



Effect of smartphone application with reminder on total fluid intake adequacy and hydration status among adults in Bontang, East Kalimantan

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Received 3 August 2023
Accepted 2 November 2023
Published 29 February 2024

Link to DOI:
[10.25220/WNJ.V07.i2.0007](https://doi.org/10.25220/WNJ.V07.i2.0007)

Citation: Sari H. E. P, Sunardi D, Sutanto K, Chandra D. N, Friska D, Insani P. N. C. Effect of smartphone application with reminder on total fluid intake adequacy and hydration status among adults in Bontang, East Kalimantan. World Nutrition Journal. 2024 February 29,7(i2): 46-53.



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Website:
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Abstract

Background: About 41% adults in Kalimantan have inadequate total fluid intake (TFI), which is higher than national inadequacy (28%). Inadequate TFI may cause dehydration. The biggest barrier to comply with TFI is to forget to drink. Smartphone application, Hidrasiku with reminder, is expected to be useful in TFI adequacy which may affect hydration status.

Objective: This study aims to determine the effect of the Hidrasiku with reminder on the TFI adequacy and hydration status among adults in Bontang.

Methods: The design of this study was quasi-experimental and cluster sampling. Inclusion criteria were healthy men, age 19-64 years and having a smartphone. Participants suffering with diseases that affected fluid balance and on diet and fluid restriction were excluded. Data collection was conducted from April to June 2023 in Bontang. A total of 106 participants were allocated into two groups, intervention and control. Both groups used Hidrasiku for four weeks, with the intervention group activating the reminder while the control group didn't. Adequacy of TFI and hydration status were assessed before-after intervention.

Results: A sample of 87 participants completed the study. The median age of the participants was 32 (19-61) years. At the end of intervention, there was significant difference in the TFI adequacy (90.2% vs 63.0%; $p=0.003$) and a significant increase in TFI +240 mL/day vs -62.8 mL/day; $p=0.002$. Meanwhile no significant difference on hydration status (87.8% vs 73.9%; $p=0.103$).

Conclusions: Hidrasiku with reminder has effect on the TFI adequacy and no effect on hydration status

Keywords: adult, fluid intake, hydration status, reminder, smartphone

Introduction

The balance between fluid intake and output reflects hydration status.^{1,2} Adequate total fluid intake (TFI) is essential for maintaining the health and functionality of the human body. Insufficient

TFI may cause dehydration. Dehydration may affect human health even cause death.³ Mild dehydration can have negative impacts, including headache, irritability, decreased physical performance, and impaired cognitive function.^{2,4,5} Acute or chronic dehydration may affect urological, gastrointestinal, circulatory, neurological, and metabolic disorder.^{1,3,6,7}

Total fluid intake (TFI) for Indonesian adults was $2,721 \pm 22$ mL/day and met the Indonesian

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recommendation on adequate intake.^{8,9} However, about 28% of adults had insufficient TFI. The three regions with the highest rate of insufficient daily fluid intake were Bali (42 %), West Java (42%), and Kalimantan (41%). The study also showed that only 67% of men met the recommended daily fluid intake, which was lower than women (75%).⁸ From 13 countries, about 40.6% of men complied with TFI recommendation, while 59.2% of women adhered to TFI recommendation.¹⁰

There were several barriers to comply TFI: not feeling thirsty, forget to drink, and not having time to drink. About 60% of subjects forgot to drink and ignored the importance of fluid intake.¹¹ Patients with a history of kidney stones used various methods as reminders to increase fluid intake to prevent recurrence of kidney stones but were unable to accurately monitor daily fluid intake.¹² The use of technology can overcome barriers and provide reminders for patients to adhere TFI recommendations. Application, smart water bottle, and wearable devices can be used to change behaviour to meet fluid intake.¹³ Smartphone applications provide useful programs for users to monitor fluid intake, with most of them providing reminders to users, sharing facilities, educational materials, and motivation related to their drinking behaviour.^{14,15} Having a reminder in the application is important for dealing with subjects who have difficulty remembering their fluid intake goals or have difficulty tracking their fluid consumption.¹⁶

The Indonesian Hydration Working Group (IHWG) developed Hidrasiku, an application designed to calculate daily fluid needs, track fluid intake, remind users to drink, and provide education regarding hydration.¹⁷ There have been no trials in healthy adults to evaluate the efficacy of applications related to fluid intake and hydration.¹⁸ Hydration-related applications provided little information about the importance of hydration and did not use other hydration measures, such as physical activity level, urine volume, or urine colour.¹⁴ The effect of Hidrasiku with reminder to TFI adequacy and hydration status using urine colour was unknown. Bontang is located in Kalimantan, the region where

insufficient TFI is higher than national.⁸ Men were chosen because TFI adequacy was lower than women.^{8,10} The study conducted for four weeks because from the previous study there were needed three to twelve weeks to change the behaviour to increase water intake.^{11,16,19} Therefore, the purpose of this study was to determine the effect of Hidrasiku with reminder on TFI adequacy and hydration status among adults in Bontang, East Kalimantan.

Methods

This study used a quasi-experimental research design to assess the effect of the Hidrasiku with reminder on TFI adequacy and hydration status. The data collection was conducted from April 2023 to June 2023 in Bontang. The inclusion criteria were men, aged 19-64 years, healthy based on a physical examination conducted by a doctor, owning a smartphone, being able to read and write, and signing informed consent. The exclusion criteria were participants who suffered with diseases that affected fluid balance (urinary tract infections, kidney disorders, hypertension, diabetes, heart disease) and on diet and fluid restriction.^{20,21} The dropout criteria were participants who suddenly had disease that affected fluid balance, refused to continue, and refused to do end line measurement. A sample size of 50 participants was determined for each group, including the possibility of missing data and a drop-out rate of 20%.²²

We conducted cluster sampling using secondary data from non-communicable disease screening results at public health centres in Bontang Utara and Bontang Selatan. Researchers and health cadres from public health centres contacted participants who met the criteria and were willing to participate in the study until the number of participants was met. Then, the researcher went on a home visit to collect data. In this study, participants who met the inclusion criteria were 1,420 men. Participants who signed the informed consent were 106 people.

Participants were allocated to two groups, intervention group (IG) and the control group (CG). Both groups used Hidrasiku for four weeks,

with the intervention group activating the reminder to drink every 2 hours from 06.00 a.m. to 10.00 p.m., while the control group didn't. This reminder to fulfil the recommendation to drink water eight glasses a day.⁹ As baseline data, interviews were conducted to obtain data on participants' sociodemographic characteristics. Physical activity was assessed using the International Physical Activity Questionnaire-short form.²³ Anthropometric examination was carried out according to standards.²⁴ TFI was recorded using a 7-day fluid record with Hidrasiku. Participants sent a screenshot from the result of Hidrasiku at 10.00 p.m. daily because the data could not be retrieved directly from the server. TFI \geq 2,000 ml/day categorized as adequate.²⁵ Participants were examined for urine colour on Saturday by collecting urine taken at 2.00 p.m. – 8.00 p.m.²⁶ This study evaluated urine colour using the eight-shade urine colour scale published by Armstrong. A transparent urine collection container was placed against a plain white background in a well-lit room.²⁷ Participants took a photo of it and sent it to the researchers by WhatsApp. For four weeks, the participants recorded their fluid intake in Hidrasiku and examined urine colour weekly with same procedure as before intervention. Participants received education about the importance of fluid intake for health every week. Participants' adherence was assessed by counting the number of days in which participants recorded TFI with Hidrasiku. Participants were considered to adhere if recorded TFI in Hidrasiku 4-7 days in a week. The adherence score calculated from adherence in four weeks. Data collection began after obtaining approval from the Research Ethics Committee of Faculty of Medicine Universitas Indonesia number KET-438/UN2.F1/ETIK/PPM.00.02/2023.

Participants who reported TFI below 0.4 L/day or higher than 6 L/day were excluded from the analysis.^{8,25} Data were analysed using Statistical Package for Social Science (SPSS) software version 26.0. All data were analysed descriptively. Numerical data were analysed using the Kolmogorov-Smirnoff or Shapiro Wilk for normality test. Statistical analysis for

numerical data was analysed by unpaired t test or Mann-Whitney. Meanwhile, categorical data were analysed using Chi-square or Fischer test. The before-after in TFI adequacy and hydration status within one group were tested using the McNemar test. The change in TFI between two groups was analysed by unpaired t test or Mann-Whitney. The before-after TFI within one group were tested by paired t or Wilcoxon. The significance level was set at $p < 0.05$.

Result

A sample of 87 participants completed the study. The characteristics of the participants are shown in **Table 1**. The median age of the participants was 32 (19-61). About 52.9% participants were obese. Most of the participants in both groups had a job and high level of education. Most of the participants' physical activity was moderate level. TFI for all participants' (n=87) was 2,216.0 \pm 433.4 mL/day. The median of urine colour was 3 (1-7).

TFI adequacy of all participants at baseline were 69.0%. TFI adequacy at baseline in IG was higher than CG (70.7% vs 67.4%; $p=0.737$). At the end of the study, the TFI adequacy of all participants were 75.9%. There was an increase in the TFI adequacy in IG at the end of intervention while in CG there was a decrease in the TFI adequacy (90.2% vs 63.0%; $p=0.003$). There was a difference in changes in the TFI adequacy before and after treatment in IG ($p=0.021$) while in CG was not ($p=0.774$).

To find out the changes before and after treatment in the two groups, the researchers added the effect of Hidrasiku on TFI. At baseline, TFI in the two groups was not significantly different ($p>0.05$). At the end of the treatment, there were significant differences and changes in the two groups ($p<0.05$).

At the baseline, 66 participants (75.9%) were categorized in euhydration. The euhydration status of IG was lower than CG (75.6% vs 76.1%; $p=0.959$). After four weeks of intervention, there was an increase in euhydration status in IG while

Table 1. Participants' Characteristic

Variable	Intervention (IG) (n=41)	Control (CG) (n=46)	P value
Age (years)*	33 (19–55)	31.5 (19–61)	0.369 ^{MW}
Nutritional status, n (%)			0.665 ^f
Underweight	2 (4.9)	5 (10.9)	
Normal	9 (22)	11 (23.9)	
Overweight	6 (14.6)	8 (17.4)	
Obese	24 (58.5)	22 (47.8)	
Education level, n (%)			0.435 ^f
Low	1 (2.4)	0 (0)	
Middle	16 (39)	22 (47.8)	
High	24 (58.5)	24 (52.2)	
Job status, n (%)			0.255 ^f
Un-employee	0 (0)	3 (6.5)	
Retired	0 (0)	1 (2.2)	
College student	1 (2.4)	2 (4.3)	
Employee	40 (97.6)	40 (87.0)	
Physical activity level, n (%)			0.193 ^{CS}
Low	7 (17.1)	11 (23.9)	
Moderate	20 (48.8)	27 (58.7)	
High	14 (34.1)	8 (17.4)	
TFI (mL/day)**	2,191.3 ± 372.7	2,238.0 ± 484.1	0.619 ^t
Urine colour*	3 (1-6)	3 (1-7)	0.914 ^{MW}

Notes:

IG: Intervention Group

CG: Control Group

*Median (minimum-maximum)

**Mean ± standard deviation

MW: mann-whitney test; ^f: Fischer test; ^{CS}: chi-square test; ^t: unpaired t test**Table 2.** Effect Hidrasiku on TFI

Variable	IG (n=41)	CG (n=46)	P value
TFI (mL/day)			
Baseline	2,191.3 ± 372.7	2,238.0 ± 484.1	0.619 ^t
End line	2,285.7 (1,458.3–3,792.9)	2,110.0 (1,348.6–3,490.0)	0.014 ^{MW}
P value before- after intervention	0.002 ^W	0.240 ^W	
Δ (mL/day)	240 (-467.9–1,214.3)	-62.8 ± 458.4	0.002 ^{MW}

^t: unpaired t test; ^{MW}: mann-whitney; ^W: wilcoxon.

there was a decrease in CG (87.8% vs 73.9%; p=0.103). However, no significant differences were found at the end of the treatment in the two groups, before and after treatment (p>0.05).

The participants' adherence in IG was higher than CG (97.6% vs 93.5%). There was no significant difference between the two groups (p=0.619).

Discussion

In the present result, the mean of TFI for all participants' (n=87) was 2,216.0 ± 433.4 ml/day. Participants on IG had a TFI of 2,191.3 ± 372.7 mL/day, while those on CG had a TFI 2,238.0 ± 433.4 mL/day. This amount of TFI was similar from the national survey which was conducted in 2016 for Kalimantan, 2,208 ± 45 ml. However, it was still lower than the national TFI average of 2,721 ± 22 mL.⁸ These rates were similar from other previous data from Indonesia 2,280 ml ±

1,020.¹⁰ But these results were higher than Indonesian Total Diet Study in 2014 which reported 1,317 ml/day.²⁸

Prior to intervention, 68.6% of participants met the recommended TFI. This value was higher than previous study, 67% of Indonesian men met the adequacy of TFI.⁸ This value was also higher when compared to a study conducted in Germany where 66% of men participants adhere with TFI recommendation.¹⁰ TFI adequacy for IG was higher than CG (70.7% vs 67.4%). This value was higher when compared TFI adequacy in Kalimantan, 59%.⁸ The need of TFI to each individual is different, influenced by age, gender, body mass index (BMI), physical activity and environment.^{1,2,29}

Hydration status based on the urine colour chart before intervention showed that 76.7% of the participants were hydrated and 23.3% were dehydrated. The euhydration status of IG was higher than that of CG. Study in Yogyakarta showed that 60.9% of students in university were dehydrated.³⁰ Another study on workers in Surabaya showed that 85.71% of participants were minimally dehydrated and 14.29% of participants were significantly dehydrated.³¹ The plasma osmolality will rise and stimulate osmoreceptors in the hypothalamus if the body loses more water than intakes. Antidiuretic hormone will be released and cause increasing water reabsorption in the kidneys. So that urine excretion will decrease and urine will be more concentrated and become a darker colour.³²

After 4 weeks, the TFI adequacy increased significantly in IG while CG decreased. The main barrier in adhering TFI adequacy was forgetting to drink.^{11,12} The use of an application with reminder is suitable for patients who have difficulty remembering their fluid intake goals or have difficulty tracking their fluid consumption throughout the day.¹⁸ Reminder is implemented as periodic messages which is sent to the user reminding them to check out the application. Daily or weekly reminders were sent to encourage users to continue using the application.³³ Reminders will be sent to users who do not reach the user's target to maintain motivation.³⁴ TFI increased in users' application

after enabling the reminder feature. However, when the reminder was turned off, TFI returned to baseline. This study shows that reminders were useful in health management. However, participants were unable to sustain these changes when the reminder was turned off.¹⁶ Another study reported a greater increase in 24-hour urine volume and decreased the difficulty remembering to drink with the use of smart drinking bottles.¹¹ A further study reported that using a drinking reminder application in nephrolithiasis patients, twenty-nine percent of patients achieved the goal of daily urine output volume >2.5L across all treatment groups ($p < 0.001$).³⁵ The key to behaviour change is self-management, which is related to the active participation of an individual in terms of treatment or in maintaining health. This includes goal setting and action planning in achieving goals in health.³⁶

For the hydration status, IG tended to experience a change in hydration status to euhydration in the end line. However, the change was not statistically significant between the two groups. Hydration status is influenced by several factors such as age, sex, BMI, physical activity, environment, and disease.^{1,2,29} Individuals who are obese have a higher need for water than individuals who are not. Water needs depend on their metabolic rate, body surface area, and body weight.²⁹ The average respiratory water loss in a person with high physical activity can reach 500 to 600 mL/day. Meanwhile, when exercising, up to 1.5 L of water loss through sweat can occur when exercise for a long time and in a hot environment.³ If it is not replaced with sufficient water consumption, it will cause a deficit of body water and may affect hydration status.¹⁻³ It is possible that there was no difference after intervention in both groups because they have the same drinking target, 2 L according to the Indonesian recommendation on adequate intake without considering BMI, physical activity, and environment. Most of the participants were obese and had a moderate level of activity. Even though the participants in IG and CG had met their TFI in the application, if on the day of the urine colour examination, the participants were

active and the weather was hot as a result, it might affect the results of the urine colour examination.

With the reminder, IG's adherence in recording TFI in Hidrasiku was higher than CG's. However, this difference was not statistically significant. This was due to the possibility that the adherence of the two groups reached > 80%, where it was the limit to adhere with the recommendations.³⁷ In addition, the researchers sent reminders to the participants every day at 9.00 p.m. to ask the participants to send the results of Hidrasiku at 10.00 p.m. because the results of the recording cannot be directly retrieved from the server. This was expected to affect the high level of participants' adherence so that the results do not differ significantly between both groups.

This study has several strengths; this study is the first to be conducted in Indonesia. Then as a preliminary study, the number of samples meets the expected number of samples. Most of the participants adhere to intervention. This study also has some limitations. Neither participants nor researchers were blinded so there was a risk of bias. Then, the data recorded in the application cannot be retrieved directly from the server. There was a problem where the application wasn't showing any data because many users opened the application simultaneously. When the application could show the data, the participants tried to input the data and they were informed that the data had failed to be registered. So, the participants tried several times to input it again. But in fact, the data had been successfully registered, and they unintentionally input the same data multiple times. In addition, the application did not limit the number of intakes that could be recorded in one input. One participant reported not intentionally input 10,000 mL and no prior warning if the amount was too large. The reminder in the application sometimes didn't provide data that matches the user's last intake. Urine colour examination was carried out by sending a photo of the urine sample alongside the urine colour chart which has the risk of giving different results due to lighting. Previously, participants had been taught to check urine colour results with a urine

colour chart, so the researchers might confirm the urine colour results with the participants.

Conclusions

Hidrasiku with reminder has an effect on TFI adequacy. However, it has no effect on hydration status. Hidrasiku with reminder can be used to promote TFI adequacy for adults because it can reduce common barriers to adhere with TFI recommendation. Application development can consider the reminder as default from the application, limit the amount of intake that can be recorded in a certain time, consider body weight, physical activity level, environment in determining daily fluid requirements, and upgrade servers so that it can be used by many people. Further research is needed regarding user acceptance and satisfaction with Hidrasiku

Declaration of interest

The authors declare that no conflict of interest with another person or institution.

Acknowledgement

We express our deepest gratitude to the supervisors and lecturer in Nutrition Department Faculty of Medicine Universitas Indonesia, and Lembaga Pengelola Dana Pendidikan (LPDP) who have funded this research.

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