

Saturated fat in the diet of Spanish children: relationship with anthropometric, alimentary, nutritional and lipid profiles

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Abstract

Objective: To compare the anthropometric, alimentary, nutritional and lipid profiles and global diet quality of Spanish children according to saturated fat intake.

Design: This was a cross-sectional study. Food data were collected using a food-frequency questionnaire.

Subjects and methods: The sample included 1112 children of both sexes, aged between 6 and 7 years, selected by means of random cluster sampling in schools. The plasma lipid profile included measurements of low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides, apolipoprotein A1 (apoA1) and apolipoprotein B (apoB). Global diet quality was evaluated by the Dietary Variety Index (DVI) and the Healthy Eating Index (HEI).

Results: Energy intake, DVI and HEI of children from the lower quartile of saturated fat intake (LL) were higher ($P < 0.01$) than in the remaining children (UL). However, there were no significant differences in average height or weight between groups. The UL children had lower intakes of meat, fish, vegetables, fruits and olive oil and a higher intake of dairy products ($P < 0.001$). The intakes of fibre, vitamins C, D, B₆, E and folic acid were higher in the LL children, who had lower intakes of vitamin A and calcium. The ratios LDL-C/HDL-C and apoB/apoA1 were lower ($P = 0.04$) in the LL children (1.87 and 0.52, respectively) than in the UL children (2.02 and 0.54, respectively).

Conclusions: The growth rate of children does not seem to be affected by the level of saturated fat intake. Furthermore, at the levels of intake observed in this study, diets with less saturated fat are associated with better alimentary, nutritional and plasma lipid profiles.

Keywords
Children
Nutrients
Diet
Dietary surveys
Fatty acids

In adults, the consumption of saturated fatty acids (SFA) induces an increase in plasma low-density lipoprotein cholesterol (LDL-C) levels and is associated with greater cardiovascular risk. Furthermore, it seems that substituting this type of fat with unsaturated fatty acids is a more effective means of preventing cardiovascular risk factors than reducing total fat intake¹. Consequently, while it is agreed that SFA intake should be less than 10% of total energy intake, in the case of total fat intake the upper limit

recommended by various societies and organisations ranges from 30 to 35%^{2–5}.

The association between SFA and plasma cholesterol levels in children is similar to that observed for adults⁶. Nevertheless, the small magnitude of this association and the negative results in some studies have given rise to doubts about its possible clinical significance for children^{7–9}. On the other hand, given the complexity of carrying out studies that evaluate the effectiveness of different diets in children to prevent them from developing atherosclerosis as adults, the possible relationship between saturated fat intake in children and later cardiovascular risk is based on indirect evidence. Nevertheless, the American Academy of

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Pediatrics recommends, based on this evidence, that children aged 2 to 18 years keep intakes of saturated fatty acids and total fat below 10% and 30% of energy intake, respectively¹⁰. While the majority of experts recommend energy intake of SFA below 10% of total intake in children aged 2 years and above, there is less agreement on restricting total fat intake in this population^{11–14}.

Although some intervention studies show that reducing fat intake in the child population does not negatively affect growth rate or nutritional intake^{15–17}, these diets with less fat have been applied in controlled conditions and with intensive medical supervision. On the other hand, there is evidence that, in normal conditions, this type of diet can be associated with delayed growth-for-age and lower intakes of certain micronutrients^{18,19}. In this context, studies that analyse the nutritional status of children with lower fat intake can provide additional relevant information about the safety of this type of diet.

The objectives of the present study, which analysed the diet of school-age children from four provinces with differing demographic and sociocultural characteristics, were to examine the diet quality and anthropometric, dietary, nutritional and lipid profiles of those children with lower saturated fat intake (lowest quintile of SFA intake) and to compare them with data from the remaining children.

Material and methods

Study subjects

We selected representative samples of schoolchildren, aged 6–7 years, in four regions in Spain (Cadiz, Madrid, Orense and Murcia) over the period 1998–1999. These regions were chosen mainly because of the large difference in cardiovascular mortality between them. More detailed information about the design of the study is available in previous publications^{20,21}.

Children were selected by means of random cluster sampling in schools, and stratified by sex and type of school (i.e. public vs. private). Type of school was an indicator of socio-economic level. Sampling was carried out in two stages. In the first stage, schools were selected from lists supplied by the regional educational authorities. In the second stage, classrooms and pupils were selected. In each region six schools were selected. Approximately 50 children were invited to participate in each school. All children reported by parents to be suffering from metabolic, endocrine, liver or kidney disorders were excluded, to rule out any possible alteration in the values of the variables of interest.

The study protocol complied with Helsinki Declaration guidelines and Spanish statutory provisions governing clinical research on humans²², and was formally approved by the Clinical Research Ethics

Committee of the Jiménez Díaz Foundation in Madrid (Spain).

Data collection and study variables

The study was presented orally to the board of governors (Consejo Escolar) of each of the schools. Following this, a letter was circulated to the parents of all children invited to participate in the study, outlining the study goals and procedures, and securing their written authorisation. In addition, this same letter urged all parents to seek the necessary consent from their children.

Food and nutritional data

At each school, data were collected by a field team comprising a physician, a nurse and a group of persons purpose-trained in the use of a food-frequency questionnaire (FFQ), who conducted the survey and obtained the information from the children's mothers or the people responsible for their food.

The FFQ, initially developed for use on adults and previously validated in Spain by Martín-Moreno *et al.*²³, was adapted for a primary-school population by amending and downscaling the list of foods and portions consumed, eliminating alcoholic beverages and including some foods frequently found in a child's diet (e.g. pizzas, hamburgers, etc.). These amendments were based on a recent, systematic, in-depth review of child-population food surveys in Spain²⁴. The final version of the FFQ included a total of 77 food items grouped under 11 headings by affinity in nutrient content. For each food, the usual size of the serving eaten was defined (e.g. 1 cup of milk equivalent to 170 ml; a dish of lentils equivalent to 60 g dry weight) and the mean frequency of consumption of such servings over the previous year ascertained. The FFQ provided five consumption frequency ratings (never, annually, monthly, weekly and daily). Standard Spanish food composition tables were used to convert the foods into nutrient and total energy intakes for each of the subjects included in the study^{25,26}.

Anthropometric variables

Measurements were taken with the children lightly dressed and barefoot. Height was measured to the last millimetre using a portable stadiometer, and weight was measured to the last 0.1 kg using a standardised electronic digital scale. From these measurements, body mass index (BMI; weight in kilograms divided by the square of the height in metres, kg m^{-2}) was then computed. The prevalence of overweight and obese children was calculated as the percentage of children exceeding BMI cut-off points proposed in a recent synthesis of international studies²⁷.

Biochemical data

Fasting (12h) venous blood samples were obtained by venepuncture into Vacutainer[®] tubes containing

ethylenediamine-*N,N,N',N'*-tetraacetic acid. Samples were kept on ice and sent to the study's central laboratory for analysis. Once centrifuged, the fractions were separated and frozen at -70°C . Cholesterol and triglycerides were measured enzymatically (Menarini Diagnostics, Italy) with an RA-1000 Autoanalyzer. The cholesterol bound to high-density lipoproteins (HDL-C) was determined after precipitation of lipoproteins containing apolipoprotein B (apoB) with phosphowolframic acid and magnesium (Boehringer Mannheim, Germany). The cholesterol bound to low-density lipoproteins (LDL-C) was calculated using the Friedewald formula.

Dietary variety and overall dietary quality indices

A Dietary Variety Index (DVI) was calculated using the number of different types of foods (items of the questionnaire) eaten more than once a month²⁸. Similar foods were grouped as one single item for their evaluation as a component of dietary variety²⁹. For example, whole milk and 1%-fat milk were grouped in the same item, as were roast, boiled or fried potatoes. Thus, the final number of items was 72. Overall dietary quality was assessed using the Healthy Eating Index (HEI)^{30–32}. This index consists of 10 items: the first five measure food groups (cereals, vegetables, fruit, dairy products and meat); the following four measure nutrients (total lipid, saturated fat, cholesterol and sodium); and the last one analyses dietary variety. For each HEI item, a value is established for which the minimum score (0 points) is obtained and another for which the maximum score (10 points) is obtained; between these two values, the score is obtained on a proportional basis. The total score, which can range between 0 and 100, is obtained by adding up the individual scores for the 10 items; the higher the score, the better the diet quality. One of our objectives was to evaluate the nutritional quality of the diet of children with a lower saturated fat intake. Given that the HEI includes saturated fat, total lipid and cholesterol intakes, we removed these three components from its calculation before comparing global diet quality between the two groups (low and high saturated fat intake). Thus, we have tried to avoid distorting effects from the fact that components of the independent variable (saturated fat intake) form a part of the dependent variable (HEI).

Statistical analysis

A *t*-test analysis or the Wilcoxon ranges sum, depending whether the variable had a normal distribution or not, was used to compare the mean values between groups. The comparisons were also made, adjusting for region, type of school and total energy intake³³, through analysis of covariance. Statistical analyses were performed using the Statistical Analysis System computer software package³⁴.

Results

The response rate was 85%, consistently in the four cities. The sample group was made up of 1112 individuals, 557 (50.1%) boys and 555 (49.9%) girls, with an average age of 6.7 years. Keeping in mind that only 0.4% of the children had SFA intake less than 10% of their total energy intake, the sample was divided into quintiles of SFA intake. The children in the lower quintile (<14.5% energy intake from SFA) formed the reference group (lower SFA intake level: LL) and the rest of the children formed the comparative group (upper SFA intake level: UL). In the low SFA intake group the percentage of girls (57.7%) was higher than that of boys (42.3%). Nevertheless, with the exception of plasma lipid levels, for which the differences between groups were slightly more pronounced in girls, no important gender differences were observed. Similar findings were observed when the results were stratified by region and type of school (data not shown). Also the results did not vary significantly when adjusting for total energy intake. This is why the tables present the results of our analysis for all of the subjects without adjusting for energy intake.

Although average daily energy intake was 230 kcal (~960 kJ) greater in children from the LL group, no differences were found between the groups in terms of weight, height or BMI. The percentage of overweight and obese subjects was slightly higher in the LL group but this was not statistically significant. The DVI and HEI scores of the LL children were also higher than those of the UL children ($P < 0.01$ and $P < 0.001$, respectively) (Table 1).

Regarding food intake, the LL children presented lower intakes of dairy products, eggs and baked goods, although the differences were statistically significant only in the case

Table 1 Demographic and anthropometric characteristics according to percentage of energy from saturated fatty acids (SFA)

	SFA intake		<i>P</i> -value
	Lower (≤ 14.5)	Upper (> 14.5)	
<i>n</i>	222	890	
Gender (%)			
Boys	42.3	52.0	0.01
Girls	57.7	48.0	0.01
Age (years)	6.8	6.7	0.36
Energy			
(kJ day ⁻¹)	9670	8708	<0.001
(kcal day ⁻¹)	2313	2083	<0.001
Weight (kg)	26.9	26.7	0.54
Height (cm)	125.4	125.4	0.97
BMI (kg m ⁻²)	17.0	17.0	0.79
Overweight (%)	21.3	18.5	0.24
Obesity (%)	13.4	11.6	0.24
DVI	42.9	41.8	0.01
HEI*	56.4	53.9	<0.001

BMI – body mass index; DVI – Dietary Variety Index; HEI – Healthy Eating Index.

* The HEI does not consider relative scores for total cholesterol and total and saturated fat intake.

of dairy products (470.8 ml vs. 666.7 ml; $P < 0.001$). The UL children had lower intakes of meat products ($P < 0.001$), sausages ($P < 0.001$), fish ($P < 0.001$), vegetables ($P < 0.001$), fruits ($P < 0.001$), cereals ($P < 0.001$), olive oil ($P < 0.001$) and carbonated beverages ($P = 0.14$). The most important differences were observed for vegetables (294.4 g in the UL group vs. 459.3 g in the LL group) and fruits (292.7 g vs. 423.4 g) (Table 2).

From Table 3 we can see that the nutritional profile of the LL children was closer to nutritional guidelines than that of the UL children. The ratio unsaturated fatty acids/SFA and intakes of carbohydrates and fibre were higher in LL group children than in those from the UL group. UL group children showed higher intakes of lipids, proteins and cholesterol ($P < 0.001$ in all cases). Although vitamin A intake and calcium intake were lower in the children from the LL group, mean values in this group (1429.7 mg and 644.8 μg) were higher than the recommended intake by 61.2% and 78.7%, respectively. The intakes of potassium and of the other vitamins studied (C, D, B₆, E and folic acid) were higher in children from the LL group, and their mean level in this group was higher than the recommended intake in all cases except vitamin B₆.

As can be seen from Table 4, children from the LL group showed slightly higher HDL-C ($P = 0.09$) and apolipoprotein A1 (apoA1) ($P = 0.05$) levels and lower LDL-C levels ($P = 0.04$). The ratio LDL-C/HDL-C was lower ($P = 0.04$) in the LL group, as was the ratio apoB/apoA1 ($P = 0.04$).

Discussion

The children with a lower saturated fat intake had a superior quality of diet as assessed according to its variety

and the HEI. Compared with the UL children, the LL children showed a higher consumption of fruits and vegetables, legumes, meat, fish and olive oil and a lower consumption of dairy products. From a nutritional point of view, the LL children showed a lower consumption of fat, proteins and cholesterol and higher intakes of carbohydrates and fibre. While vitamin A and calcium intakes were lower in the LL children, the intakes of potassium and the other vitamins studied (C, D, B₆, E and folic acid) were higher in this group. The plasma indicators for cardiovascular risk, specifically LDL-C/HDL-C and apoB/apoA1, were slightly lower in LL children than in UL children.

Energy intake was clearly higher in LL children, in contrast with the results of other studies^{9,35,36}. There were no differences between the two groups in height, weight or BMI, which is consistent with the results of most other studies^{8,9,16,17}. In spite of this, the higher percentage of overweight and obese children in the LL group may be due to their higher energy intake. Epidemiological evidence about the relationship between fat intake and obesity is highly inconsistent³⁷. Therefore, it is surprising that the decrease in the percentage of energy from fat found in children in the USA between 1987 and 1995 was accompanied by a fat intake that remained the same or increased slightly and by increases in total energy intake and the prevalence of obesity³⁸. These results seem to indicate that the important factors are the absence of regular physical activity combined with excessive energy intake, whether or not this energy comes from fat or carbohydrates³⁷.

The LL children had an HEI score that was 2.5 points higher than that of the UL children. This is comparable to the results of a study with 5- to 7-year-old American girls divided in two groups according to whether or not their

Table 2 Food intake* relative to percentage of energy provided by saturated fatty acids (SFA)

	SFA intake		P-value
	Lower (≤ 14.5)	Upper (> 14.5)	
Dairy products	470.8 (446.8–494.8)†	666.7 (649.7–683.7)	<0.001
Eggs	17.2 (16.1–18.3)	18.5 (17.8–19.2)	0.20
Meat	104.7 (99.6–109.8)	93.7 (91.1–96.4)	<0.001
Poultry	25.5 (23.8–27.3)	24.6 (23.7–25.4)	0.33
Sausages	41.9 (38.4–45.6)	34.6 (33.3–36)	<0.001
Fish	51.5 (44.0–59.1)	41.5 (39.9–43)	<0.001
Blue fish	19.8 (17.6–21.9)	17.3 (16.4–18.2)	0.04
Vegetables	459.3 (419.7–499)	294.4 (283.2–305.6)	<0.001
Fruits	423.4 (389.1–457.7)	292.7 (281.0–304.4)	<0.001
Legumes	22.9 (15.6–30.4)	16.6 (15.8–17.5)	0.11
Cereals	158.3 (148.7–167.8)	136.0 (132.0–140.0)	<0.001
Olive oil	24.6 (23.7–25.6)	19.9 (19.2–20.6)	<0.001
Baked goods	57.4 (50.5–64.3)	60.6 (56.7–64.4)	0.43
Added salt	1.98 (1.84–2.12)	1.94 (1.87–2.01)	0.62
Carbonated beverages	51 (36.1–65.9)	45 (39.9–50.2)	0.14
Natural juices	96 (79.3–112.7)	94.3 (87.4–101.3)	0.83

* In g day^{-1} or ml day^{-1} .

† Values in parentheses are 95% confidence intervals.

Table 3 Nutritional intake relative to percentage of energy provided by saturated fatty acids (SFA)

	Recommendation	SFA intake		P-value
		Lower (≤ 14.5)	Upper (> 14.5)	
SFA	$\leq 10\%$	13.2 (13.1–13.4)*	17.6 (17.4–17.7)	< 0.001
MUFA	15–20%	17.3 (17–17.7)	18.5 (18.4–18.7)	< 0.001
PUFA	$\leq 8\%$	8.4 (8.2–8.6)	8.3 (8.2–8.4)	0.27
Fats	$\leq 35\%$	43.4 (42.8–43.9)	46.6 (46.3–46.9)	< 0.001
UFA/SFA	≥ 2	1.95 (1.91–1.99)	1.55 (1.53–1.56)	< 0.001
Cholesterol	$< 200 \text{ mg day}^{-1}$	322.1 (304.2–340)	364.9 (356.2–373.6)	< 0.001
Carbohydrates	55–60%	42.5 (41.8–43.2)	37.2 (36.8–37.6)	< 0.001
Protein	10–13%	15.9 (15.6–16.2)	17.5 (17.4–17.7)	< 0.001
Fibre	11–17 g day ⁻¹	24.8 (23.6–26)	18.5 (18.0–18.9)	< 0.001
Potassium	mg day ⁻¹	3602 (3447–3756)	3004 (2950–3057)	< 0.001
Calcium	800 mg day ⁻¹	1430 (1355–1504)	1612 (1573–1651)	< 0.001
Sodium	$< 2400 \text{ mg day}^{-1}$	2734 (2581–2879)	2733 (2671–2794)	0.40
Vitamin C	55 mg day ⁻¹	241.7 (226.3–257)	187 (182.1–191.9)	< 0.001
Vitamin B ₆	1.4 mg day ⁻¹	1.26 (1.20–1.32)	1.04 (1.01–1.06)	< 0.001
Folic acid	100 $\mu\text{g day}^{-1}$	238.8 (226.6–251.1)	199.7 (196.4–203.1)	< 0.001
Vitamin E	8 mg day ⁻¹	12.6 (11.9–13.3)	10.5 (10.3–10.7)	< 0.001
Vitamin A	400 $\mu\text{g day}^{-1}$	644.8 (618.3–671.2)	668.7 (656.4–681.1)	0.09
Vitamin D	5 $\mu\text{g day}^{-1}$	5.41 (5.13–5.69)	5.14 (4.98–5.29)	0.11

MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; UFA – unsaturated fatty acids.

*Values in parentheses are 95% confidence intervals.

total fat intake exceeded 30% of their total energy intake, although the magnitude of the difference (1.5 points) and the global HEI score were lower in the American study³⁶. In both studies, and in a study carried out with a sample of children in Madrid aged 2 to 6 years⁹, intakes of vitamins B₆, C and folic acid were higher in LL children. In the case of the American girls vitamin A intake was also higher in the LL group. However, in both the Madrid study and our own, vitamin A intake was lower in LL children. This difference could be due to the fact that, while dairy product intakes were similar for both groups in the American study, in the two Spanish studies it was found to be much lower in the LL group. Even so, the average vitamin A intake in both cases was well above the minimum recommended. These observations are consistent with the fact that, except for dairy products, the LL children have higher intakes of almost all food groups, particularly fruits and vegetables, as has been previously observed^{9,39}.

While intervention studies are fairly consistent with these results, perhaps because of the strict supervision of their subjects, observational studies are not. In a nutritional educational study carried out with 4- to 10-year-old-children, the children who most reduced their fat intake had lower intakes of vitamins D and E and lower consumption of dairy products, fatty foods and oils⁴⁰. In our study, as in the Madrid study⁹, the intakes of vitamins D and E were higher in the LL children. Although the LL children consumed fewer dairy products, these differences could be explained because the consumption of blue fish and olive oil – foods rich in vitamin D and E, respectively – was higher in this group. Likewise, a British study including 18- to 43-month-old children did not observe differences in vitamin D and E intakes according to the percentage of energy intake from fat⁴¹. In this case, children from the lowest quartile of fat intake showed a similar consumption of oils and a higher consumption of fish than the rest. In the Bogalusa Study, the percentage of

Table 4 Plasma lipid concentrations relative to percentage of energy provided by saturated fatty acids (SFA)

	SFA intake		P-value
	Lower (≤ 14.5)	Upper (> 14.5)	
Cholesterol (mg dl ⁻¹)	180.9 (176–185.9)*	183.5 (181.3–185.7)	0.16
HDL-C (mg dl ⁻¹)	60.5 (58.1–62.9)	58.4 (57.4–59.5)	0.09
LDL-C (mg dl ⁻¹)	105.8 (102.2–109.3)	110.6 (109.3–111.8)	0.04
LDL-C/HDL-C	1.87 (1.78–1.96)	2.02 (1.96–2.09)	0.04
Triglycerides (mg dl ⁻¹)	74.5 (70.4–78.6)	72.9 (71.0–74.8)	0.46
ApoA1 (mg dl ⁻¹)	137.6 (134.4–140.7)	134.1 (132.6–135.6)	0.05
ApoB (mg dl ⁻¹)	70.7 (68.1–73.4)	71.2 (70.0–72.4)	0.40
ApoB/apoA1	0.52 (0.50–0.53)	0.54 (0.53–0.55)	0.04
Glucose (mg dl ⁻¹)	91.3 (89.3–93.3)	90.2 (89.5–90.9)	0.89

HDL-C – high-density lipoprotein cholesterol; LDL-C – low-density lipoprotein cholesterol; apoA1 – apolipoprotein A1; apoB – apolipoprotein B.

*Values in parentheses are 95% confidence intervals.

children who did not reach the minimum recommended intake of vitamins B₆, B₁₂ and E, thiamine, riboflavin and niacin was significantly higher among children with a fat intake lower than 30% of total intake³⁵. On the other hand, in a study carried out in Oslo with 8- to 12-year-old children, those for whom less than 30% of energy intake was from fat showed higher nutritional density of thiamine, niacin, folic acid and vitamin C³⁹. For children in the LL group of our study, total fat intake was 43.4% of the total energy intake. Thus we do not know if the nutritional profile observed will be maintained with intakes below 30%.

The lower intakes of dairy products and calcium in the LL children were consistent with those observed in other studies^{9,35,40,42}. Although calcium intake in LL children was well above the recommended intake, we do not know if this would be same if they followed a diet with a lower content in saturated fat. Besides, whole milk was the most important source of SFA for the children in our study (14.9% of SFA intake)⁴³. Consequently, a prudent and effective strategy to reduce saturated fat intake would be the substitution of whole dairy products with skimmed milk products⁴⁴. This approach has shown its efficacy in the US child population and could easily be applied in Spain, where the consumption of low-fat dairy products among children is very low²¹.

Even though some observational studies do not find any association between fatty acid intake and plasma cholesterol levels in children⁷, others observe that this relationship follows the same patterns as in adults^{6,8}. These observations have been confirmed by several interventional studies carried out in children, which show that the reduction of total or saturated fat intake induces a decrease in plasma cholesterol levels, particularly LDL-C^{45,46}. In the only clinical trial in which differences in plasma cholesterol levels between groups were not observed, the intervention produced a very small reduction in total fat in the intervention group compared with the control group, and this reduction affected all fat components (saturated and unsaturated) equally¹⁵. Besides, the changes observed in plasma cholesterol levels in Spanish children over the last few years coincide with the expected theoretical values according to the observed tendencies in fatty acid intake⁴⁷. Our results were as expected, with statically significant differences for LDL-C, LDL-C/HDL-C and apoB/apoA1, indicators considered among the best markers of cardiovascular risk in adults. These observations contrast with the results of a study carried out in Spanish children in Madrid⁹; however, children in that study were around 4 years old and the method for the evaluation of diet was different. However, the STRIP study (The Special Turku Coronary Risk Factor Intervention Project), with an intervention conducted to reduce fat intake and cholesterol, achieved reductions of between 3 and 5% for total cholesterol and LDL-C levels maintained for between 7 months and 5 years⁴⁶.

In conclusion, the growth rate of children does not seem to be affected by the level of saturated fat intake. Furthermore, in the ranges of intake observed in this study, diets with less saturated fat were associated with better alimentary, nutritional and plasma lipid profiles. However, considering the high intake of saturated fat in the population studied, it would be necessary to replicate this study on children with lower saturated fat intakes to ensure that the benefits observed are maintained when the recommended SFA intake levels are achieved.

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