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Original Research Paper

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RELATIONSHIP BETWEEN URINE COLOR SCALE AND URINE SPECIFIC GRAVITY TO HYDRATION STATUS IN ELEMENTARY SCHOOL STUDENT

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ABSTRACT

Background: Inadequate hydration state in children causes several conditions such as imbalance mood, headache, delayed cognitive function, even death. It is imperative to access the status quickly, accurately by using urine color scale and measuring the urine specific gravity. The purpose of this study is to analyze the relationship between urine color scale and urine specific gravity to hydration status in children.

Method: A cross-sectional study was conducted in March 2019 in Singkuang village. The samples were elementary children from 8 to 14 years old. All samples required to fill the questionnaire and to submit the urine sample. Then, they were examined to assess hydration state. The urine was evaluated by using a urine color scale and refractometer. Bivariate analysis, chi-square, was used to analyze the determinants. The confidence interval was set to 95% and $P<0.05$ was significant.

Result: There were 222 samples from elementary school class 4 to 6. There were 46 (20.7%) dehydrated children from a physical examination. There were 5 (2.2%) dehydrated children and 153 (65.9%) probably dehydrated children when to be assessed by urine color scale. There were 18 (8.1%), dehydrated children, when being assessed by urine specific gravity. There was no relationship between urine color scale to hydration status ($P = 0.511$). But the urine specific gravity was significantly correlated to hydration status ($P = 0.032$) and urine color scale ($P = 0.0001$)

Conclusion: Hydration status can be determined by evaluating urine specific gravity but not by evaluating urine color scale.

KEYWORDS : Urine color scale, urine specific gravity, hydration status, children.

INTRODUCTION

Water is an essential nutrient and component in a human's body. It is 73% of the ideal weight and about 50-60% of the total weight in adults. National research suggests adequate fluid intake is measured in average fluid intake. (Manz et al, 2003) Mild dehydration is a loss of 1-2% of body weight and caused by an acute fluid loss such as vomiting, diarrhea, and excessive physical training. These incidents affect future health and increasing the risk of urinary stones. (Armstrong et al, 2007 and Walawender et al, 2018)

Poor hydration harms our health. Under some circumstances, urine concentration makes a good marker for your hydration state. It correlates to the specific gravity and osmolarity of the urine. (Guelinckx et al, 2015)

Hydration state can be measured by a noninvasive method i.e. urine color scale and specific gravity. Urine color scale is validated as a hydration state marker in adults and children of 8-14 years old. By the age of 8, children can assess their urine. The awareness level in several countries is not significantly different. In Indonesia, the awareness level is similar to France (74%), Mexico (84%), and USA (94%)(Cridge et al, 2018 and Baig et al, 2011)

In 2005-2006, the research found that children and adolescents in the US did not take adequate fluid recommended by the Institue of Medicine. Using osmolarity of the urine, it reveals that 60% of samples from children of 9-11 years old had inadequate hydration state, mostly caused by not drinking water, lead them to a high risk of poor hydration state. (Kenney et al, 2015)

In line with Portuguese research, many children are classified as hypohydration, so increasing water and water-rich foods intake is necessary. (Padrao et al, 2016). The urine color scale has a positive correlation to the specific gravity. Dark yellow or score 4 is a predictive marker for the specific gravity of 1.030. Bongard et al, 2015)

Urine specific gravity assessment with a refractometer is a notable assessment proportionate to urinalysis. The refractometer described the urine specific gravity as an indicator of soluble substance and urine concentration. In general, dark yellow urine indicates high concentration. (Bongard et al, 2015)

Retrospective research in the US evaluates the correlation between urine color and specific gravity in dogs, revealed a positive correlation. However, this research has not been done on humans both in developed and developing countries. (Kavouras et al, 2016)

MATERIAL AND METHOD

Participant selection

Students in grades 4, 5, and 6 in Singkuang and Sikapas Elementary School, district of Muara Batang Gadis, Mandailing Natal, with urine samples were included. Exclusion criteria were children with proteinuria, glucosuria, hematuria, bilirubinuria, and those whose parents refused to participate. Children with fever, liver malfunction and any chronic diseases were also excluded.

Data Analysis

Those who met inclusion and exclusion criteria were asked for written consent. Data retrieval was done by interview and questionnaire about age, gender, familial socioeconomic state, nutritional state, parental info such as educational background and occupation, underlying disease, 24-hour fluid intake, and others that may affect urine assessment.

Urine was obtained using 15ml urine pot to be examined by a

urine color scale. About 2 drops or 0.1 ml of urine was transferred from the transparant pot for refractometer assessment by dropping and covering it on the prism glass and measured it through the refractometer hole.

Evaluation of children's hydration state was done using WHO standards. The data was written, collected, and input to the table master for further analysis with the computed statistical program.

Statistical method

All data were analyzed using computerized software. Characteristics of the subjects were described in the distribution of categorical data. We used a Chi-square test with $p < 0.05$ and CI 95%.

RESULTS

This research enrolled 222 elementary students age 8-11. their caharacteristic data is shown in table 1.

Table 1. Subject's Characteristics

Characteristics	Hydration Status	
	Normal	Dehydrated
Sex		
Male	96 (54.5%)	20 (43.5%)
Female	80 (45.5%)	26 (56.5%)
Age		
6-11 years old	127 (72.2%)	31 (67.4%)
12-16 years old	49 (27.8%)	15 (32.6%)
Nutritional status		
Mild malnutrition	29 (16.5%)	11 (23.9%)
Well nourish	110 (62.5%)	31 (67.4%)
Overweight	24 (13.6%)	3 (6.5%)
Obesity	13 (7.4%)	1 (2.2%)
Frequency of drinking water (24 hours)		
Little (≤ 6 glasses)	34 (19.3%)	39 (84.8%)
Adequate (7-9 glasses)	118 (67%)	7 (15.2%)
Much (> 9 glasses)	24 (13.7%)	0 (0%)

Pearson Chi-Square test revealed $p = 0.511$, so there is no significant correlation of urine color scale to their hydration state ($p > 0.05$, table 2)

Urine color scale	Hydration State			P Value
	Normal	Dehydrated	Total	
Euhydrated	53 (81.5%)	12 (18.5%)	63 (100%)	0.511*
Potential to dehydration	120 (78.9%)	32 (21.1%)	153 (100%)	
Dehydrated	3 (60%)	2 (40%)	5 (100%)	

** Pearson Chi-Square*

Statistical test using Pearson Chi-Square revealed $p = 0.032$ in urine specific gravity and hydration state. There is a significant correlation of urine specific gravity and hydration state ($p < 0.05$, table 3)

Table 3. Correlation of Urine specific gravity to hydration state

Specific gravity	Hydration state			P value
	Normal	Dehydrated	Total	
Hyperhydrated	22 (84.6%)	4 (15.4%)	26 (100%)	0.032
Euhydrated	144 (80.9%)	34 (19.1%)	178 (100%)	
Dehydrated	10 (55.6%)	8 (44.4%)	18 (100%)	

** Pearson Chi-Square*

In table 4, Pearson Chi-Square test reveals $p = 0.0001$ so there is a significant correlation of urine color scale and specific gravity ($p = < 0.05$).

Table 4. Correlation of urine color scale and specific gravity

Urine color scale	Specific Gravity			P value
	Hyperhydrated	Euhydrated	Dehydrated	
Euhydrated	20 (30.8%)	45 (69.2%)	0 (0%)	0.0001
Potential to dehydration	6 (3.9%)	132 (86.8%)	14 (9.2%)	
Dehydrated	0 (0%)	1 (20%)	4 (80%)	

** Pearson Chi-Square*

DISCUSSION

Urine usually have colour of either pale yellow or light yellow, and can be turn to dark yellow if the urine became concentrated. Fluid intake and few factors such as drugs, food, stress, and activity can affect urine colour. Cloudy urine can be caused by infection with pus, presence of microscopic blood cells, urinary stone, food, vaginal fluid, and dehydration state. Urochrome was a pigment that gave characteristic of urine colour into yellow. Medicines and other compounds can also affect urine colour. The most common thing that can turn urine colour was blood, which can turn urine colour into pink, red, or darker. Blood in urine can be cause by diseases, and bleeding in small amount causes by drugs. Basically laboratorium finding was essential if the urine colour was checked. (Lockwood et al, 2018)

In this study, there were few obstacles for assessed the colour of urine, of which there was to many that can affect urine colour. From food, drugs, infection,vaginal fluid, pus caused by urinary tract infection, microscopic blood that cannot be confirmed by macroscopic findings, direct interview, questionnaire by parents, but also needed urine laboratory to exclude factors in urine colour changing causal. Also with renal disease factors like urinary tract infection and urinary stone that needed advance examination like urinalysis, urinary tract ultrasonography, urine culture to exclude factors that effect urine colour.

In 24 hours composition and concentration of urinalysis can be change, therefore, a lot of examination tipe from specimen that can be evaluated. Generally, around 10 cc urine can be used for urinalysis. Urine specimen has to be cold first if the specimen cannot be evaluated in 2 hours after the taking, because the urine can be damaged after 2 hours, became more alkali, and causes urinalysis not longer acccurated. (Lockwood et al, 2018)

Evaluation of urine specific gravity for asses the capability of kidney to concentrated and diluted the urine and the connection with plasma for comparing the weight of urine (particle) to weight of water filtration. Because urine consist of several substance like minerals and salts, the specific gravity of urine normally higher that water, usually around 1.005-1.025, but the specific gravity of urine can increase with gain of several substance, such as protein or dehydration stated. Other things that can increase the specific gravity of urine was glucose in urine, and increased of Anti diuretic hormone (ADH), because ADH functioned to reabsorb water in tubule caused decrease of urine volume. And other several factors like trauma, stress, surgery, and drugs that can increase the secretion of ADH.

Decreased of urine specific gravity can be caused by multiple factors such as diabetes insipidus where there were not or less ADH that secreted due to the damaged of pituitary glnd, so kidney produce mre urine (15-20 litre per day) with decreased of urine specific gravity. Kidney disease such as pyelonephritis and glomerulonephritis can interefere the kidney for filtered and reabsorbed water so can lower the urine specific gravity. Kidney disease such as pyelonephritis and glomerulonephritis so it can interefe the kidney to absorband reabsorbed water, so It can lower. State of kidney

failure also create vary sepsific gravity between 1.007-1.001 as hypertrhropy . (Lockwood et al, 2018)

This can affect study where the factor that can affect urine specific gravity such as kidney disease (pyelonephritis and glomerulonephritis), diabetes insipidus, and ADH secretion that needed for laboratory urinalisys, kultur urine, blood sample, and kidney, can exluded nw

Diabetes insipidus and ADH secretion needed evaluation of investigation like urinalysis, urine culture, ADH secretion that needed further evaluation like urinalysis, and USG was needed to exluded other factor in changing of urine specific gravity. In result of study found significant correlation between specific gravity and dehydration state in children's that maybe can be explained due to less factor that can affect urine specific gravity and several factors can be excluded with questionnaire so that in result got significant correlation.

Can be concluded that the weakness from this study was there still need to have examination that support exclusion criteria such as kidney USG, blood examination, urine culture, laboratory urinalysis to proof kidney and urinary tract disease that can affect result of urine clour scale or specific gravity.

Study by Mckenzie in United stated explained that urine clour scale was usefull diagnostic to assessed hypohydation status after exercise in hot weather. Urine colour scale below 5 indicated loss of fluid more than 2 % with sensitivity of 88,9% and specificity of 84,8%. This paramatre was helpful to assessed on field when theres no equipment (for examples refractometry or osmometry). (Shirreffs et al, 2015)

Study of Shirreffs in Europe said that collection of urine for analysis can investigated and used for marking of hydration status. Osmolarity of urine can exchange with urine specific gravity as potential marker. Theres was correlation between urine colou scale to urine specific gravity and conduction force. Use eight scale and weigth shoeed that theres linear correlation between urine colour scale to urine specific gravity and urine osmolarity to estimated the hydration status. (Brewster et al, 2012)

Study by Garcia in Spain for adolescent stated that validation result showed that water balance, water intake, water excretion correlated with some of important marker from hydration status, these were urine specific gravity, total weight, and urine colour scale. Recent study explained that urine specific gravity strongly correlated with urine osmolarity, so that recommended as promising marker for assessed the hydration status. Urine colour scale was subjective and depend on several factors such as drugs and food, so this marker have to combinated with other methods. (Garcia et al, 2016)

Chew in Kuala Lumpur compares urine colour scale that taken with handphone to urine laboratorium, stated that there was a strong correlation between urine osmolarity to urine specific gravity and urine colour scale to assessed hydration. (Chew et al, 2018)

Trabelsi in Tunisia explained that urine urine strip urine specific gravity had the same result compare the one that on laboratory to determined hydration status. In other study showed that theres a linear correlation between urine colour scale with urine specific gravity and urine osmolarity to determined hydration status. There were 6 studies that stated urine specific gravity or urine osmolarity with proof of A category as indicator to hydration status of male and athlete. (Trabelsi et al, 2017)

Ersoy in Turkey studied of hydration status in male soccer with urine colour scale, urine specific gravity (laboratorium, refractometry, and strip). He stated that there was no standard for examination of hydration status, even though with plasma and urine osmolarity, but urine colour scale can be used as valid method. For additionaly, monitoring of weight when the bladder was empty, urine analysis (colour scale, urine specific gravity, and urine osmolarity) was effective methods that strongly correlated with hydration status. (Ersoy et al, 2016)

Overall there was a strong correlation between urine specific gravity and urine colour scale for hydration status. There was similarity of result and validity between urine colour and urine specific gravity to urine osmolarity and plasma ormolarity. This was convenient with the result of this study that there was significant correlation between urine specific gravity to hydration status and urine colour scale to urine specific gravity. Although there was distinction with result of study that there was no significant correlation between urine colour scale with hydration status.

CONCLUSION

There was no significant correlation between urine color scale and hydration state. However, there was a significant correlation of urine specific gravity to hydration state and urine color scale to urine specific gravity.

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