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BRIEF REPORT

Overweight and obesity as risk factors for the asymptomatic carrier state of *Neisseria meningitidis* among a paediatric population

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Abstract We analysed the asymptomatic carrier state of *Neisseria meningitidis* in a sample of 339 children. We obtained data for the children's weight and height, in order to calculate the body mass index (BMI). The cutoff points defined by Cole were employed in determining the BMI, and the population was divided into three groups: normal, overweight and obese. Twenty carriers of *N. meningitidis* were identified. There was found to be a statistically significant trend to increased risk of being a carrier with increased BMI (z=2.03; P=0.04); after adjusting for age using the Mantel–Haenszel weighting method, this relationship was strengthened (z=2.38; P=0.01). Paediatric patients with increased BMI in the range of obesity present a three times greater risk of being carriers of *N. meningitidis* than non-obese patients, with a trend for this risk to increase with higher BMI.

In the last 15 years, there has been a progressive increase in the prevalence of overweight and obesity, which, in some industrialised countries, has risen to almost 30% of the child population [1]. Overweight, obesity and, in general, increased adiposity have been identified as factors favouring lipoperoxidation and inflammation [2]. Some authors [3] have reported a cause–effect relation between immunological hyporesponse and oxidative stress. Other authors [4] have reported an increase in the prevalence of carriers of *Neisseria meningitidis* during adolescence, a period during which, moreover, there exists a high prevalence of overweight and obesity [5]. We believe that, if the redox balance of the organism is related to the carrier state of *N. meningitidis*, then the nutritional state of the individual must be of equal importance. With this as a starting point, we set out to examine the contribution of overweight and obesity to the risk of *N. meningitidis* carrier status among a paediatric population.

This study was carried out on a paediatric population of 704 children. The participating subjects were recruited at the express request of the parent or guardian. The research project was approved by the local research committee, and there were no conflicts of interest in its implementation. Cutoff points were established for defining overweight and obesity in accordance with the criteria published by Cole et al. [6] for the body mass index (BMI). A pharyngeal smear was obtained from all participants and the carriers of *N. meningitidis* were identified. The statistical analysis consisted of a descriptive analysis of the variables and a stratified trend analysis, with calculation of the crude and weighted risk (Mantel–Haenszel) using the SPSS v14.0 statistical package.

Of the whole sample, 32 (10.7%) were obese and 35 (11.7%) were overweight, according to the criteria of Cole et al. [6], and there were no statistically significant differences between boys and girls, although a linear increase in the percentage of obesity with age was seen (Table 1). Analysis of the carrier state of *N. meningitidis* showed there to be 20 carriers, of whom 12 were boys and 8 girls. The gender-related risk of carrier state was 0.81 (95% confidence interval [CI]: 0.32–2.02).

We calculated the risk of *N. meningitidis* carrier status according to age group and found that, among those aged under 3 years, it was 11.5% (95% CI: 4.7–22.2), among those aged 3–7 years, it was 4.1% (95% CI: 1.1–10.1), and in those aged over 7 years, it was 5.6% (95% CI: 2.6–10.4).

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Table 1 Analysis of the risk of carrier state of *Neisseria meningitidis*, stratified by age groups and body mass index (BMI) in the three categories of normal, overweight and obese, taking as a reference the normal BMI

Age		BMI			
		Normal	Overweight	Obese	Total
<3 years	Carriers	6	0	1	7
	Non-carriers	47	6	1	54
	Test for trend: z=0.75; P=0.45				
3–7 years	Carriers	0	0	4	4
	Non-carriers	82	3	9	94
	Test for trend: z=5.03; P=0.0001				
>7 years	Carriers	6	3	0	9
	Non-carriers	103	26	22	151
	Test for trend: z=0.52; P=0.60				
All ages	Carriers	12	3	5	20
	Non-carriers	232	35	32	299
	Crude risk	–	1.6 (0.5–5.4)	2.75 (1.0–7.4)	
	Test for trend: z=2.03; P=0.04				
Mantel–Haenszel adjusted risk		–	1.3 (0.4–4.6)	3.6 (1.3–9.9)	
	Corrected test for trend: z=2.38; P=0.01				

We also assessed the influence of BMI for the three age groups defined above (normal BMI, overweight and obese). We took as a reference category the subjects who were not overweight and performed a trend analysis stratified by age, the results of which are shown in Table 1. There was found to be a statistically significant trend towards increased risk of *N. meningitidis* carrier state with increased BMI (z=2.03; P=0.04). After adjusting for age using the Mantel–Haenszel weighting method, this ratio increased (z=2.38; P=0.01). From the risk evaluation, we conclude that the risk of *N. meningitidis* carrier state among obese children is three times higher than among those who were not overweight (95% CI: 1.3–9.9).

According to the results obtained in the present study, and to our review of the present state of knowledge, it can be concluded that paediatric patients with raised BMI, in the range of obesity, present a three times higher risk of being carriers of *N. meningitidis* than non-obese patients, and this risk tends to increase with increasing BMI. Overweight, obesity and, in general, increased adiposity have been identified as factors that favour lipoperoxidation, increased oxidative stress and inflammation [2]. Our previous study [7] has shown that there is a decrease in the total antioxidant capacity of plasma in children who are carriers of *N. meningitidis*. This fact led us to consider the hypothesis that children who are carriers of *N. meningitidis* present an oxidative balance that is favourable to pro-oxidants, with a compensatory consumption of antioxidant molecules. This situation seems to occur frequently among obese children, who present increased peroxidation of the adipose tissue and among whom the redox balance is biased towards pro-oxidants [8].

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