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The relationship between beverage intake and weight status in children: the Cuenca study

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Abstract

Introduction: **Beverage consumption is becoming more important in current research regarding its possible association with the childhood obesity epidemic. The influence of physical activity on fluid intake has been poorly studied, and cardiorespiratory fitness (CRF) may be a reliable marker for this type of assessment. The present study analysed beverage intake related to weight, adjusted by CRF, in children aged 9 to 11 years.**

Methods**: A cross-sectional, school-based study was conducted on 373 children, aged 9 to 11 years, from the Cuenca province in Spain. To obtain beverage consumption we averaged two 24-h recalls, collected using the YANA-C assessment tool, validated for HELENA study. CRF was assessed by the 20-m shuttle run test.**

Results: **Fluid intake was 1483.39 mL/day, and energy ascribed to fluids was 16% of total energy intake. Beverages were 40% of total sugar intake from diet. The largest amount of fluid consumed among thinness boys came from fruit juices and milk drinks. Thinner girls consumed more diet drinks and whole milk than their normal and overweight counterparts, after adjusting for age and CRF.**

Conclusions: **Overweight-obese boys consumed less fruit juices and milk drinks and girls ingested less diet drinks and whole milk than their normal-weight counterparts. These results suggest the importance of investigating the hydration habits of children to draw reliable conclusions about the best way to hydrate in different situations to avoid adiposity increases.**

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Key words: *Beverage intake; cardiorespiratory fitness; children; ponderal status*.

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RELACIÓN ENTRE LA INGESTA DE BEBIDAS Y EL ESTATUS PONDERAL EN NIÑOS: ESTUDIO CUENCA

Resumen

Introducción: **El consumo de bebidas está cobrando mayor importancia en las investigaciones actuales en relación a una posible asociación con la epidemia de obesidad infantil. La influencia de la actividad física en este consumo de fluidos ha sido escasamente estudiada y la resistencia cardiorespiratoria (RCR) puede resultar un marcador fiable para su valoración. Nuestro estudio analiza la ingesta de fluidos y su relación con el estatus ponderal ajustado por RCR en niños de 9-11 años.**

Métodos**: Estudio transversal en el que participaron 373 niños de 9-11 años de colegios de la provincia de Cuenca (España). Para obtener la ingesta de bebidas, se realizó la media de dos recordatorios de 24 horas obtenidos mediante el programa YANA-C, validado para el estudio HELENA. La condición física cardiorrespiratoria fue evaluada a través del test de 20 metros ida y vuelta.**

Resultados: **La ingesta media de líquidos fue de 1483,39 ml/día, y la energía proveniente de fluidos supone un 16% del aporte energético diario. Las bebidas suponen el 40% del aporte de azúcares ingeridos en la dieta. Las bebidas más consumidas en niños son los zumos naturales y las bebidas lácteas. Las niñas delgadas consumen más leches enteras y bebidas refrescantes "light" que sus homólogas con peso normal y sobrepeso-obesidad.**

Conclusiones: **Los niños con exceso de peso consumen menos zumos naturales y bebidas lácteas, y las niñas consumen menos leches enteras y bebidas refrescantes "light" que sus compañeras en normopeso. Es de gran importancia revisar los hábitos de hidratación de los escolares para establecer conclusiones fiables sobre cuál es la mejor forma de hidratarse en diferentes situaciones para evitar ganancias ponderales.**

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Palabras clave: *Ingesta de bebidas, estatus ponderal, resistencia cardiorespiratoria, niños*.

Abbreviations

BMI: Body mass index.

CESNID: Centre for Superior Studies in Nutrition and Dietetics.

CRF: Cardiorespiratory fitness.

FM: Fat mass.

FFM: Fat-free mass.

ml/kg: Milliliters per kilograme.

WC: Waist circumference.

YANA-C: Young Adolescents' Nutrition Assessment on Computer.

Introduction

Children and adolescents obesity is a serious public health problem around the world. In Spain, excess of body weight prevalence in children aged 9-to-10 has been growing at alarming rates[1]. The estimates in 4 years old children in Europe during last decade placed Spain among the countries with higher rates obesity prevalence (around 32%), although latest data suggest that population preventive strategies are being effective[2].

Lifestyles have most of the studies analyzing factors associated to the current obesity epidemic in children have been focused on lifestyle modifications, particularly in physical activity and eating behaviors. Regarding eating habits, most of the studies have analysed solid food intake, not considering as important the fluids intake. However, in USA, but also in Spain[3], recent publications have reported the patterns of beverage intake and its contribution to the development of childhood obesity [4]. The association of many types of beverages with obesity, diabetes, and cardiovascular disease should be clarified yet[5-7].

Many studies have reported the association between energy intake or macronutrient composition and adiposity[8,9]. However, they did not consider the influence of physical activity on energy intake. Cardiorespiratory fitness (CRF) is considered as an accurate marker of habitual physical activity that has previously shown an inverse association with adiposity in children[10]. This parameter appears to be related to food intake in the adult population[11,12], showing that subjects with higher levels of fitness meet dietary recommendations[12]. Meanwhile, in the pediatric population, few studies have examined this relationship[13]. To our knowledge, the relationship between fluid intake and body composition controlling for cardiorespiratory fitness has not been established. The aim of this study was to evaluate the beverage intake patterns by body weight status, adjusting the potential confounder effect of CRF, in children aged 9 to 11 years.

Material & Methods

Subjects

This was a cross-sectional analysis of baseline data (September-October 2010) in a subsample of 373 fifth year Primary School 9-11 years old from a cluster randomized trial aimed to assess the effectiveness of a physical activity program on prevention of excess weight in children from twenty public schools in the province of Cuenca, Spain[14].

The study protocol was approved by the Clinical Research Ethics Committee of the 'Virgen de la Luz' Hospital in Cuenca. After the approval of the study by the Director and Board of Governors (Consejo Escolar), parents received all information about the study and gave written consent to their children's participation in the study. Finally, informative talks were then held class-by-class, where schoolchildren were asked to collaborate. After data were obtained, the parents were informed by letter of their children's results.

Body composition

Participants wearing light clothing were weighed twice using a digital scale with an accuracy of 100g. Height was measured twice to the nearest 0.1cm, without shoes, using a wall-mounted stadiometer. The mean of these measurements was used to calculate body mass index (BMI) as weight in kilograms divided by the square of the height in metres (kg/m^2). Thinness, normal-weight, overweight, and obese were defined according to the BMI cut-offs published for children and adolescents[15] . Waist circumference (WC) was determined by the average of two measurements taken with a flexible tape at the waist (at the midpoint between the last rib and the iliac crest). Fat mass (FM) percentage and fat-free mass (FFM) percentage were estimated by a bioimpedance analysis system (BC-418, Tanita Corp, Tokyo, Japan). A mean of two readings was taken in the morning, under controlled temperature and humidity conditions, with the child being shoeless, fasting, and after urination and a 15-min rest.

Cardiorrespiratory fitness

CRF was assessed by the 20-m shuttle run test[16]. Participants were required to run between two lines 20 m apart, while keeping pace with audio signals emitted from a pre-recorded compact disc. The running speed started at 8.5 km/h and increased 0.5 km/h each minute. The children were stopped when they could not follow the signal any more. We recorded the last half-stage completed as an indicator of his or her CRF. This CRF was categorized as follows: poor (1st quartile), satisfactory (2nd and 3rd quartiles), and good (4th quartile) as performed in previous studies.

Beverage consumption

The energy and nutrients intake of each participant was estimated using the Young Adolescents' Nutrition Assessment on Computer (YANA-C), a self-administered computerized 24-h dietary recall validated for European adolescents. This instrument consisted of a questionnaire asking for six meal occasions in the day (breakfast, mid-morning snack, midday meal, afternoon snack, evening meal, and evening snack) that have been described extensively elsewhere[17]. The Spanish version of the YANA-C questionnaire was administered twice a week, once asking about a weekday and another a weekend day (on Mondays). The YANA-C program was installed in the computer room of each school, where pupils completed the questionnaire in groups. After a short introduction, a staff member instructed children about the structure of the software by completing the questionnaire with the data of a fictitious breakfast in order to illustrate the features of the program to them. Thereafter, the pupils completed the program autonomously, although two or three staff members were present to provide assistance as required. At the end, the researchers checked the overview screen to look for extreme values and oversights. Interviewers were previously trained with specific instructions about obtaining fluids, bread, sauce, and other foods that children often forget when they fill in these questionnaires. The mean of two 24-h recalls was used to determine intake associated to beverage (in ml related to weight – ml/kg). The software allowed us to get complete information about the composition of nutrients and minerals included in each food or drink. The compositions of all of food and beverages were estimated using the food composition tables of the Centre for Superior Studies in Nutrition and Dietetics (CESNID).

Beverages were grouped in nine categories: 1) Water as a beverage (plain water, bottled water, and water with flavor without sugars added); 2) Soft drinks (calorically-sweetened soda and sport drinks); 3) Diet drinks (non-caloric sweetened beverages, diet sodas, or other diet beverages); 4) Fruit drinks (< 100% fruit juices and others with added sugars); 5) 100% fruit juices (natural fruit juices and commercial 100% fruit juices without added sugars); 6) Skimmed and semi-skimmed milk; 7) Whole milk; 8) Milk drinks (beverages from a milk base with or without sugars); and 9) Other beverages (soya beverages, vegetable juices, coffee, tea, infusions, horchata, cereal drinks, etc.). The last group included various types of beverage consumed sporadically, with the aim of making further analysis more accurate. Alcoholic beverages were excluded.

Statistical analysis

The normality of the variables distribution was examined by using both graphical (normal probability plot) and statistical procedures (Kolmogorov-Smirnov test). Descriptive statistics (mean and standard deviation) were calculated. One-way analysis was used to assess differences in energy and macronutrient intake among sexes. ANCOVA models were estimated to test differences in mean of beverage intake by weight status (thinness, normoweight, and overweight-obese) adjusting for age (model 1), and also including cardiorespiratory fitness in a second step (model 2), by sex. Pairwise post-hoc comparisons were examined using Bonferroni test. The statistical analyses were conducted with SPSS version 22 (SPSS Inc., Chicago, IL).

Results

Baseline descriptive statistics, energy, and macronutrients intake were presented Table I. In general, around 40% of boys and 35% of girls were overweight/obese. On the other hand, boys had better CRF levels than girls ($p < 0.001$). Beverage intake mean (from food and beverages) was 1443.0 ml/day in boys and 1519.9 ml/day in girls ($p = 0.011$) and beverage intake mean was 966.0 ml/day in boys and 1061.8 ml/day in girls ($p = 0.003$). The contribution of energy from beverages in boys was 251.3 kcal/day – 1047.3 kJ/day and 267.1 Kcal/day – 1113.0 kJ/day in girls, representing 15% and 17% of total energy intake, respectively. Finally, boys consumed less water (62.9-65.9%, $p = 0.004$) and sugar from beverages than girls (38.6-42.2%, $p = 0.025$).

Beverage patterns by weight status

Figure 1 show the beverage consumption based on weight status. Overweight and obese children consumed more beverages compared to their normal and thinness peers (in milliliters). Thinness children con-

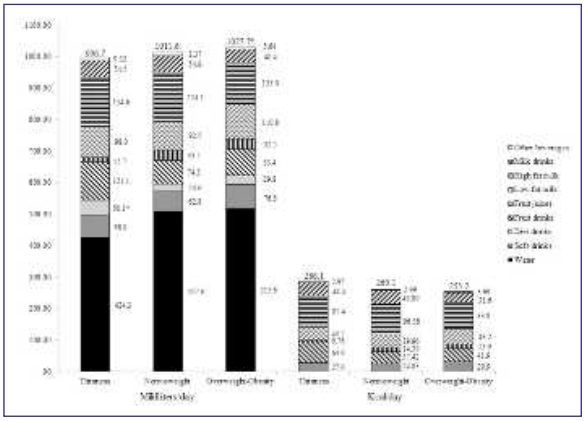

*Fig. 1.—Mean volume intake (ml/day), and mean of energy intake (Kcal/day) according to volume, of each beverage category by weight status. #p<0.05 "overweight-obesity" vs "normoweight" and "thinness"; *p<0.05 "thinness" vs "normoweight" and "overweight-obesity".*

Table I
Study sample characteristics.

	Total (n= 373)		*Boys (n= 177)*			*Girls (n= 196)*			*p* Boys vs Girls*
	Mean	*SD*	*Mean*	*SD*	*%TC[1]*	*Mean*	*SD*	*%TC[1]*	
Age, (years)	9.99	0.47	10.03	0.49		9.96	0.44		0.125
Body composition									
Height, (cm)	141.77	6.88	140.75	6.65		142.69	6.97		0.016
Weight, (cm)	39.24	9.05	38.90	8.60		39.55	9.44		0.790
BMI, (kg/m^2)	19.39	3.63	19.51	3.52		19.28	3.72		0.363
Thinness, n (%)	30 (8.00)		13 (7.30)			17 (8.70)			0.746
Normoweight, n (%)	206 (55.2)		101 (57.1)			104 (53.1)			0.864
Overweight-Obese, n (%)	137 (36.7)		63 (39.5)			75 (34.2)			0.418
FM, (%)	25.62	6.43	24.15	6.86		26.95	5.71		<0.001
FFM, (%)	28.71	4.74	28.99	4.28		28.46	5.12		0.096
WC, (cm)	68.80	9.21	69.12	9.13		68.51	9.29		0.449
Cardiorespiratory fitness									
CRF, (ml*kg^{-1}min^{-1})	3.75	1.72	4.37	1.90		3.19	1.32		<0.001
Total intake									
Energy intake, (Kcal/day)	1599.51	674.39	1659.43	787.54		1545.40	549.22		0.363
Energy intake, (kJ/day)	6664.62	2809.95	6914.28	3281.40		6439.17	2288.40		0.363
Water[2], (ml/day)	1483.39	507.10	1443.00	489.06		1519.87	521.41		0.011
Proteins, (gr/day)	70.88	31.27	74.43	34.19		67.68	28.09		0.051
Lipids, (gr/day)	71.82	39.32	75.17	44.67		68.79	33.61		0.322
Carbohydrates, (gr/day)	167.38	74.38	171.38	85.26		163.77	62.44		0.799
Sugars, (gr/day)	90.45	47.95	90.68	50.83		90.25	40.96		0.202
Total beverage intake									
Beverage intake from food and beverages (ml/day)	1483.39	507.10	1443.00	489.06		1519.87	521.41		0.011
Beverage intake, (ml/day)	1016.36	402.21	966.04	399.71		1061.81	400.05		0.003
Energy intake, (Kcal/day)	259.64	146.68	251.35	156.06	15.2	267.12	137.64	17.3	0.068
Energy intake, (kJ/day)	1081.81	611.16	1047.28	650.25	15.2	1113.0	573.48	17.3	0.068
Water[3], (ml/day)	957.91	390.08	908.91	383.30	62.9	1002.17	391.82	65.9	0.004
Proteins, (gr/day)	10.18	5.41	9.98	5.28	13.4	10.37	5.54	15.3	0.407
Lipids, (gr/day)	7.99	5.97	7.90	5.88	10.5	8.07	5.68	11.7	0.537
Carbohydrates, (gr/day)	36.76	25.46	35.16	27.78	20.5	38.21	23.15	23.3	0.024
Sugars, (gr/day)	36.71	25.39	35.04	27.63	38.6	38.12	23.04	42.2	0.025

SD: Standard deviations; BMI: Body mass index; FM: fat mass; FFM: fat free mass; WC: Waist circumference, CRF: cardiorespiratory fitness; [1]%TC: Percentage of total consumption; [2]Total water intake from food and beverages; [3]Total water intake from beverages; * U Mann Whitney Test.

sumed more diet drinks (p= 0.046). Overall, the water accounted for the largest amount of drinks consumed by the schoolchildren, and whole milk for the energy intake from beverages.

Differences between beverage intake and weight status

Mean differences in beverage consumption by body weight status categories, by sex are presented in Table II. In boys, data shows that thinness children consumed more fruit juices (4.45 ml/kg) than their normal and overweight peers (1.19 ml/kg) even after controlling for both models. Similarly, thinness boys consumed more milk drinks (2.97 ml/kg) than their peers with more weight in both models.

Among girls, thinness girls consumed more water (18.4 ml/kg) and whole milk (5.43 ml/kg) than girls with normal weight or overweight. About consumption of diet drinks, our results revealed that thinness girls consumed more (2.10 ml/kg) than the other two categories of ponderal status in both models.

Discussion

The role of beverage intake in the current obesity epidemic in children is controversial, because of could be different depending on the region of the world, and because of potential confounder variables should be considered in the estimations. Overall, our study suggest that there are not substantial differences in beverage patterns by weight status categories, even after controlling for CRF, in Spanish children aged 9 to 11 years. The only differences that we found were that overweight-obese boys drink less fruit juices and milk drinks, and overweight-obese girls drink less diet drinks and whole milk.

Water is the most consumed fluid by children in all weight status categories, and it accounts for about half

Table II
Mean differences in beverage intake (milliliters per kilogram of weight) by weight status categories, by sex

	Thinness (a)	*Normoweight (b)*	*Ow-Ob (c)*	*Pairwise comparisons**							
				Model 1				*Model 2*			
				p	*a-b*	*a-c*	*b-c*	*p*	*a-b*	*a-c*	*b-c*
Boys (n=177)											
Water	12.2±10.5	12.9±8.89	10.8±9.01	0.396	ns	ns	ns	0.641	ns	ns	ns
Soft drinks	3.20±4.65	2.51±4.60	1.89±3.97	0.504	ns	ns	ns	0.927	ns	ns	ns
Diet drinks	2.03±4.49	1.15±3.42	0.67±1.67	0.274	ns	ns	ns	0.743	ns	ns	ns
Fruit juices	4.45±7.61	1.98±3.86	1.19±2.16	0.014	ns	>	ns	0.029	ns	>	ns
Fruit drinks	1.05±2.24	0.48±1.42	0.61±1.74	0.497	ns	ns	ns	0.196	ns	ns	ns
Skimmed milk	3.96±5.18	2.49±3.38	2.35±2.75	0.244	ns	ns	ns	0.380	ns	ns	ns
Whole milk	6.01±6.48	4.53±4.52	3.20±3.78	0.043	ns	ns	ns	0.122	ns	ns	ns
Milk drinks	2.97±3.63	1.19±2.31	1.05±2.18	0.028	>	>	ns	0.031	>	>	ns
Other beverages	0.41±1.48	0.19±0.90	0.61±0.36	0.291	ns	ns	ns	0.535	ns	ns	ns
Girls (n=196)											
Water	18.4±9.88	15.9±12.5	11.0±7.85	0.004	ns	>	>	0.062	ns	ns	ns
Soft drinks	2.11±6.33	1.43±3.55	1.39±2.50	0.746	ns	ns	ns	0.782	ns	ns	ns
Diet drinks	1.89±3.99	0.32±1.27	0.61±1.59	0.004	>	>	ns	0.002	>	>	ns
Fruit juices	4.51±5.33	2.29±3.70	2.35±3.08	0.068	ns	ns	ns	0.088	ns	ns	ns
Fruit drinks	0.29±1.23	1.49±2.88	0.77±1.55	0.082	ns	ns	ns	0.099	ns	ns	ns
Skimmed milk	3.34±4.62	2.77±4.41	2.19±2.80	0.435	ns	ns	ns	0.414	ns	ns	ns
Whole milk	5.43±6.16	4.43±4.15	2.53±2.67	0.002	ns	>	>	0.008	ns	>	>
Milk drinks	1.18±2.08	1.87±3.32	0.62±1.02	0.012	ns	ns	ns	0.029	ns	ns	>
Other beverages	0.31±1.29	0.30±1.62	0.18±1.35	0.876	ns	ns	ns	0.967	ns	ns	ns

Values are mean ± standard deviation. OW, overweight; Ob, obese. Model 1 after adjusting by age; Model 2 adjuster adjusting by age and cardiorespiratory fitness.
* Bonferroni-adjusted pairwise comparisons: the symbol < in the column 1-2, for instance, indicates a significant difference (P<0.05) in the direction 1<2; ns, non-significant.

of the daily consumption of beverages[18]. These data are similar to those reported in other countries[19,20] . Some data from experimental studies suggest that water consumption would be associated with weight loss because it decreases total energy intake while producing metabolic changes[21]. Other authors have inversely associated water intake with worse dietary patterns such as increased intake of sugars, sweetened beverages, and lower intake of vegetables[7]. Our data show that girls with excess of weight drink significantly less water (ml/kg of body mass) than peers in other categories of weight status. Whereas this is the first study to present these differences by weight status in Spanish children, is difficult to reasonably argue some reason to explain these differences, and because it was volume intake by weight unit, could be attributed to that the adipose tissue is metabolically less active than lean tissue.

The contribution of whole-fat dairy intake to obesity remain is a controversial issue yet. First, whole milk ranks second in the drink consumption statistics, but ranks first in terms of the energetic content of fluids (92.6 Kcal – 385.8 kJ), and high intake of whole milk has been especially observed in children from USA, a country with very high prevalence of children's obesity[22]. And secondly, it has been reported that low-weight preschool children seem to consume a greater quantity of whole milk than peers with other weight status.[23,24]. Our data show that leaner children drink more bout whole and skimmed milk, although significant differences were found only in whole-fat milk in girls. Several arguments have been outlined to explain these seemingly surprising relationship between high-fat dairy intake and thinness, among them a reduction in total energy intake in the children that consume this kind of milk because of his greater satiating power[24]. However, the *American Academy of Pediatrics* and the *American Heart Association* recommend drink skim or low-fat milk for children aged 2 years or more, and parents of obese children tend to replace whole milk by skimmed milk following these recommendations. Further research would be required to investigate not only the potential bioactive properties of milk fat, but also the impact that livestock feeding practices could have on the fat´s quality in these products[25].

The relationship between consumption of sugary soft drinks and obesity has been also thoroughly studied[26], and remains as a debatable issue[27] Our data did not show differences in the intake of these kind of beverages by weight status. Furthermore, when investigating diet drink intake, it has been shown that low-weight girls consume greater amounts of diet drinks compared to normoweight, overweight, and obese girls. These data contrast with those of other findings in which diet soda intake links to a higher BMI[28].

In general, our data show that lesser intake of fruit juices and milk drinks in boys and diet drinks and whole milk in girls were associated with being overweight-obese, adjusting for a surrogate measure of physical activity, i.e. CRF. Further high-quality, long-term prospective studies and well-designed randomized controlled trials investigating the relationship among beverage consumption, total energy intake, and the development of childhood obesity are needed. In conclusion in our opinion the present findings are valuable from the public health point of view. They are the first approach to examine the self-reported 10-years children's fluids intake, and show that, overall, no differences in the amount of beverages intake by weight status categories in this age group. Since there is no evidence of this kind, we could begin to develop actions that can improve hydration habits in children of this country.

Limitations

A number of limitations of this study need to be kept in mind. The study was a cross-sectional design, thus and the observational findings do not allow us to evaluate whether beverages have a possible direct or causal relationship with weight status over time. Additionally, the assessment of diet in children, either directly or by adult proxy, has some methodological challenges. It has been suggested that 10-year-old children are not able to give valid responses to food frequency questionnaires covering periods of more than a day. In our study, the use of pictures in the YANA-C software helped children to remember not only the food eaten during the last 24 hours, but also the portion size.

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