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Impact of body mass index on urinary solutes in Egyptian adolescents

Nermine N. Mahfouz[1,2*], Azza Abd El-Shaheed[1,2], Reham F. Fahmy[1,2], Sara F. Sallam[1,2], Salwa Refat El-Zayat[3], Hiba Sibaii[3], Mahitab I. EL-Kassaby[3] and Hagar H. Mourad[3]

Abstract

Background: High body mass index constitutes a risk for nephrolithiasis in the context of metabolic syndrome. The majority of these renal stones are either composed of Urate or Calcium Oxalate. We aimed to evaluate the ratios of urinary Calcium and Uric Acid to urinary Creatinine as an early alarming pathological sign in overweight and obese adolescents. Ninety adolescents of both sexes participated in the study. Anthropometric measures were fulfilled, and calculation of body mass index and waist to height ratio were assessed. Urinary Calcium and urinary Uric Acid to Creatinine ratios were estimated in an early morning spot urine sample.

Results: Males and females had comparable values for solutes/Creatinine ratios. A highly significant negative correlation was detected between urinary Urate/Creatinine ratio and age of the child (*P*-value 0.001). Adolescents with higher body mass index had higher urinary Calcium/Creatinine and higher urinary Urate/Creatinine ratios but P-values were insignificant in our research.

Conclusion: At the age range of 10 to 18 years, the sex of the adolescent has an equivocal effect on urinary concentration of both Calcium and Uric Acid. Urinary solutes/Creatinine ratio decrease significantly by age in adolescence. Overweight and obesity tend to be risk factors for higher urinary solutes 'concentration.

Keywords: Urinary solutes, Adolescents, Body mass index, Obesity

Background

Nowadays, the occurrence of nephrolithiasis is on the rise and is more frequently documented in adolescence than was before (Tasian et al. 2016; Ward et al. 2019). Kidney stone formation represents the tip of an iceberg. It is just a mark on the surface that indicates a deeper and former pathogenesis lying underneath (Hoppe and Kemper 2010).

The urine does not only provide data about renal functions but it also reflects the metabolic status of the whole body. Therefore urine sampling serves in routine investigations of many ongoing pathological processes (Lee et al. 2020).

Obese and overweight individuals are more predisposed to urolithiasis than those with normal body mass index (BMI). Many studies have been dedicated to explain this association. The lower urinary pH in obese and overweight individuals was found to have a key role in precipitation of solutes and eventually stone formation (Tessaro et al. 2018; Lee et al. 2020).

As regards the composition of renal calculi, the Urate stones are the ones mostly affected by urinary pH. On the other hand, Calcium containing stones are by far the commonest type encountered overall (Tilahun and Beyene 2018).

Early screening for the precipitating factors in high risk groups could possibly prevent the eventual event of urolithiasis. A spot urinary solute to creatinine ratio is of

*Correspondence: nerminabil@yahoo.com
[1] Department of Child Health-Medical Research and Clinical Studies Institute, National Research Centre, 33rd El Buhouth Street, Former El Tahrir Street, Dokki, PO 12622, Cairo, Egypt
Full list of author information is available at the end of the article

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value and should be included in the screening panel of investigations (Hope and Kemper 2010).

Methods

The study took place at the Medical Research Centre of Excellence (MRCE) in the Clinic of Nutrition and Immunity, in the NRC. This research point was in integrity with the in-house project: "Early Renal injury markers in obese adolescents". Ninety Egyptian adolescent children were involved in this study. Forty-five cases were selected according to a high BMI ≥ 85th percentile. The control group involved forty-five of their counterparts with BMI < 85th percentile.

Inclusion criteria

Children of both genders, obese and non-obese, at stage of adolescence.

Exclusion criteria

Secondary obesity and chronic kidney disease.

Anthropometric measures

The measurement of the height was approximated to the nearest 0.5 cm on a Holtain portable stadiometer. The weight was defined according to the nearest 0.1 kg on a Seca scale. BMI was calculated as Weight (kg)/Height (m^2). Waist circumference was measured at end of normal expiration, while standing, having arms by the sides, feet adducted and abdomen relaxed. The measurement was done by a nonelastic tape. It was taken at midpoint between the lower border of the last rib and the upper border of the iliac crest. The plan of the contour was horizontal and parallel to that of the ground. Waist to height ratio was calculated for each candidate (WHO 2008).

Data were plotted on WHO curves through the data entry by software AnthroCalc v1.66 Home. WHO growth charts for Canada March 2014 revision; available at <whogrowthcharts.ca> https://www.dietitians.ca/Dietitians-Views/Prenatal-and-Infant/WHO-Growth-Charts.aspx.

Waist circumference and waist–hip ratio: report of a WHO expert consultation, Geneva, 8–11 December 2008. Available at: https://apps.who.int/iris/bitstream/handle/10665/44583/9789241501491_eng.pdf?sequence=1.

Laboratory methodology

A spot morning urine sample was provided by each participant. ERBA XL200, Biochemical analyzer, was used to assess the urinary concentrations of Calcium, Uric Acid and Creatinine. A photometric method served for color indication of sample analysis https://www.erbalachema.com/en/products-and-solutions/clinical-chemistry/biochemical-analyzer-xl-200/.

Statistical analysis

Statistical Package for the Social Science SPSS version 16.G served for data analysis. Results were presented as mean and standard deviation for quantitative parameters, while qualitative ones were presented by number and percent. Comparison of the quantitative nonparametric data between groups was done through Mann–Whitney test. The statistical significance was settled at P-value < 0.05, and considered highly significant at P-value < 0.01. Spearman test was used to describe the degree of correlation between two variables, whether positively or negatively (SPSS version 16.G.).

Results

The candidates in the current study were ninety adolescents. Forty-five were having a BMI ≥ 85th percentile and constituted the case group. The other forty-five had a BMI < 85th percentile and presented the control group. Their ages were in the range of 10 to 18 years old.

The two groups were homogenous as regards age and sex distribution. The mean age was 13.05 ± 2.61 and 12.62 ± 2.60 in the case and control groups, respectively (P-value 0.446). Females were predominant in both groups. Among the case group 32 were females (71.1%) comparable to the control group where 27 were females (60.0%) (P-value 0.267).

Both groups were heterogeneous as regards BMI and waist/height ratio. A highly significant discrepancy was present with a P-value of 0.001 for these two parameters between the two groups. In the case group, the mean BMI ± SD was 30.55 ± 5.61 and the mean ± SD Waist / height ratios was 0.58 ± 0.08 in contrast with the control group where the mean BMI ± SD was 17.22 ± 2.71 and the mean ± SD Waist/height ratios was 0.42 ± 0.05.

As shown in Table 1, males and females had comparable values for urinary Uric Acid/Creatinine ratios of 1.61 ± 5.94 and 0.56 ± 0.34, respectively (P-value 0.892). Similarly, the gender had no impact on urinary Calcium/

Table 1 Gender effect on uriary Ca and U.A. to Creatinine ratios

Parameters	Groups	Mean ± S.D	*Z* value	*P* value
U. UA (mg\dl)/U. Creat (mg\dl)	Male	1.607 ± 5.942	− 0.135	0.892
	Female	0.557 ± 0.340		
U. CA (mg\dl)/U. Creat (mg\dl)	Male	0.792 ± 4.040	− 0.787	0.431
	Female	0.102 ± 0.287		

Creatinine ratios of 0.79 ± 4.04 in boys and 0.10 ± 0.29 in girls (*P*-value 0.431).

The BMI was found to have an incremental effect on urinary solutes concentration. Higher BMI was associated with higher urinary Uric Acid and Calcium. The mean ± SD value of urinary Calcium/Creatinine was 0.65 ± 3.50 in the case group compared to 0.07 ± 0.11 in the control group. Also, a higher mean ± SD value of urinary Urate/Creatinine of 1.37 ± 5.14 was detected in those with BMI ≥ 85th percentile in comparison to 0.53 ± 0.33 in those with BMI < 85th percentile. *P*-values were insignificant statistically for both urinary solutes (Ca and UA) concentrations in our research as noted in Table 2.

At the age range of 10 to 18 years, the older the child the lower is the Uric Acid concentration in urine. But this inverse relation was absent concerning urinary Calcium concentration (Table 3).

A non-significant positive correlation was noticed between the values of the waist/height ratio and urinary Uric Acid concentration. The higher central obesity was associated with more Uric Acid in urine. Although this finding in our study did not reach a statistical significance (Table 3).

A highly significant negative correlation was detected between urinary Uric Acid /Urinary Creatinine ratio and age of the child (*P*-value 0.001) as illustrated in Table 3.

Table 3 Correlations of urinary solutes/creatinine ratios with age, waist/height ratio and bmi values using spearman correlation coefficient test (nonparametric data)

Parameters	*R* (Spearman correlation)	*P* value
U. UA (mg\dl)/U. Creat (mg\dl) with age	− 0.354**	0.001
U. Ca (mg\dl)/U. Creat (mg\dl) with age	0.003	0.976
U. UA (mg\dl)/U. Creat (mg\dl) with W\HT ratio	0.200	0.079
U. Ca (mg\dl)/U. Creat (mg\dl) with W\HT ratio	− 0.032	0.782
U. UA (mg\dl)/U. Creat (mg\dl) with BMI	0.050	0.661
U. Ca (mg\dl)/U. Creat (mg\dl) with BMI	0.047	0.678

**Correlation is significant at the 0.01 level

Discussion

The great majority of Egyptian adolescents suffer from an excess fat mass (Ibrahim et al. 2017; Mahfouz et al. 2018). A bundle of complications coexist with high BMI and result in chronic lifelong health threats (El Kassas et al. 2018; Shehata et al. 2015). In many researches, a strong link was found between central obesity and urolithiasis. The key to this link was the increment in urine acidity in relation to high BMI. The higher urinary acidity favors insolubility, oversaturation and precipitation of crystals. That will end up in urinary stone formation (Tessaro et al. 2018; Lee et al. 2020).

The current study was conducted to assess the urinary Calcium and urinary Uric Acid to Creatinine ratio in obese versus non-obese adolescents. Spot urine sample was provided as it is easy to obtain and highly informative. Many studies confirmed that the spot urine solute concentration in relation to urinary Creatinine is as accurate as the cumbersome 24 h urine collection (Marwaha et al. 2019; Pal et al. 2013; Dana et al. 2005; Sorkhi et al. 2005; So et al. 2001).

Although the calciuria was higher in boys than girls, still the gender impact was statistically insignificant. In accordance, Slev et al. (2010) and Marwaha et al. (2019), reported same range of urinary Calcium in both males and females in pediatric age group. On the opposite, In Su et al. (2013) found more elevated urinary Calcium in boys than in girls.

Bouziani et al., noticed that in children above 10 years old the urinary excretion of Calcium decrease as their needs mandate to retain more Calcium. This is crucial for appropriate bone mineralization at this stage of rapid growth to attain the expected final adult height (Bouziani et al. 2019). While, like our results, Sönmez et al. (2007), mentioned that age has no effect on urinary Calcium level. According to Sorensen and Sorkhi et al., this wide variability is due to the overlap of multiple and dynamic factors in calcium homeostasis (Sorkhi et al. 2014; Sorensen 2014).

In our study, those with BMI above or equal to 85th percentile tend to have higher urinary Ca to Creatinine. This goes in agreement with In Su et al. (2013) and Shavit et al. (2015), who detected an association between hypercalciuria and high BMI. On the other hand, Marwaha

Table 2 Urinary solutes/Creatinine ratio in obese versus non-obese

Parameters	BMI percentile	Mean ± S.D	*Z* value	*P* value
U. UA (mg\dl)/U. Creat (mg\dl)	Obese	1.374 ± 5.143	− 1.478	0.139
	Non-Obese	0.531 ± 0.333		
U. CA (mg\dl)/U. Creat (mg\dl)	Obese	0.654 ± 3.505	− 0.046	0.964
	Non-Obese	0.069 ± 0.107		

et al. attributed no impact of BMI on urinary Ca concentration (Marwaha et al. 2019).

At adolescence stage the urinary Uric Acid goes down in inverse relation to age from 10 to 18 years old. This matches the conclusion made by Poyrazoğlu et al., that urinary concentration of Uric Acid decreases by age in a Turkish study involving healthy children (Poyrazoğlu et al. 2009).

Higher urinary Uric Acid to Creatinine ratios in overweight and obese were found compared to their peers with BMI below 85th percentile. This goes in harmony with the higher risk expected due to the lower urinary pH in association with high BMI thus favoring UA insolubility. Similar finding was deduced by Bernhard in their review article (Bernhard 2012) and by Shavit et al. who associated elevated urinary Uric Acid with high BMI (Shavit et al. 2015).

We included the waist/height ratio in our anthropometric measurements and evaluated its influence on the concentration of urinary solutes. We noticed that the higher waist to height ratios were associated with more urinary Uric Acid to Creatinine ratios. Zvonar et al., Yoo et al., and Ibiza et al., demonstrated that in case of high BMI, the fat distribution counts much more than the total amount of excess fat. The visceral fat serves as a prognostic tool that predicts the expected complications in obesity. Moreover, the waist to height ratio is more useful than the waist to hip ratio in determining abdominal obesity (Zvonar et al. 2019; Yoo et al. 2016; Ibiza et al. 2008).

Conclusions

Urinary U.A./Creatinine ratio was found to be significantly decreased by age in the stage of adolescence. Adolescents with high BMI and high visceral fat tend to have increased urinary solutes' concentration but without reaching statistical significance in this study for further evaluation in larger studies.

Limitations

The weak point of this study was the small number of participants. Thus, there is no possibility to generalize the findings deduced on all adolescents. Further larger studies are needed to ascertain or nullify the results obtained.

Recommendations

The spot urine sample is an easy informative one. Therefore, it is recommended to be included in the routine workup of overweight and obese candidates to assess the urinary Calcium/Creatinine and urinary Uric Acid/Creatinine ratios.

Abbreviations

BMI: Body mass index; Ca: Calcium; MRCE: Medical Research Center of Excellence; NRC: National Research Centre; UA: Uric Acid.

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Author contributions

The child health team: NM, RF and SS cooperated in the history taking and examination of children under supervision of Professor AA. The medical Physiology team ME and HM performed the laboratory work under supervision of Professor SE and Professor HS. NM is the corresponding author and wrote the research under supervision of Professor AA. All authors have read and approved the final manuscript.

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Availability of data and materials

Data used during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained prior to implementation of the work. The permission code 16130 was given by the committee of ethics of the National Research Centre (NRC). The legal guardian of the candidates accepted their participation and provided their signature on the consent after full explanation of the steps of enrollment. This is matching with the code of ethics of the world medical association (Declaration of Helsinki) https://www.wma.net/wp-content/uploads/2018/07/DoH-Oct2008.pdf

Consent for publication

Neither identifying images nor other personal or clinical details of participants are presented that compromise anonymity; a statement of consent to publish from the patient is NOT Applicable. All authors were informed about publication and they agreed.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Department of Child Health-Medical Research and Clinical Studies Institute, National Research Centre, 33rd El Buhouth Street, Former El Tahrir Street, Dokki, PO 12622, Cairo, Egypt. [2]Medical Research Centre of Excellence (MRCE), Cairo, Egypt. [3]Department of Medical Physiology, Medical Research and Clinical Studies Institute, National Research Centre, 33rd El Buhouth Street, Former El Tahrir Street, Dokki, PO 12622, Cairo, Egypt.

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