ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue V May 2023

Short-Term Dehydration Status Based on The Type of Drinking Water Consumed by Workers Exposed to High Temperatures

Satria Haritsatama[1] , Ulfa Nurullita[2] , Zoky Abadi Harahap[3]

[1*] Student of Faculty of Public Health, Universitas Muhammadiyah Semarang, Indonesia

[2*] Department of Occupational Health and Safety, Universitas Muhammadiyah Semarang, Indonesia

[3*] Department of Environment of Health, Universitas Muhammadiyah Semarang, Indonesia

DOI: https://doi.org/10.51244/IJRSI.2023.10517

Received: 18 May 2023; Accepted: 01 June 2023; Published: 29 June 2023

Abstract

Background: The process of making tofu in the home industry has the risk of exposing high heat to the environment. This heat comes from the process of boiling soybeans in high temperatures and for a long time. The heat that exposes workers will encourage excessive sweating and cause dehydration. Dehydration is a condition experienced by the body when losing fluids. The body needs fluids containing electrolytes to replace electrolytes lost due to dehydration. For this reason, it is necessary to supplement drinking water to overcome dehydration by choosing drinks that have the potential to reduce dehydration, namely those that have high electrolytes, including mineral water and isotonic beverage. The purpose of the study was to determine the effect of the type of drinking water on dehydration status in tofu industry workers. Method: Quasi-experimental with *time series* design. the sampling technique, used a total of 40 workers using inclusion and exclusion criteria. The provision of mineral water and isotonic beverage were given on different days with a break of one day. Drinking water was given for 3.5 hours of work, with an intensity of 200 ml every 30 minutes. Measurement of dehydration status using urine color standards and subjective complaints of dehydration. Measurement of dehydration status was performed after administration of the intervention. Data analysis used the Friedman test. Results: Dehydration status on pre-treatment, 100% of workers were dehydrated, after giving mineral water as many as 97.2% of workers were dehydrated while after giving isotonic beverage as much as 85.8% were dehydrated. The Friedman test showed a value of p = 0.001. Conclusion: There is a significant effect of the type of water on dehydration status.

Keywords: isotonic beverage, mineral water, dehydration status, heat exposure

I. Introduction

Heat stress is one of the main burdens for humans today. One of the heat stresses is generated from production processes in various industries. One industry that produces heat stress is the tofu industry.[1], [2]. Tofu is made from finely ground soybean seeds. The grinding result is then boiled. At the time of boiling soybeans, heat coming from the furnace is needed. This heat travels to the environment, so it is exposed to workers.[1] Due to prolonged and continuous exposure to heat in the workplace, can cause the risk of *heat* stress in workers.[3], [4] Heat stress can trigger dehydration.[5] Dehydration can cause several health problems such as fatigue, impaired concentration, to a decrease in the level of consciousness.[6]–[9] During long-duration heat exposure, continuous sweating can induce hypovolemia and hyperosmolality because of the hypotonic nature of sweat.[10] The disorders caused by dehydration can be prevented by consuming drinking water in sufficient quantities.[6], [11], [12]

Dehydration is a term which, in clinical use, refers to a deficiency in total body water.[7] The body will be dehydrated when most of the fluid comes out greater than what enters.[13] Body fluids come out faster through urine, sweat to feces. Body fluids will decrease by about 5-10% without activity so body fluid balance needs to be controlled to avoid dehydration. To determine the status of dehydration in the body of workers, one of the parameters used is the color of urine.[14], [15] Many substances can cause urine color to appear abnormal. Cloudy urine may be caused by infection *(pyuria)*, but the most common cause is *phosphaturia*, in which phosphate crystals precipitate in alkaline urine.[16]

Dehydration can be prevented by consuming enough drinking water. Ensuring the body is hydrated is one effective way to increase productivity and protect occupational health and safety from hot ambient temperatures.[3], [17] To meet the fluid needs of workers can consume mineral water as an element of body cooling with the intensity of drinking water every 30 minutes with a water temperature of 10°C-21°C.[18] In addition, workers also need drinks containing electrolytes to replace lost electrolytes in the body.[19]

Based on the results of preliminary studies that have been conducted in the tofu-making industry located in Jomblang Village, Candi Sari District, Semarang City, it showed that the high temperature in the work environment is sourced from a heating furnace

ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue V May 2023

that produces steam in the process of boiling tofu making raw materials. Many workers sweated and complained of feeling thirsty quickly, weak, tired, with dry mouth, and dizzy. From the results of previous studies, heat pressure measurement using a heat stress meter obtained the results of the Wet and Ball Temperature Index on average 34.21° C so that it is said to exceed the Threshold Value (TLV= 28°C). The indoor room temperature is more influence on the performance of the workers.[20]

The results of previous studies have also shown that less water consumption on worker who preferred to consume drinks. They prefered to consume drinks other than water such as tea, coffee, and syrup which are classified as diuretic drinks. Diuretic drinks are drinks that can accelerate the occurrence of excretion through urine.[21], [22]

To reduce dehydration status in workers are by providing drinking water, both mineral water and isotonic beverage. Mineral water has an important role in the body's needs in everyday life. The price of mineral water is very easy to reach for all people besides mineral water can reduce the risk of dehydration. On the other hand, isotonic beverage can help to replace fluids and electrolytes lost because it contains sodium chloride, potassium chloride, calcium lactate, magnesium, and anti-oxidants ascorbic acid. The most effective drinks in maintaining fluid balance are those that contain macronutrients and electrolytes.[23], [24]

Mineral water and isotonic beverage are used in lowering the level of dehydration because they can replace fluids lost in the body when working in hot environments. Previous studies have shown that the administration of mineral water can improve hydration status better, which is indicated by changes in the hydration status of subjects in conditions before and after the intervention which can be seen directly from changes in urine color levels for the better.[25] In this study, dehydration status will be compared in workers who will be given mineral water and isotonic beverage. The results of this study are expected to help workers to choose fluids that are better at preventing the emergence of occupational diseases caused by dehydration due to heat exposure

II. Methods

This type of research is quasi-experimental, with a time series approach using only one group. The population is all workers in the tofu-making industry in Jomblang Village, Semarang City, with as many as 40 people. The sample was the entire population selected with inclusion criteria (willing to be respondents, physically and spiritually healthy, did not have diabetes, ulcer, diarrhea, and kidney disorders), and exclusion criteria (sick or absent from the study). The independent variables of the study were the type of beverage (mineral water and isotonic beverage), while the dependent variables were dehydration status and subjective risk of dehydration. The independent variable is given by giving drinks on the second and fourth days. The first-day respondents were allowed to drink activities such as days while working daily, the third-day subjects were given mineral water, and the fifth-day subjects were given isotonic beverage. On the second and fourth days, the study subjects were left to work as usual (no treatment) to give pause. Air mineral and isotonic are given to workers from the time they start working at 08.00 to 11.00, with an intensity of giving 30 minutes once as much as 200 ml. We ensure that the water given is drunk out before the water is given at a later stage.

On the first, third, and fifth days, urine samples were collected at 12:00 (in the break time) by accommodating the urine of the study subjects in a urine container. Furthermore, urine colour was observed by comparing with the urine colour chart. Subjective complaints of dehydration were identified through a questionnaire consisting of 11 signs of subjective complaints of dehydration.[26]. The research data were analyzed by looking at the distribution of data and tested with the Friedman test with 95% meaningfulness.

III. Results and Discussion

1. Characteristics of Research Subjects

Table 1. Characteristics of Research Subjects

Variable	Categories	Frequency	%
Age	- < 40 years	17	48.6
	- ≥ 40 years	18	51.4
Gender	- Man	29	82.9
	- Woman	6	17.1
Types of clothing	- Cotton	16	45.7
	- Non cotton	19	54.3
Amount of drinking water consumption	- < 8 cups/day	19	54.3
	- ≥ 8 cups/day	16	45.7
Years of service	- < 6 years	16	45.7
	- ≥ 6 years	19	54.3
Total		35	100

ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue V May 2023

Tabel 1 illustrates that the age of workers were almost equal, but greater than 40 years (51.4%) with the majority male sex (82.9%). The type of clothing used was mostly non-cotton (54.3%). The amount of drinking water consumption was mostly less than 8 cups/day (54.3%), and most have a working life of more than 6 years (54.3%).

2. Subjective complaints of dehydration

The subjective complaints of dehydration felt by workers were as follows:

Table 2. The Subjective Complaints of Dehydration

Subjective complaints	Frequency	%
Dizzy:		
- Yes	7	20
- No	28	80
Nauseous:		
- Yes	0	0
- No	35	100
Get tired quickly:		
- Yes	29	82.9
- No	6	17.1
Dry skin:		
- Yes	0	0
- No	35	100
Reddish skin:		
- Yes	0	0
- No	35	100
Stinging itching:		
- Yes	0	0
- No	35	100
Muscle cramps:		
- Yes	3	8.6
- No	32	91.4
The body feels hot:		
- Yes	8	22.9
- No	27	77.1
Loss of consciousness:		
- Yes	1	2.9
- No	34	97.1
Sweating :		
- Yes	34	97.1
- No	1	2.9
Quickly thirsty:		
- Yes	34	97.1
- No	1	2.9

The dominant subjective complaints of dehydration experienced by workers were fatigue (82.9%), sweating a lot (97.1%), and quickly thirsty (97.1%).

3. Dehydrated Status

Dehydrated status based on the type of drinking water consumed in workers obtained results in graph 1:

ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue V May 2023

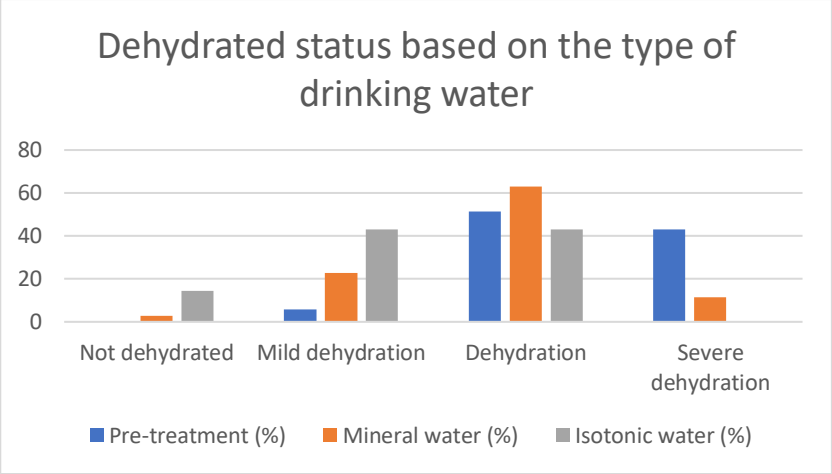

Figure 1. Dehydrated Status of Workers

Status dehydration based on urine color shows before treatment and after administration of mineral water is dominated by dehydration category, while isotonic beverage administration was dominated by mild dehydration status. Severe dehydration before treatment decreased significantly after the administration of mineral water from 42.9% to 11.4% (a decrease of 31.5%) and after the administration of isotonic beverage, no one was severely dehydrated. Test normality data shows the following results:

Table 3. Normality of Dehydration Status

Dehydrated Status	p value	Meaning
Dehydrated status before treatment	0.007	Abnormal distribution
Dehydrated status after mineral water	0.000	Abnormal distribution
Dehydrated status after isotonic administration	0.003	Abnormal distribution

Based on data analysis showed that all data were abnormally distributed, so further tests were carried out with the Friedman test

4. Differences In Dehydration Status Between Before Treatment, After Administration Of Mineral Water, And After Administration Of Isotonic beverage.

Table 3 shows the distribution of the average of dehydration score pre-treatment, after administration of mineral water, and after administration of isotonic beverage. Based on the results of the Friedman test, p-value of 0.001 was obtained, which means that there was a significant differences in dehydration status in 3 treatment groups. Based on the average value of the dehydration score, it shows a decrease in dehydration score after the administration of mineral water and isotonic beverage compared to pre-treatment. The lowest urine color score was in the group that received isotonic beverage until it was concluded that the best dehydration status was in the group given isotonic beverage

. Table 4. Differences in dehydration status based on urine color scores

Dehydrated Status	Average score	dehydration	p value
Dehydrated status before treatment		2.71	0.001
Dehydrated status after mineral water		2.04	
Dehydrated status after isotonic administration		1.26	

ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue V May 2023

5. Differences in dehydration status between treatments.

The results of the Wilcoxon test to determine the difference in dehydration status between treatment groups are presented in tabel 5 as follows:

Table 5. Differences in dehydration status between treatment groups

Dehydrated Status	p value	Meaning
Pre-treatment –mineral water	0.000	There is a significant difference
Pre-treatment - isotonic beverage	0.000	There is a significant difference
Mineral water - isotonic beverage	0.000	There is a significant difference

It was concluded that the dehydration status of all treatment partners showed significant differences

Subjective complaints of dehydration

The most complaints felt by workers in this industry are quickly thirsty, sweating a lot, and getting tired quickly. The complaint was thought to result from heat stress at work. High heat stress will encourage the body to release heat to adapt to the environment[27], [28] When the ambient temperature increases, the body temperature will increase. This efferent impulse drive in the hypothalamus will stimulate the sweat glands to work, allowing sweat to come out.[29] Sweat that comes out causes body fluids to be unbalanced, causing thirst. [30] In a state of lack of fluid, the body also undergoes anaerobic metabolism. Anaerobic metabolism occurs from the breakdown of glycogen stores in muscles as energy materials which causes the concentration of glycogen in muscles to decrease to form lactic acid.[31] Lactic acid can inhibit the process of muscle work because lactic acid accumulates in muscle tissue it affects fatigue.[32] Each person's body fluid needs vary depending on their activities.

Differences in Dehydration Status Based On The Type Of Drink

In this study, it was concluded that there were differences in dehydration status between before treatment, after administration of mineral water, and after administration of isotonic beverage. Dehydrated status was worst in the group before treatment, and best in the group given isotonic beverage.

In the pre-treatment group, workers were allowed to consume drinking water as per daily habit, with an unspecified amount. The amount of water consumed varies from 1.5 to 2 liters/day. Some workers also consume tea, coffee, fruit juice with sugar or energy drinks. In the group given mineral water, dehydration status showed a decrease better than the pre-treatment group. This is possible because the amount of mineral water was regulated according to NIOSH, which is 200 ml every 30 minutes or 1.4 liters for 3.5 hours for workers in hot places. Mineral water is effective in reducing thirst because it can replace fluids that come out of the body in the form of sweat and urine, resulting in a rehydration process. Deep mineral water with moderate mineralization was more effective in inducing recovery of aerobic capacity and leg muscle power compared with plain water following prolonged dehydrating aerobic running exercise.[33] Mineral water contains magnesium sulfate, potassium, calcium, sodium chloride, and sulfate ions that the body needs to restore the fluid that comes out. Potassium was an essential mineral needed by the body in regulating body fluid balance and maintaining a healthy nervous system. Several minerals were key to regulating water balance in different compartments of the body; the most important of these are sodium, potassium, and chloride. [34] Mineral water can restore potassium lost through urine and sweat.[35] From previous studies, the water intervention improved urinary markers of hydration and children's cognitive flexibility selectively benefits from greater habitual hydration and water intake.[36] Hydration in health in the general population, specifically in skin health, neurological function (cognition, mood, and headache), gastrointestinal and renal functions, and body weight and composition.[37]

The group given isotonic beverage showed the best dehydration status compared to the pre-treatment group and the group given mineral water. It is assumed, isotonic can reduce dehydration status because it contains minerals that are needed by the body, such as water, carbohydrates and electrolytes are high.[24] The high presence of carbohydrates and electrolytes helps replace lost body fluids more quickly. The electrolyte content in isotonic beverage has a composition similar to human body fluids, making it easier to absorb and quickly replace lost fluids and electrolytes. Hypotonic carbohydrate–electrolyte drinks ingested continuously during exercise provide the greatest benefit to hydration.[38]

The results of this study were in line with previous research conducted on healthy male subjects either consumed isotonic beverage over a period of 8 hours in a controlled air-conditioned environment and sports science students who were given 5000 m of physical activity, where the administration of isotonic drinking water affected dehydration status.[24] [23].

ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue V May 2023

IV. Limitation the Study

In this study, there was no recording of the frequency of urination while working so that the amount of fluid that came out (excretion) during the intervention was not known.

V. Conclusion

The dominant subjective complaints of dehydration experienced by workers were fatigue, sweating a lot, and quickly thirsty. Isotonic water administration results in better dehydration status compared to mineral water.

References

1. Zulhanda. D, Lestari.M, Andarini. D, Novrikasari. N, Windusari. Y, and Fujianti.P. 2021. "Gejala Heat Strain pada Pekerja Pembuat Tahu di Kawasan Kamboja Kota Palembang", Jurnal Kesehatan Lingkungan Indonesia Vol. 20 No. 2 (120–127).
2. Hartono. TBW. 2019. "Physiological Responses of Workers' Vital Signs in High Temperature Environments at The Tofu Home Industry Kedung Tarukan Surabaya." Jurnal Kesehatan Lingkungan Vol. 11 No. 3 (242-251).
3. Huda.AI, Suwandi. T. 2018. "Hubungan Beban Kerja Dan Konsumsi Air Minum Dengan Dehidrasi Pada Pekerja Pabrik Tahu." The Indonesian Journal of Occupational Safety and Health Vol. 7 No. 3 (310-320).
4. Entianopa. E, Wahyuni.A, Kurniawati. E. 2020. "Hubungan Iklim Kerja Panas Terhadap Dehidrasi Pada Pekerja Di Bagian Dryler di PT X Tahun 2020." Indonesia Journal of Helath Community Vol. 1, no. 1 (1–7).
5. Akerman. AP, Tipton. M, Minson. C.T, and Cotter. J. D. 2016. "Heat Stress And Dehydration In Adapting For Performance: Good, Bad, Both, Or Neither?," Temperature Vol. 3 No. 3 (412–436).
6. Shaheen. N.A, Alqahtani. A.A, Assiri. H, Alkhodair. R, and Hussein. M. A. 2018. "Public Knowledge Of Dehydration And Fluid Intake Practices: Variation By Participants' characteristics," BMC Public Health Vol. 18 No. 1(1–8)
7. Lacey.J. *et al.* 2019. "A Multidisciplinary Consensus On Dehydration: Definitions, Diagnostic Methods And Clinical Implications," Annals of Medicine *V*ol. 51 no. 3–4 (232–251).
8. Ekpenyong. C. E, Akpan. I.-A. M. 2017. "High Prevalence And Associated Risk Factors Of Dehydration Among College Students: Implications For Health And Academic Performance." International Journal of Community Medicine and Public Health Vol. 4 No. 4 (1043-55)
9. El-Sharkawy. A. M, Sahota. O, Lobo. D. N. 2015. "Acute And Chronic Effects Of Hydration Status On Health." Nutrition Review Vol. 73 (97–109).
10. Wakabayashi. H, Wijayanto. T, Lee. J. Y, Hashiguchi. N, Saat. M, and Tochihara. Y. 2014 "A Comparison Of Hydration Effect On Body Fluid And Temperature Regulation Between Malaysian And Japanese Males Exercising At Mild Dehydration In Humid Heat." Journal of Physiological Anthropology Vol. 33 No. 1 (1–11).
11. Sari. M. P. 2017. "Iklim Kerja Panas dan Konsumsi Air Minum Saat Kerja Terhadap Dehidrasi." HIGEIA (Journal of Public Health research and Development). Vol. 1 No. 2 (108–118).
12. Jones, K. T. E. B. 2023. " Adult Dehydration." StatPearls, National Libraby of Medicine, 2022.
13. MedlinePlus, "Fluid imbalance," National Library of Medicine, 2023. https://medlineplus.gov/ency/article/001187.htm.
14. Belasco. R, Edwards. T, Munoz. A. J, Rayo. V, and Buono. M. J. 2020. "The Effect of Hydration on Urine Color Objectively Evaluated in CIE L*a*b* Color Space," Frontiers in Nutrition. Vol. 7 (1–9).
15. Dan. T. C. S, Rahim. A. 2014. "Sistem Pendeteksi Dehidrasi Berdasarkan Warna dan Kadar Amonia pada Urin Berbasis Sensor." Vol. 1 No. 5 (436–444).
16. Carter. C, Stallworth. J, and Holleman. R. 2012. "Urinary Tract Disorders," MusculoskeletalKey (935–1013). https://musculoskeletalkey.com/urinary-tract-disorders/
17. Andayani. K, Dieny. F.F. 2013. "Hubungan Konsumsi Cairan Dengan Status Hidrasi Pada Pekerja Industri Laki-Laki," Journal of Nutrition College. Vol. 2 No. 4 (547–556).
18. Nofianti. D. W, Koesyanto. H. 2019. "Masa Kerja, Beban Kerja, Konsumsi Air Minum dan Status Kesehatan dengan Regangan Panas pada Pekerja Area Kerja." HIGIEA (Journal of Public Health research and Development). Vol. 3 No. 4 (524–533).
19. Cahyaningsih. D. A. 2018. "Keluhan Subjektif Akibat Paparan Panas pada Operator dan Pemeliharaan Boiler PT.IP tahun 2018." Jurnal Kesehatan Lingkungan. *V*ol. 7 No. 1 (52–66).
20. Vimalanathan. K, Babu. T. R. 2014. "The Effect Of Indoor Office Environment On The Work Performance, Health And Well-Being Of Office Workers." Journal of Environmental Health Science and Engineering Vol. 12 No. 1 (1–8).
21. Sari. N. A, Nindya. T. S. "Hubungan Asupan Cairan, Status Gizi Dengan Status Hidrasi Pada Pekerja Di Bengkel Divisi General Engineering PT Pal Indonesia." Media Gizi Indonesia. Vol. 12 No. 1 (47-53).
22. Urdampilleta. A, Gómez-Zorita. S. 2014. "De La Deshidratación A La Hiperhidratación; Bebidas Isotónicas Y Diuréticas Y Ayudas Hiperhidratantes En El Deporte," Nutrion Hospitalaria. Vol. 29 No. 1 (21–25).

ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue V May 2023

23. Samudera. I. P.P, Ashadi. K. 2019. "Perbandingan Beragam Jenis Air Minum Terhadap Status Hidrasi Melalui Aktivitas Fisik 5000 Meter," Multilateral. Jurnal Pendidikan Jasmani dan Olahraga. Vol. 18 No. 1 (32–40).
24. Siow. P. C, Tan. W. S. K, Henry. C. J. 2017. "Impact Of Isotonic Beverage On The Hydration Status Of Healthy Chinese Adults In Air-Conditioned Environment," Nutrients. Vol. 9 No. 3 (1-10).
25. Rahmuniyati. M. E, Rahfiludin. Z, Kartini. A. 2016. "Pengaruh Pemberian Air Minum Dan Air Glukosa Terhadap Status Hidrasi Dan Kelelahan Pekerja Pande Besi," Jurnal Formil (Forum Ilmiah) Kesmas Respati. Vol. 1 No. 2 (69–78).
26. Hidayat. R. A. 2016. "Hubungan Konsumsi Air Minum Dengan Keluhan Subjektif Akibat Tekanan Panas pada Pekerja Pandai Besi Di Desa Bantaran Probolinggo," Jurnal Keperawatan Muhammadiyah. Vol. 1 No. 1 (32–43).
27. Andayani. K, Dieny. F. 2013. "Hubungan Konsumsi Cairan Dengan Status Hidrasi Pada Pekerja Industri Laki-Laki." Journal of Nutrition College , Vol 2 No. 4 (547-556).
28. Kenny. G. P, Sigal. R. J, McGinn. R. 2016. "Body Temperature Regulation In Diabetes," Temperature. Vol. 3 No. 1 (119–145).
29. Tan. C. L, Knight. Z. A. 2018. "Regulation of Body Temperature by the Nervous System," Neuron. Vol. 98 No. 1(31–48).
30. Zimmerman. C.A, Leib. D.E, Knight, Z.A. 2017. "Thirst," Physiology and Behavior. Vol. 176 No. 3 (139–148).
31. Blanco. 2017. "Medical Biochemistry : 14. Carbohydrate Metabolism," Medical Biochemistry. (283–323).
32. Theofilidis. G, Bogdanis. G. C, Koutedakis. Y, Karatzaferi. C. 2018. "Monitoring Exercise-Induced Muscle Fatigue And Adaptations: Making Sense Of Popular Or Emerging Indices And Biomarkers." Sports. Vol. 6 No. 4 (1–15)
33. Stasiule. L, Capkauskiene. S, Vizbaraite. D, Stasiulis. A. 2014. "Deep Mineral Water Accelerates Recovery After Dehydrating Aerobic Exercise: A Randomized, Double-Blind, Placebo-Controlled Crossover Study." Journal of the International Society of Sports Nutrition. Vol. 11 No. 1 (1–7).
34. Alice. C, Heather. L, Tamberly. P. 2018. "Nutrition: Science and Everyday Application, V. 1.0.
35. Siregar. N. S. 2016. "Pengaruh Rehidrasi Setelah Olahraga Dengan Dengan Air Kelapa," Journal of Sports Nutrition. Vol. 15 No. 2 (12–20).
36. Khan. N. A, *et al.*, 2019. "A 4-d Water Intake Intervention Increases Hydration and Cognitive Flexibility among Preadolescent Children," The Journan of Nutrition. Vol. 149 No. 12 (2255–2264).
37. Liska. D, Mah. E, Brisbois. T, Barrios. P. L, Baker. L. B, Spriet. L. L. 2019. "Narrative Review Of Hydration And Selected Health Outcomes In The General Population," Nutrients, Vol. 11 No. 1 (1–29).
38. Rowlands. D. S, Kopetschny. B. H, Badenhorst. C. E. 2022. "The Hydrating Effects of Hypertonic, Isotonic and Hypotonic Sports Drinks and Waters on Central Hydration During Continuous Exercise: A Systematic Meta-Analysis and Perspective," Sports Medicine. Vol. 52 No. 2 (349–375).