labour and Welfare: Pregnancy Weight Gain Chart)[10]. Furthermore, it has been reported that weight gain of 7 kg or less during pregnancy increases the risk of delivering LBW infants[11]. However, the risk of LBW infants can be reduced by high-quality maternal diet during pregnancy[12]. Therefore, adequate and appropriate nutrition intake during pregnancy is considered essential for both neonates and mothers. It has already been shown that consumption of processed brown rice, which contains well-balanced nutrition, significantly increased neonatal weight at the one-month checkup compared to previous years, along with improved maternal health status[13].

In Nagano Prefecture, both birth numbers and birth rates have shown a slight decline compared to national averages. The number of births in fiscal year 2021 (Reiwa 3) was reported as 12,514, with a birth rate of 6.3%[14]. Additionally, the total fertility rate has been declining in recent years. The total fertility rate represents the sum of age-specific birth rates for women aged 15 to 49 and estimates the number of children a woman would bear in her lifetime. It is a key indicator for understanding population birth trends. From fiscal year 2002 (Heisei 14) to 2008 (Heisei 20), Nagano's total fertility rate remained between 1.43 and 1.59, consistently higher than the national average (***Fig. 1***)[15]. However, a downward trend has been observed from fiscal year 2019 (Reiwa 1) to 2021 (Reiwa 3), revealing various challenges related to childbirth. Regarding LBW infants, the overall percentage in the prefecture in fiscal year 2021 was 9.4%, comparable to the national average, though some regions exhibited markedly higher rates[16]. Notably, Minamiminowa Village had an exceptionally high LBW infant rate of 13.4% in fiscal year 2014 (Heisei 26), significantly exceeding rates in other municipalities in the prefecture (***Fig. 2***)[17].

Given this situation, Minamiminowa Village established its first Food Education Promotion Plan in fiscal year 2011 (Heisei 23). Over the following decade, through the second plan, the village has promoted food education activities based on the fundamental philosophy of "nurturing people through food" across the entire community. Currently, the third Food

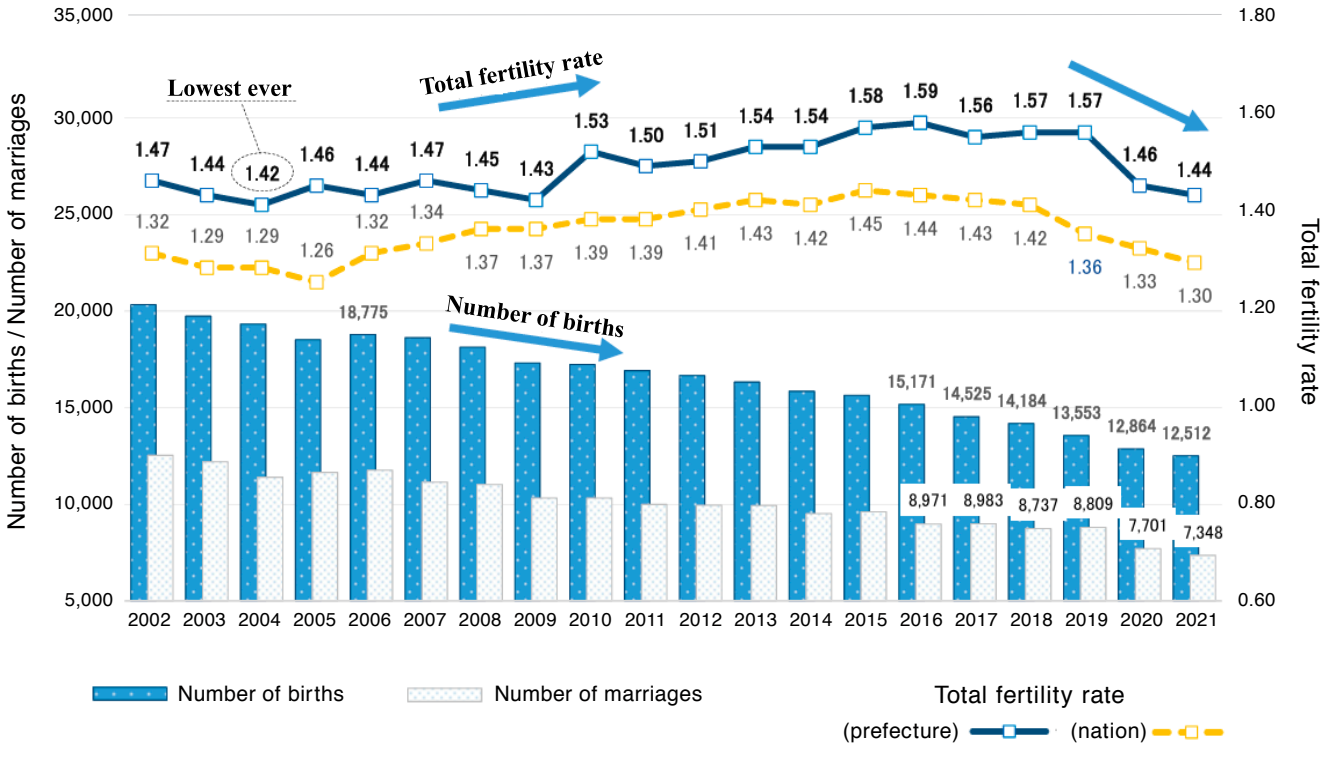
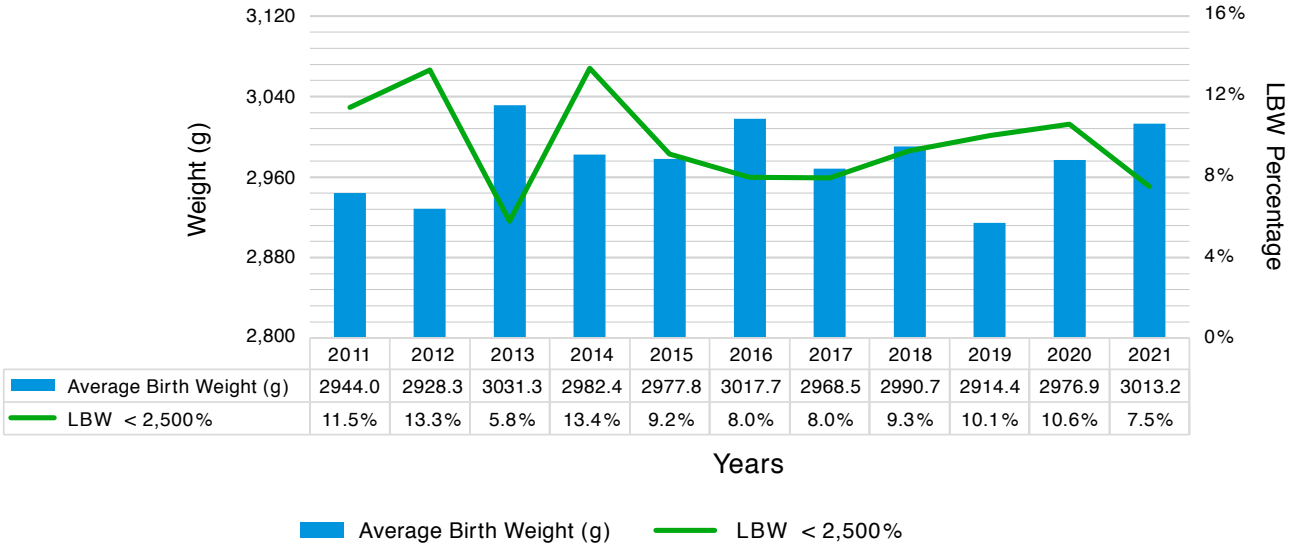


Fig. 1. **Trends in the number of births, number of marriages, and total fertility rate in Nagano Prefecture (Fiscal Years 2002–2021).**



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Average Birth Weight (g)	2944.0	2928.3	3031.3	2982.4	2977.8	3017.7	2968.5	2990.7	2914.4	2976.9	3013.2
LBW < 2,500%	11.5%	13.3%	5.8%	13.4%	9.2%	8.0%	8.0%	9.3%	10.1%	10.6%	7.5%

Fig. 2. **Trends in birth weights and the proportion of LBW infants in Minamiminowa Village (Fiscal Years 2011–2021).**
LBW, low birth weight.

Education Promotion Plan is underway, covering the period from fiscal year 2021 (Reiwa 3) through 2025 (Reiwa 7). Against this backdrop, the "Minamiminowa Next-Generation Aid" Maternity Support Project was launched to promote maternal and child health and support the healthy growth of newborns through coordinated efforts involving villagers, related organizations, and volunteers. As part of this project, preliminary investigation focusing on the effects of processed brown rice consumption on pregnant and postpartum women and on neonatal birth weight was conducted.

Methods

Agreement

Prior to commencing the study, a comprehensive collaboration agreement was concluded between the (Public Interest Incorporated Foundation) Isyoku-Dogen Research Foundation and Minamiminowa Village Government.

Agreement on Comprehensive Collaboration between Minami Minowamura Village and the Isyoku-Dogen Research Foundation

(Purpose)

Artcle 1 Minamiminowamura Village (hereinafter referred to as "Party A") and the Isyoku-Dogen Research Foundation (hereinafter referred to as "Party B") will promote mutual collaboration that respects the perspectives of medical and food-based herbal medicine, and will analyze health issues in Party A's region and conduct research led by Party B. In addition, the purpose is to create new social value and promote the health of citizens, leading to preventive measures to reduce medical expenses in the region and the development of the local community.

(Matters of collaboration)

Artcle 2 After consultation between Party A and Party B, in order to achieve the purpose of the previous article, Party A and Party B will collaborate and cooperate on the following matters. **(1)** Matters related to promoting the health of citizens **(2)** Matters related to the analysis and interpretation of health issues in Party A's region **(3)** Matters related to the promotion of Party B's research using Party A's field **(4)** Other matters necessary to achieve the objectives of this agreement.
2. Specific implementation matters will be decided through consultation between Party A and Party B.

(Review and termination of the agreement)

Artcle 3 When either Party A or Party B requests changes to the contents of the agreement or its termination, the necessary changes or termination will be made following consultation each time.

(Period)

Artcle 4 The validity period of this agreement will be from the date of its conclusion of the agreement to March 31, 2025. However, unless Party A or PartyB requests the other party to terminate the agreement in writing one month prior to the expiration date, this agreement will be renewed for another year, and the same shall apply thereafter.

(Confidentiality)

Artcle 5 Party A and Party B shall not disclose, provide or leak to a third party any confidential information that they learn in the course of carrying out the matters set out in Article 2, nor shall they use such information for purposes other than those of the initiatives under this Agreement. However, this does not apply if the other party gives prior written consent.

2. The obligations set out in the preceding paragraph shall survive the termination of this Agreement.

(Resolution of doubts)

Artcle 6 If doubts arise regarding matters not specified in this Agreement, or matters specified within this Agreement, Party A and Party B shall negotiate in good faith to reach a settlement. As evidence of the above and the conclusion of this Agreement, two copies of this Agreement shall be prepared, and Party A and Party B shall each sign and seal one copy and retain one copy.

August 26, 2023
Party A: 4825-1 Minamiminowa Village,
Kamiina district, Nagano
Mayor of Minamiminowa Village:
Hidefumi Fujishiro
Party B: 5-10-13 Ginza, Chuo-ku, Tokyo
Isyoku-Dogen Research Foundation
Representative Director: Yoshikazu Yonei

Minamiminowa Village

Minamiminowa Village, located in Kamiina District in southern Nagano Prefecture, is located upstream of the Tenryu River (latitude and longitude: E137°58'N35°52'). It spans an area of 40.99 km² and is rich in nature. Since its founding on February 18, 1875, the village has never merged or separated, and in 2025 will celebrate its 150th anniversary. The population is approximately 16,000 (as of March 2025), and is growing thanks to its comprehensive childcare support system, affordable residential land, and convenient transportation. As of April 1, 2022, the aging rate is at 23.7%, the lowest among municipalities in Nagano Prefecture. Interest from those looking to relocate to the village is high, with 70% of the village's residents originally from outside the village. With a rich natural environment and a pleasant climate, the village continues to develop in harmony with its agricultural, commercial, industrial and residential areas, and in terms of education, it is a village blessed with an excellent educational environment, with everything from nursery schools to high schools, junior colleges and national universities.

Data collection methods

The subjects analyzed in this study were 25 individuals who applied between November 1, 2023, and October 31, 2024. After completing their application, participants were asked to complete questionnaires twice: once at the time of application and once again after childbirth. The questionnaires included the Edinburgh Postnatal Depression Scale (EPDS)[18,19] and the Anti-Aging Quality of Life common inquiry form (AAQol)[20,21], consistent with previously reported methods[13]. All questionnaires were conducted online via smartphones. The URL for the questionnaire was provided as a QR code on a flyer given to participants at application, and participants completed the surveys independently. The questionnaire content is included in the supplementary materials. Regarding the provision of processed brown rice during pregnancy, participants were given a voucher for 5 kg of processed brown rice at the JA direct sales facility "Ajina" when submitting their pregnancy notification. Subsequently, JA delivered up to 15 kg of processed brown rice monthly by home delivery on dates requested by the participants, ensuring continuous availability and consumption of processed brown rice throughout pregnancy.

Village cooperation framework

This project was initiated by Minamiminowa Village Mayor Hidefumi Fujishiro, who promoted collaboration from the perspective of the idea that food is medicine. Through analysis and research of local health issues, the village aims to promote the health of villagers, reduce medical costs, and develop the region. Overall project management was led by the Industry Division, while on-site management (including survey and processed brown rice distribution scheme planning, and survey data entry and organization) was carried out by the Agriculture Policy Section of the Industry Division. The Maternal and Child Health Section of the Children's Division provided information about this project to pregnant women.

Food information about processed brown rice

The processed brown rice provided in this project was "Kinmemai～Kaze no Mura Mai Dayori～", a Koshihikari variety produced in Minamiminowa Village. This rice is processed using a special polishing machine that gradually removes the bran layer from the surface of the brown rice, leaving a uniform sub-aleurone layer intact on the grain surface. This processed brown rice is referred to as Sub-aleurone layer residual wash-free rice (SARFR) (*Fig. 3*)[22-24]. The sub-aleurone layer contains vitamins, minerals, dietary fiber, and rice bran oil components such as γ-oryzanol[25-28], lipopolysaccharides (LPS), ferulic acid[29], and phytic acid[30], which have been reported to have various beneficial effects[22-24,31]. Furthermore, it is believed that the consumption of processed brown rice is associated with improved health in adulthood, which may result in reduced medical costs[32]. It has also been reported that processed brown rice reduces the risk of infectious diseases in young children[33]. This suggests that processed brown rice may contribute to the health of people from young children to adults.

Fig. 3. **Sub-aleurone layer residual rice (Kinmemai) produced in Minamiminowa Village, provided to pregnant women.**

From the perspective of glycative stress, brown rice nutrients contribute to improvements in postprandial hyperglycemia[34], suppression of advanced glycation end products (AGEs) formation[29], and mitigation of animal fat dependency[25-29]. Aldehydes, which induce glycative stress, are generated from both carbohydrates and lipids (fatty acids), so rice bran oil components help correct high-fat diets. Moreover, nutrients in brown rice alleviate dysbiosis of the gut microbiota[27, 35], increasing the production of short-chain fatty acid-producing bacteria, which enhance basal metabolism through specific receptors (GPR41/43)[36-38]. These combined effects contribute to improving glycative stress.

Ethical standards

This study was conducted based on the comprehensive collaboration agreement between Minamiminowa Village and the Integrated Traditional and Western Medicine Research Foundation (Public Interest Incorporated Foundation).

Results

Participant characteristics and satisfaction with the project

The age distribution of participants is shown in ***Fig. 4***, and the mean and standard deviation of participants' age, height, and weight are presented in ***Table 1***. Participants in their 30s were the largest group, with only one participant in her 40s. There were no significant differences in height or weight among participants, with overall values being comparable. ***Table 2*** summarizes the questionnaire results collected at the end of the project. All responses were "satisfied" or higher, with the majority indicating "very satisfied." Furthermore, all participants responded that they would recommend this project to other pregnant women, with most answering that they "would like to recommend" it. No participants reported dissatisfaction or strong dissatisfaction. However, many reported little change in their physical condition.

Among these, one participant had Hashimoto's disease and initially experienced insomnia but reported improved sleep after the intervention. For the 16 participants who reported little change in physical condition, a comparison of scores from application to project completion using a t-test revealed improvements in symptoms of Lasy, Epigastralgia, and dizziness (***Table 3***). Although these participants did not subjectively feel a change in their overall physical condition, the data suggest that some degree of physical improvement may have occurred.

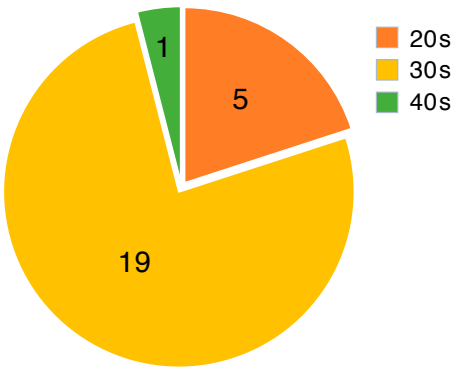


Fig. 4. **Number of subjects (pregnant women) by age group.**

Table 1. Participant information.

n = 25	Mean	SD
Age	33.36	4.17
Height	157.32	6.5
Weight	53.4	9.15

SD, standard deviation.

Table 2. Thoughts on the project.

How satisfied are you with participating in the project?	Very satisfied	22
	Satisfied	3
	Neutral	0
	Unsatisfied	0
	Very unsatisfied	0
Would you recommend this project to other pregnant women?	Would recommend	22
	May recommend	3
	Neutral	0
	Not really recommended	0
	Wouldn't recommend	0
Quantity of Kinme-rice	There was quite a lot	0
	There was a little too much	1
	Just right	19
	A little insufficient	4
	There wasn't enough	1
Changes in physical condition after eating Kinme-rice	Much better	6
	Improved	3
	Not much different	16
	Worsened	0
	Very badly	0

Table 3. Changes in physical condition among 16 people who answered that their physical condition had not changed much: Items that improved significantly.

Items where significant differences (tendencies) were observed in the before-and-after comparison	p value/effect size
Lasy	0.04/0.43
Epigastralgia	0.05/0.42
Dizziness	0.06/0.40

Discussion

Effects of the intervention

Changes in each questionnaire score between the time of application and the end of the project were calculated by subtracting the final score from the initial score. To explore the relationship between these changes and participants' satisfaction with the project, a correlation analysis was conducted (***Table 4***). A larger negative value indicates a greater improvement and tended to be associated with higher satisfaction.

Furthermore, a paired *t*-test was performed to examine items with significant differences between pre- and post-intervention scores. The results showed that several symptoms significantly improved (***Table 4***, right side). Of the participants in this study, one was in her 40s (43 years old) and three were in their 30s (all 38 years old), so the age group analysis was conducted for those in their 20s and those in their 30s and 40s. For some items, differences were observed between those in their 20s and those in their 30s and 40s (***Table 4***, right side).

In addition, effect sizes were calculated to identify which items were most strongly impacted by the intervention. Larger effect sizes indicate stronger effects for the respective items.

Some differences were observed between these two age groups. Notably, "Scared" showed the greatest effect size, followed by "skin problem" which was significantly reduced only in the 20s group. In contrast, symptoms like "Early satiety," seen among the 30s and 40s group, often naturally improve postpartum, making it difficult to determine whether the observed improvements were due to the intervention or simply the timing of the post-survey, which may have taken place after delivery. Mental health symptoms, such as "Mentally irritated", "Short-tempered", "Unhappiness", "Not livable", "Anxious without reasons", and fear, showed particularly notable improvements. However, since hormonal fluctuations during pregnancy can stabilize postpartum, it remains unclear whether the observed improvements were directly due to the processed brown rice intervention. Nevertheless, previous studies have reported the antidepressant effects of brown rice[39], suggesting a possible link rather than a complete lack of association. Therefore, while it is difficult to conclusively attribute these improvements to the intervention, the results clearly show a trend toward improvement in various symptoms following processed brown rice consumption, supporting the intervention's potential efficacy. Additionally, correlation analysis revealed that participants with higher satisfaction also tended to show improvements in Epigastralgia, Arthralgia, and cold sensitivity (***Table 4***, left side). These symptoms are easily perceived by the participants themselves, which likely contributed to their overall satisfaction with the project.

Depressive symptoms during pregnancy are known to influence subsequent mother-child bonding, attachment formation, and the development of postpartum depression[40]. Since significant effects on psychological aspects were observed in the items that showed differences based on t-tests, it can be inferred that improvements occurred before and after the intake of processed brown rice. Furthermore, the strong correlation between improvements in personally perceptible symptoms, such as pain, and overall satisfaction suggests that the alleviation of physical symptoms may also have contributed. These findings imply that the intake of processed brown rice had positive effects on both mental and physical health. Naturally, the sense of security stemming from being in a municipality that implements support programs for pregnant and postpartum women—such as this project—may have contributed to the observed outcomes (see participants' feedback). It is also possible that mental improvements were achieved through the alleviation of physical symptoms. In either case, the analysis suggests that many participants were satisfied with the project and experienced positive effects both physically and psychologically.

Table 4. Items with significant relationships and differences between the time of application and the end of the project.

Items that showed a significant relationship with satisfaction	Correlation coefficient	Items that showed a significant difference (tendency) in the before-and-after comparison	p value/effect size
Epigastralgia	-0.27	Feel tired	0.04／0.42
Arthralgia	-0.34	Skin problems (only in 20s)	0.04／0.45
Sensitivity to cold	-0.22	Early satiety (only in 30s & 40s)	0.02／0.27
		Epigastralgia	0.06／0.40
		Frequent urination	0.07／0.38
		Mentally irritated (only in 30s & 40s)	0.05／0.41
		Short-tempered (only in 20s)	0.09／0.35
		Unhappiness	0.07／0.38
		Not livable	0.07／0.38
		Anxious without reasons	0.05／0.42
		Scared	0.03／0.40

Effects on maternal and neonatal health status after delivery

As an additional analysis, follow-up data were collected from maternal health checkups and birth assessments. A total of 22 participants were included in the follow-up. Birth weights were obtained for all 22 newborns, and EPDS (Edinburgh Postnatal Depression Scale) responses were collected from 19 mothers. The EPDS is a screening tool for postnatal depression, where higher scores indicate a higher risk. ***Table 5*** presents the birth weights and EPDS scores. Although an EPDS score above 10 is generally considered indicative of potential postnatal depression, none of the participants in this study met that threshold. While it is not possible to definitively determine whether the observed psychological benefits were a result of processed brown rice intake or other factors, it is noteworthy that no cases of suspected postnatal depression were observed among study participants.

To explore factors associated with neonatal weight gain, a correlation analysis was conducted between changes in responses to pre- and post-intervention questionnaires and the newborns' birth weights (***Table 6***). The results suggest that improvements in symptoms such as Muscle pain and strain, coughing and sputum production, and sleep quality were positively associated with neonatal weight gain. Conversely, increased Strained was found to be negatively associated with birth weight. Combined with the results of ***Table 4***, where symptoms like Lasy were significantly improved, these findings imply that improvements in maternal physical condition may have contributed to increased neonatal birth weight. Additionally, improved physical well-being may have enhanced sleep quality, further supporting healthy neonatal development.

The number of newborns, their birth weights, and the distribution of birth weights in Minamiminowa Village from 2011 to 2021 were obtained (***Table 7, Fig. 5***). The average proportion of LBW infants (< 2500 g) was 9.7%, and no clear decreasing trend was observed.

Among the 25 registrants over the one-year period, 22 cases were analyzed. The average birth weight was 2,886.5 g, with a standard deviation of 348.3 g. A particularly noteworthy finding was the decrease in the proportion of very low birth weight (VLBW) infants weighing less than 2,000 g.

Table 5. Neonatal height, weight, chest circumference, head circumference and results of EPDS.

ID	Sex	Gestational week	Body weight (g) (at birth)	Body weight (g) (at one month)	Height (cm)	Chest circumference (cm)	Head circumference (cm)	EPDS
1	F	39	2,490	3,540	51.6	34.2	34.5	4
2	F	39	3,132	4,244	55.7	36	38	1
3	F	38	3,092	3,906	50.3	34.4	36.8	0
4	M	38	2,944	4,556	53.1	38.7	37.5	1
5	F	34	2,356	2,966	48	30	34.3	6
6	M	39	3,224	4,192	53.6	35.5	35.5	3
7	F	37	2,352	3,830	49.4	35.5	36.8	1
8	M	38	2,802	4,518	54.7	37.9	38.1	1
9	M	39.4	3,242	4,392	54.5	37.5	38	0
10	F	38.6	3,418	4,398	55.1	34.5	36.8	3
11	M	40	3,054	4,188	52.4	36.6	38.8	0
12	F	38	2,502	3,614	49.9	35.3	36.3	5
13	M	38.1	2,418	3,470	48.8	34.6	36.5	0
14	M	40	3,042	3,042	DN	DN	DN	DN
15	M	37	3,200	4,064	52.9	35.5	38	0
16	M	41	2,244	3,382	50.8	34.4	35.6	7
17	F	40	2,776	3,840	51.1	35	35	
18	M	38	3,180	4,026	53.2	34	36.6	6
19	M	38	2,994	4,688	56.1	37.5	37.5	4
20	M	38	3,396	4,198	51.9	34	37.1	1
21	M	37	2,844	3,996	53.1	34.2	36	3
22	M	38	2,802	3,368	49.1	34.8	35	

EPDS, Edinburgh Postnatal Depression Scale; DN, data not available.

Table 6. The relationship between monthly weight gain in newborns and maternal symptoms and symptoms.

Items	Correlation coefficient
Filmed eyes	-0.34
Muscle pain and strain	-0.38+
Overweight	-0.36
Thirsty	-0.31
Have a weak chest	-0.3
Cough and sputum	-0.42+
Sweat	-0.32
Sleep quality	-0.32+
I want to know the amount of processed brown rice.	0.22
Cannot resolve the problem	0.32
Anxious before sleeping	0.35
Strained	0.44+
Anxious without reasons	0.34

Table 7. Trends in newborn weight in Minamiminowa Village and results of this intervention.

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	after intervention (2024)
Average Birth Weight (g)	2944	2928.3	3031.3	2982.4	2977.8	3017.7	2968.5	2990.7	2914.4	2976.9	3013.2	2886.5
Subjects (number)	157	150	155	179	153	175	138	129	149	160	133	22
Normal Weight 2500 < 4000 g	139	130	145	155	138	161	126	116	133	143	123	17
precentage %	88.5%	86.7%	93.5%	86.6%	90.2%	92.0%	91.3%	89.9%	89.3%	89.4%	92.5%	77.3%
LBW < 2500 g	18	20	9	24	14	14	11	12	15	17	10	5
LBW < 2500 g %	11.5%	13.3%	5.8%	13.4%	9.2%	8.0%	8.0%	9.3%	10.1%	10.6%	7.5%	22.7%
LBW < 2000 g	1	5	2	3	3	2	3	2	2	1	0	0
LBW < 2000 g %	0.6%	3.3%	1.3%	1.7%	2.0%	1.1%	2.2%	1.6%	1.3%	0.6%	0.0%	0.0%
Average Birth Weight (g)	2944	2928.3	3031.3	2982.4	2977.8	3017.7	2968.5	2990.7	2914.4	2976.9	3013.2	2886.5

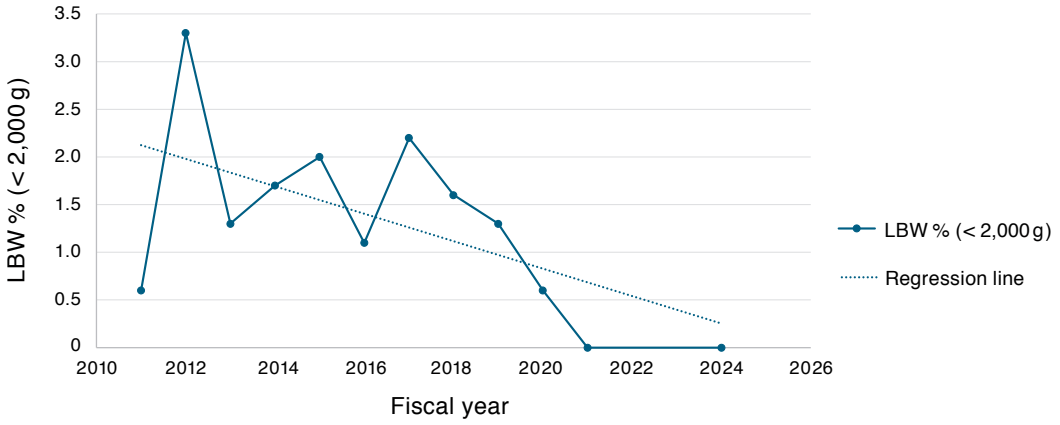


Fig. 5. **Trends in the Proportion of LBW Infants (< 2000 g) in Minamiminowa Village (2010–2024).**
LBW, low birth weight.

In the Japanese population, it has been reported that very LBW is associated with an increased risk of attention-deficit/hyperactivity disorder (ADHD)[41].

In contrast, the proportion of LBW infants under 2,500 g was higher than previous levels. Known risk factors for LBW include preterm birth, short maternal stature, maternal dieting or weight loss[4], increased stress[4], advanced maternal age[4], as well as alcohol[5,6] and tobacco use[7,8] during pregnancy. Since none of the participants in this study reported alcohol consumption or smoking, other factors may have played a role, although these could not be identified in the present analysis. A notable characteristic of Minamiminowa Village is its unique social structure, where approximately 70% of residents are from outside the village, resulting in a high proportion of in-migrants. This demographic pattern may have contributed to variations in lifestyle and dietary habits during pregnancy. In comparison with previous studies[13], the average weight of pregnant women in this study was 59.49 kg, but the average weight of pregnant women in this study was 53.40 kg, so there was a slight difference in weight, which may have also influenced the results. Importantly, not all infants born weighing less than 2,500 g had health complications. Among the five LBW cases, the average birth weight was 2,372 ± 81 g (minimum: 2,244 g; maximum: 2,490 g), with four of the five infants weighing more than 2,350 g. All infants exhibited normal developmental progress postnatally. A 3-year-old health check is scheduled for these children, which is expected to provide further insights.

From the standpoint of reducing the incidence of LBW, this project can be regarded as a partial success. However, given that the annual number of births in Minamiminowa Village ranges from 130 to 180 (from 2000 to 2023), the number of cases analyzed in this pilot year represented only about one-sixth of the total.

One possible reason for the low number of registrants is that some pregnant individuals received rice from relatives or acquaintances who are rice farmers, reducing the need to participate. A similar trend was observed in the 2023 "Izumiotsu Next-Generation Aid" project, where approximately 70% of expectant mothers registered for participation when the maternal and child health handbook was issued[13]. Effectively communicating the significance of this project to pregnant individuals is essential. The project aims to protect the health of both mothers and fetuses and to support a healthier pregnancy period. Its outcomes should be appropriately analyzed and disseminated through media, academic societies, and journal publications. Ensuring that pregnant participants fully understand the project's objectives and background will help foster reassurance and trust, encouraging their participation. Such communication is expected to cultivate a proactive attitude among expectant mothers toward making healthier lifestyle choices. Increasing the registration rate will be a key goal for the next fiscal year.

Table 8. Participant information in Izumiotsu Project.

n = 101	Mean	SD
Number of people per household	2.85	0.79
Age	30.9	3.81
Height	159.32	4.92
Weight	59.49	7.87

SD, standard deviation. Quoted from Reference 13.

Glycative stress experienced by fetuses during the embryonic period

Humans are exposed to not only exogenous aldehydes but also endogenous formaldehyde, which is generated as a byproduct of metabolic processes. Under physiological conditions, formaldehyde is detected in the bloodstream at low concentrations (0.01–0.08 mmol/L)[42]. Exogenous sources include smoking, sick building syndrome, and the consumption of fish and shellfish containing organic mercury, all of which can increase blood formaldehyde levels. Compared to traditional tobacco, e-cigarettes contain lower levels of nicotine and tar in their smoke, but the proportion of harmful aldehydes, such as formaldehyde, is markedly higher. Consequently, secondhand smoke now carries a stronger and more irritating aldehyde odor, and the smaller molecular weight of these aldehydes allows them to disperse over greater distances[43-45]. Sick building syndrome is primarily caused by inhalation of formaldehyde released from plywood[46]. Organic methylmercury is demethylated in the liver, and the released methyl groups can result in formaldehyde production[47-49]. Formaldehyde is also generated during the metabolism of dietary serine, glycine, methionine, and choline. However, because these nutrients are essential from a nutritional standpoint and due to the existence of multiple metabolic side pathways, formaldehyde generation accounts for only a small fraction of their metabolic fate, and thus dietary restrictions are not considered necessary.

The most important factor in endogenous formaldehyde production is demethylation, which occurs during cell division, proliferation, and differentiation. DNA methylation and demethylation are epigenetic modifications involved in the regulation of gene expression. Demethylation can be classified into passive demethylation, which is dependent on cell division, and active demethylation, which is independent of cell division. In particular, DNA demethylation by TET (ten-eleven translocation) enzymes is known to regulate gene expression without altering DNA sequence and contribute to DNA repair mechanisms[50-52]. During fetal development, cell division and differentiation are extremely active, and repeated DNA methylation and demethylation lead to the formation of organ-specific methylation patterns.

During fetal development or implantation, cells are already under strong epigenetic control, with demethylation activated to prevent the inheritance of abnormal cytosine methylation[53,54]. During fetal development, intensive demethylation occurs in both the paternal and maternal genomes, with demethylation of the paternal genome occurring much more rapidly than that of the maternal genome[55]. DNA copying errors frequently occur in rapidly dividing and proliferating stem and progenitor cells, but these errors are repaired by DNA repair enzymes excising methylated DNA and replacing it with unmethylated DNA[56]. To counteract this stress, stem and progenitor cells express high levels of aldehyde-metabolizing enzymes, such as aldehyde dehydrogenase (ALDH)[57-59], glyceraldehyde-3-phosphate dehydrogenase (GAPDH)[60], and glyoxalase (GLO)[61].

As one example, there is the issue of LBW infants. Risk factors for LBW infants include smoking and drinking, which result in a strong aldehyde load (glycative stress load) on the fetus. Therefore, glycative stress countermeasures (GS care) starting from the fetal period are reasonable.

Points to note when intervening with pregnant women

The most important consideration in conducting intervention studies is the safety of the test substance administered. During pregnancy, both mother and child have heightened sensitivity to harmful substances, and adverse events affecting the fetus must absolutely be avoided. In this respect, the nutritional components of brown rice, whose safety is ensured through a long history of dietary experience, were judged to be safe. Providing brown rice as-is involves complicated cooking and indigestibility issues, and there is a risk of gastrointestinal symptoms due to abnormal intestinal fermentation caused by insufficient chewing. Therefore, processed brown rice (partially retained aleurone layer rice) [18-20], which is rich in nutritional components and easy to digest and absorb, was provided.

The nutritional components contained in brown rice are expected to have the following effects:

(1) The ability to increase beneficial bacteria in the intestinal microbiota[35]. As confirmed by questionnaires, it also improves "bowel movements". Short-chain fatty acids (butyrate, acetate) and lactic acid produced by beneficial bacteria suppress the formation of advanced glycation end-products (AGEs)[36-38].

(2) Improvement of glucose metabolism. By lowering "postprandial hyperglycemia"[62-65], it is possible to reduce subsequently generated sugar-derived aldehydes.

(3) Assistance in breaking dependence on animal fats[25-28]. It helps correct poor lifestyle habits such as "fat preference" and "dislike of exercise," thereby reducing lipid-derived aldehydes.

Epidemiological survey results from the international research project Global Burden of Disease (GBD) point out that insufficient intake of whole grains such as brown rice is associated with an increased excess mortality rate related to "cardiovascular disease," "diabetes," and "cancer"[66]. Conversely, it means that consuming 140–160 g of whole grains daily can prevent these related deaths. This amount corresponds to approximately one serving (1 go) of Kinmemai (a type of processed brown rice). The excess mortality rate related to diabetes, a representative disease with strong glycative stress, is as high as 4.6%, indicating that whole grain components may alleviate glycative stress.

Another point to emphasize is the significance of reducing LBW infants. In recent years, there has been a trend to place more importance on healthy life expectancy rather than average life expectancy; however, this applies primarily to modern adults in middle, mature, and old age, and the outcomes depend on future interventions. Considering that the definition of average life expectancy is the "expected lifespan of a 0-year-old infant," there is no guarantee that today's children will live out their average life expectancy. This project aims to promote the health of children (fetuses) in the fetal period. I am confident that its significance is extremely large.

Conclusion

Based on the results of this survey, effects of processed brown rice intake were observed in many items. Furthermore, the satisfaction of participants in this project was high, strongly indicating that it was a meaningful study for all participants. Although the number of participants was not large, and therefore the validity of the analysis results may not be high, it is at least unlikely that there were no effects of processed brown rice intake. In the future, it will be necessary to accumulate results from each region and conduct longitudinal observations, and statistically integrate these multiple outcomes to derive more reliable conclusions regarding the health effects of processed brown rice intake on mothers and children.

Conflict of interest statements

There are no conflicts of interest related to this study.

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References

1) Ministry of Health, Labor and Welfare (MHLW). Document. Regarding nutritional issues that should be prioritized from the perspective of realizing a vibrant and sustainable society. The Second Meeting: "Study Group for Promoting the Creation of a Sustainable Food Environment that Naturally Makes People Healthy". March 29, 2021. (in Japanese) https://www.mhlw.go.jp/content/10904750/000761522.pdf
2) Yamamoto Y. Research on the burden of disease, including lifestyle-related diseases in adulthood, due to low birth weight. Ministry of Health, Labor and Welfare (MHLW) Research Report "FY2018 Child and Childcare Support Promotion Research Project", March 2019. (in Japanese) https://www.mhlw.go.jp/content/11900000/000592934.pdf
3) Hirano K, Kubota A, Nakayama M, et al. Parenteral nutrition-associated liver disease in extremely low-birthweight infants with intestinal disease. *Pediatr Int*. 2015; 57: 677-681.
4) Mizuho Information & Research Institute, Inc. Low birth weight babies: Health guidance manual. Ministry of Health, Labor and Welfare (MHLW) "Survey on health guidance for babies born low in birth" Study Group. March 2019. (in Japanese) https://www.mhlw.go.jp/content/11900000/000592914.pdf
5) Tamura N, Hanaoka T, Ito K, et al. Different risk factors for very low birth weight, term-small-for-destational-age, or preterm birth in Japan. *Int J Environ Res Public Health*. 2018; 15: 369.
6) Cho K, Kobayashi S, Araki A, et al; Japan Environment and Children's Study Group.Prenatal alcohol exposure and adverse fetal growth restriction: Findings from the Japan Environment and Children's Study. *Pediatr Res*. 2022; 92: 291-298. doi: 10.1038/s41390-021-01595-3.
7) Hawkins SS, Baum CF. Associations between local cigarette and e-cigarette prices and smoke-free legislation with prenatal smoking and birth outcomes. *Drug Alcohol Depend*. 2025; 274: 112777.
8) Romero Villela PN, Kelly KM, Balbona JV, et al. Maternal smoking during pregnancy interacts with genetic factors to increase risk for low birth weight but not harmful offspring smoking behaviors in Europeans. *Nicotine Tob Res*. 2024: ntae310.
9) Uchinuma H, Tsuchiya K, Sekine T, et al. Gestational body weight gain and risk of low birth weight or macrosomia in women of Japan: A nationwide cohort study. *Int J Obes (Lond)*. 2021; 45: 2666-2674.
10) Ministry of Health, Labour and Welfare. Press release February 2006: Optimal weight gain chart during pregnancy. (in Japanese) https://www.mhlw.go.jp/houdou/2006/02/dl/h0201-3a4.pdf
11) Nishiyama K, Sanefuji M, Kurokawa M, et al. Maternal chronic disease and congenital anomalies of the kidney and urinary tract in offspring: A Japanese cohort study. *Am J Kidney Dis*. 2022; 80: 619-628el.
12) Okubo H, Nakayama SF; Japan Environment and Children's Study Group. Periconceptional maternal diet quality influences blood heavy metal concentrations and their effect on low birth weight: The Japan Environment and Children's Study. *Environ Int*. 2023; 173: 107808.
13) Ukezono M, Minamide K, Saika K, et al. Report from Izumiotsu Maternity Support Project: Next Generation Aid. *Glycative Stress Res*. 2024; 11: 204-211.
14) Nagano Prefecture. Overview of the 2021 population dynamics statistics. Table 3-1, Overview of population dynamics statistics by Prefectures. September 16, 2022. (in Japanese) https://www.mhlw.go.jp/toukei/saikin/hw/jinkou/kakutei21/dl/06_h3-1.pdf
15) Nagano Prefecture. "FY2022 Happiness Shinshu Creation Plan 2.0" Policy Evaluation: 3. Evaluation results based on key goals: (5) Achieving the prefecture's desired birth rate of 1.84 by 2025 (total fertility rate). (in Japanese) https://www.pref.nagano.lg.jp/seisaku-hyoka/hyouka/documents/r04_08goukeitokusyu.pdf
16) Nagano Prefecture. Statistical data for 2022. I. Statistics on maternal and child health standards. 2. Birth. (2) Trends in low birth weight babies (Nagano Prefecture) 2022. (in Japanese) https://www.pref.nagano.lg.jp/shippei-kansen/boshishika/documents/r4shiryo1.pdf
17) Minamiminowa Village. Minamiminowa Village Health Plan: (5th) 2025 to 2030. 9. Maternal and Child Health [Current status and issues]. (1) From pregnancy to childbirth (previous plan evaluation). 2) Situation regarding low birth weight babies (under 2,500 g). pp.42, March 2025. (in Japanese) https://www.vill.minamiminowa.lg.jp/uploaded/life/27000_71541_misc.pdf
18) Eberhard-Gran M, Eskild A, Tambs K, et al. Review of validation studies of the Edinburgh Postnatal Depression Scale. *Acta Psychiatr Scand*. 2001; 104: 243-249.
19) Salehi A, Zhang M, Kithulegoda N, et al. Validation of the culturally adapted Edinburgh postpartum depression scale among east Asian, southeast Asian and south Asian populations: A scoping review. *Int J Ment Health Nurs*. 2023; 32: 1616-1635.
20) Oguma Y, Iida K, Yonei Y, et al. Significance evaluation of Anti-Aging QOL Common Questionnaire. Glycative Stress Res. 2016; 3: 177-185.
21) Sekimoto I, Ogura M, Yagi M, et al. Walking-based health promotion intervention and anti-aging medical checkups: A long-term observational study Glycative Stress Res. 2024; 11: 121-137.
22) Kyo H, Suzuki N, Enomoto T, et al. Influence of the special processing rice on the factors of lifestyle related disease. *Japanese Journal of Complementary and Alternative Medicine*. 2018; 15: 103-108. (in Japanese)
23) Wickramasinghe PU, Uenaka S, Tian Z, et al. Effects on skin by sub-aleurone layer residual rinse-free rice (Kinmemai rice): An open label test. *Glycative Stress Res*. 2020; 7: 248-257.
24) Yonei Y, Uenaka S, Yagi M, et al. Effects on skin by dewaxed brown rice: An open label test. *Glycative Stress Res*. 2021; 8: 29-38.
25) Kozuka C, Kaname T, Shimizu-Okabe C, et al. Impact of brown rice-specific gamma-oryzanol on epigenetic modulation of dopamine D2 receptors in brain striatum in high-fat-diet-induced obesity in mice. *Diabetologia*. 2017; 60: 1502-1511.

26) Masuzaki H, Kozuka C, Yonamine M, et al. Brown rice-specific γ-oryzanol-based novel approach toward lifestyle-related dysfunction of brain and impaired glucose metabolism. *Glycative Stress Res*. 2017; 4: 58-66.
27) Masuzaki H, Kozuka C, Okamoto S, et al. Brown rice-specific γ-oryzanol as a promising prophylactic avenue to protect against diabetes mellitus and obesity in humans. *J Diabetes Investig*. 2019; 10: 18-25.
28) Masuzaki H, Fukuda K, Ogata M, et al. Safety and efficacy of nanoparticulated brown rice germ extract on reduction of body fat mass and improvement of fuel metabolism in both pre-obese and mild obese subjects without excess of visceral fat accumulation. *Glycative Stress Res*. 2020; 7: 1-12.
29) Yagi M, Sakiyama C, Kitaba T, et al. Antiglycative effect of ferulic acid. *Glycative Stress Res*. 2022; 9: 186-193.
30) Summpunn P, Deh-Ae N, Panpipat W, et al. Nutritional profiles of Yoom Noon rice from Royal Initiative of Southern Thailand: A comparison of white rice, brown rice, and germinated brown rice. *Foods*. 2023; 12: 2952.
31) Ogura M, Yagi M, Nishiyama N, et al. A study of the health actions of consuming a mature extract of brown rice, consisting of the sub-aleurone layer, germ blastula, and crushed cells. *Glycative Stress Res*. 2022; 9: 15-23.
32) Saika K, Yonei Y. Reduction of medical expenses by ingesting processed brown rice (sub-aleurone layer residual rinse-free rice, dewaxed brown rice). *Glycative Stress Res*. 2021; 8: 115-122.
33) Ukezono M, Nishiyama N, Maruyama H, et al. The influence of the type of rice served at school lunches on COVID-19 infection in kindergartens and nursery schools. *Glycative Stress Res*. 2023; 10: 64-69.
34) Seki T, Nagase R, Torimitsu M, et al. Insoluble fiber is a major constituent responsible for lowering the post-prandial blood glucose concentration in the pre-germinated brown rice. *Biol Pharm Bull*. 2005; 28: 1539-1541.
35) Xiao J, Zhang R, Wu Y, et al. Rice bran phenolic extract protects against alcoholic liver injury in mice by alleviating intestinal microbiota dysbiosis, barrier dysfunction, and liver inflammation mediated by the endotoxin-TLR4-NF-κB pathway. *J Agric Food Chem*. 2020; 68: 1237-1247.
36) Li X, Watanabe K, Kimura I. Gut microbiota dysbiosis drives and implies novel therapeutic strategies for diabetes mellitus and related metabolic diseases. *Front Immunol*. 2017; 8: 1882.
37) Shimizu H, Ohue-Kitano R, Kimura I. Regulation of host energy metabolism by *Clostridium butyricum*. *Gut Microbes Rep*. 2024; 1: 181-191.
38) Ikeda T, Nishida A, Yamano M, et al. Short-chain fatty acid receptors and gut microbiota as therapeutic targets in metabolic, immune, and neurological diseases. *Pharmacol Ther*. 2022; 239: 108273.
39) Patil SB, Khan MK. Germinated brown rice as a value added rice product: A review. *Journal of Food Science and Technology*. 2011; 48: 661-667. doi: 10.1007/s13197-011-0232-4
40) Tichelman E, Warmink-Perdijk W, Henrichs J, et al. Intrapartum synthetic oxytocin, behavioral and emotional problems in children, and the role of postnatal depressive symptoms, postnatal anxiety and mother-to-infant bonding: A Dutch prospective cohort study. *Midwifery*. 2021; 100: 103045.
41) Rahman MS, Takahashi N, Iwabuchi T, et al. Elevated risk of attention deficit hyperactivity disorder (ADHD) in Japanese children with higher genetic susceptibility to ADHD with a birth weight under 2000 g. *BMC Med*. 2021; 19: 229.
42) He R, Lu J, Miao J. Formaldehyde stress. *Sci China Life Sci*. 2010; 53: 1399-1404. https://doi.org/10.1007/s11427-010-4112-3
43) Suzuki Y. Current status and problems of electronic cigarettes in Japan. *Jpn J Clin Ecol*. 2017; 26: 24-30. (in Japanese)
44) Horinouchi T, Mazaki Y, Miwa S. Possible involvement of alpha, beta-unsaturated carbonyl compounds in ferroptosis induced by the cigarette smoke extract of heated tobacco products in vascular smooth muscle cells. *J Pharmacol Sci*. 2025; 158: 8-12.
45) Nishimoto-Kusunose S, Sawa M, Inaba Y, et al. Exposure to aerosol extract from heated tobacco products causes a drastic decrease of glutathione and protein carbonylation in human lung epithelial cells. *Biochem Biophys Res Commun*. 2022; 589: 92-99.
46) Taguchi S, Hagiwara M, Shibata A, et al. Investigation and modeling of diurnal variation in suburban ambient formaldehyde concentration. *Environ Sci Pollut Res Int*. 2021; 28: 13425-13438.
47) Tada Y, Marumoto K, Iwamoto Y, et al. Distribution and phylogeny of mercury methylation, demethylation, and reduction genes in the Seto Inland Sea of Japan. *Mar Pollut Bull*. 2023; 186: 114381.
48) Marumoto M, Sakamoto M, Nakamura M, et al. Organ-specific accumulation of selenium and mercury in Indo-Pacific bottlenose dolphins (*Tursiops aduncus*). *Acta Vet Scand*. 2022; 64: 1.
49) David J, Muniroh M, Nandakumar A, et al. Inorganic mercury-induced MIP-2 expression is suppressed by N-acetyl-L-cysteine in RAW264.7 macrophages. *Biomed Rep*. 2020; 12: 39-45.
50) Zhang Y, Peng Z, Guo M, et al. TET3-facilitated differentiation of human umbilical cord mesenchymal stem cells into oligodendrocyte precursor cells for spinal cord injury recovery. *J Transl Med*. 2024; 22: 1118.
51) Kristensen DG, Nielsen JE, Jørgensen A, et al. Evidence that active demethylation mechanisms maintain the genome of carcinoma in situ cells hypomethylated in the adult testis. *Br J Cancer*. 2014; 110: 668-678.
52) de Andrés MC, Kingham E, Imagawa K, et al. Epigenetic regulation during fetal femur development: DNA methylation matters. *PLoS One*. 2013; 8: e54957.
53) Rosado IV, Langevin F, Crossan GP, et al. Formaldehyde catabolism is essential in cells deficient for the Fanconi anemia DNA-repair pathway. *Nature Struct Mol Biol*. 2011; 18: 1432-1434.
54) Gkountela S, Zhang KX, Shafig TA, et al. DNA demethylation dynamics in the human prenatal germline. Cell. 2015; 161: 1425-1436.
55) Guo H, Zhu P, Yan L, et al. The DNA methylation landscape of human early embryos. *Nature*. 2014; 511: 606-610.
56) Nadalutti CA, Wilson SH. Using human primary foreskin fibroblasts to study cellular damage and mitochondrial dysfunction. *Curr Protoc Toxicol*. 2020; 86: e99.

57) Ueda H, Ishiguro T, Mori Y, et al. Glycolysis-mTORC1 crosstalk drives proliferation of patient-derived endometrial cancer spheroid cells with ALDH activity. *Cell Death Discov.* 2024; 10: 435.
58) Foucault A, Hérault O. ALDH enzymes and hematological diseases: A scoping review of literature. *Discov Med.* 2024; 36: 2313-2324.
59) Langevin F, Crossan GP, Rosado IV, et al. FancD2 counteracts the toxic effects of naturally produced aldehydes in mice. *Nature.* 2011; 475: 53-58.
60) Seidler NW. Basic biology of GAPDH. *Adv Exp Med Biol.* 2013; 985: 1-36.
61) Kim JY, Jung JH, Lee SJ, et al. Glyoxalase 1 as a therapeutic target in cancer and cancer stem cells. *Mol Cells.* 2022; 45: 869-876.
62) Gruneck L, Marriott LK, Gentekaki E, et al. A non-randomized trial investigating the impact of brown rice consumption on gut microbiota, attention, and short-term working memory in Thai school-aged children. *Nutrients.* 2022; 14: 5176.
63) Nakayama T, Nagai Y, Yasunaka Y, et al. Effect of eating glutinous brown rice twice a day for 6 weeks on serum 1,5-anhydroglucitol in Japanese subjects without diabetes. *J Nutr Metab.* 2020; 2020: 8847781.
64) Misawa K, Jokura H, Shimotoyodome A. Rice bran triterpenoids improve postprandial hyperglycemia in healthy male adults: A randomized, double-blind, placebo-controlled study. *Food Nutr Res.* 2018; 62.
65) Karupaiah T, Aik CK, Heen TC, et al. A transgressive brown rice mediates favourable glycaemic and insulin responses. *J Sci Food Agric.* 2011; 91: 1951-1956.
66) Tsugane S. Diet for health maintenance: Current evidence. *Food Science.* 2022; 64: 14-18. (in Japanese).