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The Impact of Dehydration in the Third Trimesters on Pregnancy Outcome-Infant Birth Weight and Length

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ABSTRACT

This cohort study aimed to analyze the effect of dehydration on pregnancy outcome. A total of 66 pregnant women aged (18-35 years) at second trimester (>12 weeks) of pregnancy was recruited from seven health centers (*Puskesmas*) Kebon Jeruk, West Jakarta from December 2016 to January 2018. Five biomarkers (urine color, urine osmolality, urine specific gravity, serum osmolality, serum sodium) were utilized to determine hydration status. Based on the result, subjects were then assigned to dehydration group (DG) and normal group (NG), 51.5% was in the DG and 48.5%, in the NG respectively. Independent t-tests and Chi-square were employed to answer research questions. There were differences in weight of the mothers in the second and third trimester between the two groups ($p<0.05$), but no differences in weight gain during pregnancy ($p\geq0.05$). More than fifty percent of subjects suffered nausea and vomiting during pregnancy in the two groups. Water intake level in DG (72.53±14.41%) were lower than NG (118.68±14.37%). The accounted difference in Infant birth weight, length, chest circumference and head circumference; were 491.84 g, 0.98 cm, 0.98 cm, and 1.11 cm, respectively where infant from the NG had higher measurements than DG. After adjustment for water intake level, the infant birth weight and length in DG (2,798.53±97.85 g; 47.32±0.32 cm) was lower than NG (3,371.77±102.60 g; 49.09±0.33 cm). The aacounted difference in infant birth weight and length between the two groups were 596.1 g and 1.8 cm, respectively. Thus in addition to nutrient intake and weight gain during pregnancy, pregnant mothers should also concern for their fluid intake in order to maintain their health condition and feotal growth - development.

Keywords: birth length, birth weight, dehydration, pregnancy outcome

INTRODUCTION

Dehydration is an imbalance of body fluid where the body loses more water than it takes (Almatsier 2009). The occurrence of dehydration within 24 hours during pregnancy is represented by; urine specific gravity >1.026, urine volume <531 ml, fluid intake from drink <954 ml, the total of fluid intake <1,507(Armstrong *et al.* 2012; Manz & Wentz 2003), urine osmolality ≥500 mOsm/kg, and urine color scoring higher than 4 (McKenzie *et al*. 2015). In addition, the cut off for plasma osmolality in the morning is >299 mOsm/kg and hematocrit >44.4% (Armstrong *et al.* 2012; McKenzie *et al*. 2015; Stuempfle & Daniel 2003).

In Greece, the prevalence of dehydration in pregnant women were 34%, however this prevalence were increasing in the course pregnancy with 30.0% in the first trimester, 33.0% in the second trimester, and 39.0% in the third trimester (Malisova *et al*. 2014). The contributor factors for dehydration are education level, parity, level of knowledge (Hardinsyah *et al*. 2010), fluid intake in each trimester (Malisova *et al*. 2014), body weight before pregnancy (percent of body fat) (Shirreffs 2003; Widden & Gallagher, 2014), pregnancy duration, sex of the fetus, smoking, body height/resistance (bio impedance score) at 25 and 30 weeks of pregnancy, height/reactant at 20 and 25 weeks, season, activity, UTI (urinary tract infection) (Schrier 2006; Chassin *et al*. 2007), hypertension, amniotic fluid as well as growth hormone changes (Ghezzi *et al*. 2001; Malisova *et al*. 2013; Malhotra & Deepika 2002; Forbes & Melissa 2010; Beetz 2003).

Study in pregnant mice showed that water intake level significantly affects foetal growth, with the body length determination coefficient of 76.33%, but not significantly affects the IGF-1 hormone levels (Sari *et al*. 2015). Due to the high prevalence of hypo-hydration in pregnancy and its significant role to determine foetal growth in animal study, hence a human study to analyze the

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effect of dehydration in pregnancy on the weight gain of mothers and the infant birth weight and length is needed.

METHODS

Design, location, and time

This study was an observational study using a cohort-longitudinal (prospective) design, to observe the effect of dehydration in the third trimesters of pregnancy on the mothers' weight gain and infant birth weight and length. The study was conducted in seven areas of Kebon Jeruk Public Health Center, West Jakarta, i.e., Kebon Jeruk Health Center, South Sukabumi Health Center, North Sukabumi Health Center, North Kedoya Health Center, South Kedoya Health Center, Duri Kepa Health Center, and Kelapa Dua Health Center, from December 2016 to January 2018.

Materials and tools

The materials used were blood and urine samples. The intravenous blood and urine sample was taken once for each of six points. Urine sample was from spot urine, taken at 02:00 to 04:00 pm (Bottin *et al*. 2016). The measurement related to hydration biomarkers: urine color, urine specific gravity, urine osmolality, plasma osmolality, and serum sodium are performed by the accredited laboratory. The tools used in this study were digital scales on Camry®, microtoise, meterline, 24 hr recall form, Combur 10 M (Roche), Osmomat 3000 Gonotec GmBH, Indicator PURI®, ADVIA® 1800 (for sodium).

Sampling

The subject of this study are pregnant women in their second trimester (16-18 weeks) with the inclusion criterias as follows, 1) had their antenatal care at the health center in the study site, 2) in the second trimester (>12-24 weeks), 3) were healthy (no secondary infections), 4) no history of cesarean section, 5) no history of delivering a low birth weight and stunted infant (<48 cm), 6) age of >18-35 (y), 7) height of 150-165 (cm), 8) BMI of 18.5-25.0, 9) having experienced of urinary tract infection (medical record or doctor's diagnosis), 10) having experienced of diarrhea, nausea and vomiting, 11) plan to deliver their baby at the health center, 12) recieved explanation about the study and granted their 'approval' by signing the informed consent, and 13) willing to comply with the study procedure.

Based on the recruitment criterias, 66 subjects participated until the end of the study. Subjects were divided in two groups based on their hydration status, measured at 6 points of observation in 32-34 weeks and 35-37 weeks of pregnancy. Flow chart for subjects' recruitment and retention are described as follows:

The research was approved by the Ethics Committee of the Faculty of Medicine, Universitas Indonesia, Jakarta (ethical approval Number:No.869/UN2.F1/ETHICS/2016, October 10th, 2016).

Data collection

The study started with a preliminary study and followed by an observational study. A pre-

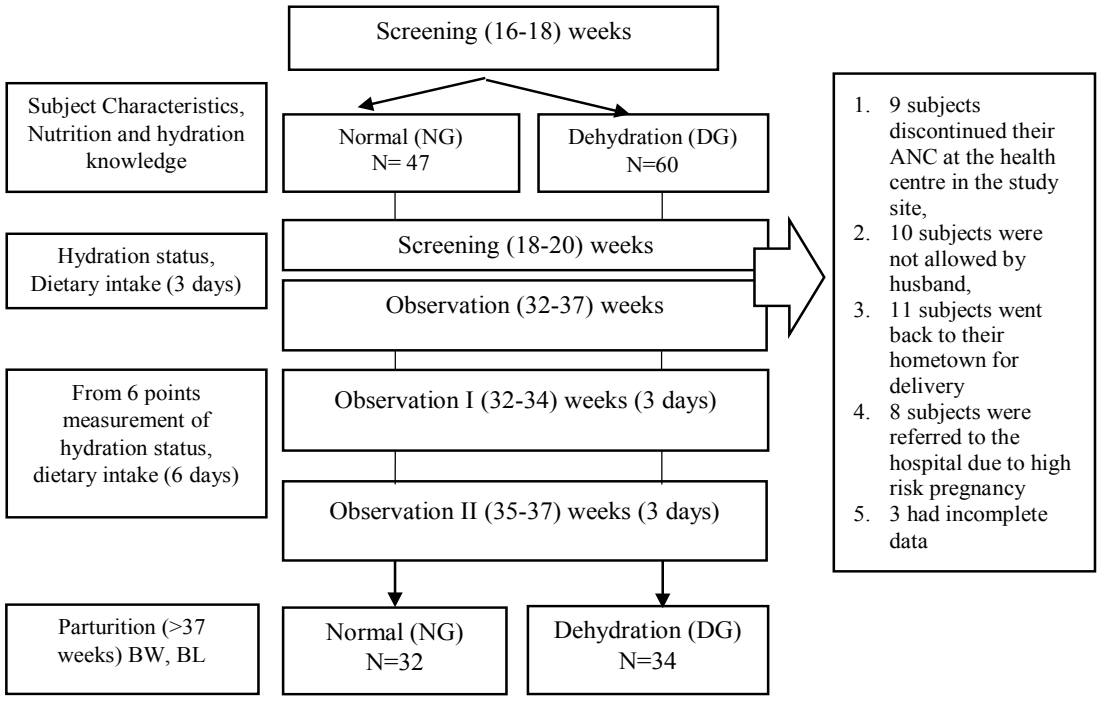

Figure 1. Subjects' recruitment

liminary study of 35 subjects was obtained, 15 non-dehydration and 20 dehydration. The objective of preliminary study was to investigate the hydration status and appropriate biomarkers for determination of hydration status in pregnant women. In the screening stage 107 subjects were obtained however only 66 subjects available for the whole course of observation for hydration status in the third trimester until delivery. The hydration status was observed at 32-37 weeks' gestation with blood and urine samples were taken at 6 points, namely 3 points at 32-34 weeks' gestation and 3 points at 35-37 weeks' gestation. Infant birth weight and birth length (parturition stage) were measured at the time of delivery.

Maternal characteristics data obtained were; maternal age, parity, weight before and during pregnancy, height, upper arm circumference, waist circumference, pelvic circumference, nutritional status before pregnancy, body temperature, pulse rate, fundal height, and hydration status. Meanwhile, infant's data obtained were; birth weight, birth length, chest circumference, and head circumference. Maternal characteristics data were collected using questionnaires, direct measurements and interviews. Biomarkers of hydration status were taken and measured from blood and urine. Examination of urine specific gravity was done using urinometer, urine and plasma osmolality were determined with osmometer, urine color was classified using PURI® indicator, and serum sodium was examined by ISE method. Dietary intake data was obtained from recall 1x24 hours for six consecutive days during third trimester. Water intake level in percentage, which was calculated based on water intake compared to water requirement. If the level was lower than 90.0%, the subject was catagorized as deficient conversely, the level higher than or equal to 90.0% was catagorized as sufficient.

Data analysis

Data analysis were conducted with Microsoft Office Excel and SPSS programs. The data were analyzed descriptively and presented in mean value, median, standard deviation (SD). The t-two independent test was employed for bivariate analysis to see the differences in hydration biomarkers, maternal characteristics, dietary intakes, and pregnancy outcome between the two groups of DG and NG, and chi-square to see the relationship of parity, mother's health history and hydration status. Covariate analysis was conducted to see the correction of birth weight and birth length based on weight gain during pregnancy and water intake. Data were analyzed at 95% confidence level and significant level of $p<0.05$.

RESULTS AND DISCUSSION

Hydration status

Hydration status was determined by 5 biomarkers (urine color, urine specific gravity, serum sodium, urine, and plasma osmolality). These five biomarkers were measured in three consecutive days on the week of 34 and 35, and another three consecutive days on the week of 36 and 37. Dehydration was established when two biomarkers values were higher than the normal cut off. The distribution of biomarkers assessment are as follows (Table 1).

From the 6 points observation of blood and urine in 66 subjects 51.5% of the subjects belong to dehydration group (DG) and 48.5% in normal group (DG). Similarly, study in Greece found that 39.0% pregnant women were experiencing dehydration in their third trimester (Malisova *et al*. 2014). Closer to home, in Indonesia, Bardosono found that about 42.0% pregnant women and 54.0% breastfeeding mothers had inadequate fluid intake (Bardosono *et al*. 2017).

Water is an essential nutrient for hydration and health, and also to maintain body fluid homeostasis (Jequier & Constant 2010). Studies about hydration in pregnancy in Brazil, Mexico, and Poland found that urine color can be a simple and easy tool to detect hydration status (Rigaud *et al*. 2017). In addition, urine osmolality and urine specific gravity can also be used as biomarkers for dehydration in pregnancy (Mulyani *et al*. 2017). The sensitivity of these indicators in the target population was confirmed in our preliminary study which showed that there were differences in urine color, urine specific gravity, and urine osmolality between hypohydration and normal group

Table 1. The distribution subject based on hydra tion biomarker

Biomarkers	Dehydration (n=34)	Normal (n=32)	p
Urine colour*	4.02±0.59	2.24±0.80	0.00
Urine specific gravity*	1,015.16±2.97	1,009.33±2.86	0.00
Urine osmolality (mOsm/kg)*	657.59±154.17	353.05±126.87	0.00
Serum osmolality (mOsm/kg)	316.25± 38.48	311.31±17.98	0.52
Serum sodium (mEq/L)	137.56±1.02	137.76±1.22	0.48

*) independent t-test, significant in $p<0.05$

Characteristics of subject

Table 2 obtained two comparable hydration groups, namely dehydration (34 subjects) and normal (32 subjects) after hydration status measurements at 6 points. There were differences in maternal weight in the 2nd and 3rd trimesters between the two groups ($p<0.05$). Subjects in both group had gained weight during pregnancy, therefore there were no differences of maternal weight gain between the two groups ($p\geq0.05$). Parity is the main factor for maternal weight gain in 10 years after a first delivery (Abrams *et al.* 2013). In this study the subjects had experienced weight gain, even though they suffered from nausea and vomiting. Low maternal weight gain, protein intake, and pesticide exposure are the risk factors for low birth weight (LBW) (Ratnasari *et al.* 2017). Another study found that obesity can increased the risk of hyperemesis gravidarum about 50%. This is related to estradiol levels in which increased by 26% and sex hormone-binding globulin (binding-globulin) by 37% in the case of hyperemesis gravidarum. In obesity case, the estrogen levels increased and it is produced by the ovaries and adipose tissue (Lee & Saha 2011), it can cause disruption of body hydration (Committee on Practice Bulletins-Obstetrics 2018; Wegrzyniak *et al.* 2012).

Macro and micronutrient intake

Table 3 shows the macro and micronutrients intake of subjects obtained from 6 consecutive days of 24 hours reacall in the 3rd trimester (32-37 weeks). There were no differences in energy, carbohydrate, protein, fat, iron, zinc, and calcium intake between the two groups ($p\geq0.05$). However there was a difference in the water intake levels ($p<0.05$).

Water intake levels in percentage (%) obtained from calculating intake of mineral water, colored and tasteless beverages, water from food and metabolic water compared to individual water requirements. Based on the percentage of water intake levels, the mothers in DG (dehydration) were in the deficient category. Meanwhile, the mothers in NG (normal) were in the sufficient category. Hypo-hydration amongst Indonesian young men and women (18-30 years) is not uncommon, despite the homeostatic response to changes in osmolality which then activate the osmoreceptor to increase ADH level to stimulate thirst (Ibrahim *et al.* 2018), a study found the majority of them were in the deficient category (81.9%) (Febriyani *et al.* 2012).

Dietary intake during pregnancy is an important factor for feotal development and growth. Studies have found that although pregnant women were still lacking in nutrients intake, especially folic acid, iron, energy, protein and some other macronutrients, both in terms of quality and quantity (Blumfield & Clare 2014; Wiltbank MC *et al*. 2014; Emmett & Louise 2015).

Maternal medical history

Table 4 shows the mothers' medical history during pregnancy and some symptoms that may contribute to hypohydration. The symptoms experienced related to hydration status by subjects during pregnancy are follows.

Table 2. Characteristics of subject

Variables	Dehydration (n=34)	Normal (n=32)	p
Mother's age (y) [a)]	25.53±4.75	26.81±4.94	0.28
Height (cm) [a)]	154.65±5.16	154.04±4.65	0.99
Weight in second trimester (kg) [a),*)]	60.76±9.87	54.83±9.09	0.01
Weight in third trimester (kg) [a),*)]	69.70±11.28	62.96±10.37	0.01
Weight gain (kg) [a)]	12.44±4.16	11.49±3.88	0.34
Upper arm circumference (cm) [a)]	27.83±3.15	26.59±3.32	0.12
Fundal height (cm) [a)]	12.79±2.87	13.59±2.28	0.21
Body temperature (^{0}C) [a)]	36.43±0.66	36.11±1.80	0.32
Pulse rate (minutes) [a)]	87.82±18.57	90.31±18.29	0.58
Blood pressure:			
Systolic (mmHg) [a)]	108.76±10.28	108.38±7.70	0.86
Diastolic (mmHg) [a)]	67.85±6.20	69.44±6.71	0.32
Haemoglobin in third trimester (g/dL) [a)]	16.74±1.11	16.44±1.27	0.31
Haematocrit in third trimester (%) [a)]	32.89±1.72	32.46±2.05	0.36
Parity :			
First [b)]	14 (41.1)	13 (40.6)	0.74
Second [b)]	11 (32.4)	13 (40.6)	
Third [b)]	9 (26.5)	6 (18.8)	

[a)] independent t-test, mean±SD. [b)]chi-square test, n(%).[*)]significant in $p<0.05$

Table 3. Dietary and water intake in pregnant women during third trimesters

Variables	Dehydration (n=34)	Normal (n=32)	p
Energy (kcal) [a)]	1,684±330	1,620±374	0.46
Energy (%)	62.9±12.8	62.4±15.0	0.87
Carbohydrate (g) [a)]	211.0 ±50.0	216.0±86.0	0.77
Carbohydrate (%)	91.5±13.2	95.9±27.9	0.40
Protein (g) [a)]	59.4 ±15.0	56.4±1714.3	0.41
Protein (%)	93.3±9.2	92.9±10.8	0.87
Fats (g) [a)]	70.7±19.7	66.0±17.2	0.30
Fats (%)	149.4±23.1	147.2±21.5	0.68
Fe (mg) [a)]	11.7±8.3	11.9±14.9	0.93
Zinc (mg) [a)]	6.7±1.9	6.6±1.8	0.79
Calsium (mg) [a)]	326.0±153.0	365.0±378.0	0.58
Water intake level (%)[a)] ,[*)]	72.5±14.4	118.7±14.8	0.00

[a)]independent t-test, mean±SD.[*)]significant in p<0.05

Table 4. Mother's health history during pregnancy

Variables	Dehydration (n=34)	Normal (n=32)	p
Nausea and vomiting [a)]	24 (70.6)	17 (53.1)	0.20
Fever [a)]	3 (8.8)	4 (12.5)	0.70
Painful urination, frequent, and less [a)]	11 (32.4)	13 (40.6)	0.61
Yellow skin/eyes [a)]	1 (2.9)	1 (3.1)	1.00
Dizziness, pale, listless and tiredness [a)]	18 (52.9)	13 (40.6)	0.33

[a)] chi-square test, n(%),[*)]sign. p<0.05

Nausea and vomiting commonly occurred in the early trimester (4th week of pregnancy) to second trimester (16th week of pregnancy). Increasing of HCG (human chorionic gonadotrophin) concentrations can cause nausea and vomiting. When the condition continued, characterized by severe nausea and vomiting, dehydration, and weight loss it is called hyperemesis gravidarum (Festin 2014). This study found, the prevalence nausea and vomiting in the DG and NG were 70.6% and 53.1%, respectively. This high proportion of pregnant women who suffered from nausea and vomiting was in line to other study which found that about 80% of pregnant mothers were suffered from both symptoms however some treatments available to alleviate the symptoms (Anderka *et.al* 2012). In addition, diarrhea is a disease occurrence that can affect mother's health during pregnancy. About 60.0% of pregnant women have a history of measles accompanied by diarrhea (Ogbuanu *et al.* 2014).

Pregnancy outcome and hydration status

Table 5 shows significant differences in the pregnancy outcomes measured by anthropometric measurement (birth weight and birth length, chest circumference, head circumference) between the two hydration status groups (p<0.05).

Between the two groups there were significant differences on birth weight, birth length, head circumference, and chest circumference, in which the DG infants were lower than NG (p<0.05). In this study, we controlled the pregnancy outcome by water intake levels which was differ between the two groups. Therefore, Table 6 shows the adjustment in pregnancy outcome (infant birth weight and length) to mother's weight in the second and third trimesters as well as water intake levels between two groups.

After adjustment in water intake level, the differences in value of infant birth length in the DG and NG were 0.4 cm and 0.5 cm, respectively. Meanwhile, the differences values of infant birth weight in DG and NG were 53.7 g and -50.6 g, respectively (Table 6). Thus differences between the two groups persist despite adjustment in the water intake level where the infant birth weight and length in the DG were lower than the NG.

The feotal weight growth is accelerated at 32 weeks and peak of at 34 weeks, by weeks 34-36 of gestation, feotal growth slowed down due to space limitation in the womb. But extra uterine growth will significantly increase in the first 6 months of birth, especially in the first 8 weeks after birth (Tanner 1978; Ghezzi *et al*. 2001). Due to larger feotal size, during the late pregnancy, mothers are starting to feel full and lack of appetite for eating and drinking but nutrients and water requirements are still very necessary to support feotal development.

Normal growth and function of the placenta is necessary to achieve a healthy pregnancy indicated by normal feotal growth. Feotal growth depends on the nutrient transfer from

Table 5. Pregnancy outcome and hydration status

Variables	Dehydration (n=34)	Normal (n=32)	p
Gender:			
Boys [b)]	22 (64.70) [a)]	14 (43.80)	0.13
Girls [b)]	12 (35.30)	18 (56.20)	
Weight (g) [a),*)]	2,838.00±411.66	3,329.84±339.09	0.00
Length (cm) [a),*)]	47.70±1.58	48.68±0.78	0.00
Pulse rate (minutes) [a)]	141.38±2.76	140.68±2.11	0.25
Head circumference (cm) [a),*)]	32.23±1.34	33.21±1.00	0.00
Apgar score [a)]	8.38±0.65	8.59±0.49	0.14
Chest circumference (cm) [a),*)]	32.35±1.72	33.46±1.07	0.00
Placenta weight (g) [a)]	633.37±47.65	623.75±57.18	0.46
Duration of pregnancy (weeks) [a)]	38.50±0.92	38.53±0.87	0.88

[a)]t-test independent, mean±SD. [b)]chi-square test, n(%).[*)]significant in p<0.05.

Table 6. Pregnancy outcome (infant birth weight and length) to mother's weight in second and third trimesters, and water intake levels

Variables	Dehydration (n=34)	Normal (n=32)
Length*		
Before corrected	47.7±1.58	48.6±0.7
After corrected	47.3±0.3	49.1±0.3
Δ *(d)*	-0.4	0.5
Weight*		
Before corrected	2,838.0±411.6	3,329.8±339.1
After corrected	2,7874±100.9	3,383.5±105.8
Δ *(d)*	-50.6	53.7

*)ANCOVA, significant in p<0.05. R-squared : length=0.19, weight=0.31. Δ (d)=after-before corrected to mother's weight in second and third trimesters, and water intake levels

mothers to fetus through the placenta (Forbes & Melissa 2010). This study highlights the negative impact of hypo hydration to infant birth weight and length (p<0.05) (Table 5). Consistent with the pregnant mice study, this study proved the level of fluid intake significantly affects feotal growth indicated by lower birth length.

Hydration plays a role in regulating blood pressure and body temperature as well as digestion and absorption transport of carbohydrates, vitamins, minerals, and other essential nutrients as well as oxygen into the cells. These signal the cell to produce energy for the body function. Hydration also serves to remove waste of metabolism from chemical reactions in the cell. Thus, the case of stunting/short (restriction of linear growth) was influenced by the quantity and quality of nutrient intake, as well as the growth of hormone levels (Sari *et al.* 2015; Savitz *et al.* 1995). The best quality and quantity of nutrient intake will absorb into the cells with the help of hydration system (Danileviciute *et al.* 2012).

This study confirmed result from previous study in Greece highlighting the importance of water intake in pregnant women (Malisova *et al.* 2014). Therefore, increase in water intake to ensure good hydration status is pivotal to achieve optimal pregnancy outcomes, which measured by the infant birth weight and length.

CONCLUSION

Most of subject had dehydration in the third trimester, where more than two biomarkers were in higher than normal. There were differences of maternal weight in second and third trimesters, however we didn't find differences in maternal weight gain between two groups. More than fifty percent pregnant women had suffered nausea and vomiting during pregnancy in the two groups. There were significant differences in water intake levels between two groups. There were differences of infant birth weight and length, head circumference and chest circumference between the two groups. After adjustment in water intake level, the infants' birth weight and length in DG were lower than NG as much as 596.1 g and 1.8 cm respectively.

Pregnant women should continuously monitor their weight and perform simple examination to check hydration status (urine color) as well as ante natal care. Pregnant women should carefully monitor their dietary and water intake, that to ensure drinking water as much 3.0 L/days. It's advisable to conduct a cohort study, to observe the effects of hypo hydration to post natal growth of the infants up to the first 6 months of life considering the theory that the infant birth weight and length will increase at speed during that age.

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