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Application of a Rapid Dark Adaptation Test in Children

Noel W. Solomons, Robert M. Russell, Elizabeth Vinton,
Aura-Marina Guerrero, and Luis Mejia

Institute of Nutrition of Central America and Panama, Guatemala City, Guatemala; Veterans Administration Medical Center, University of Maryland School of Medicine, Baltimore, Maryland; and The Department of Nutrition and Food Science, Massachusetts Institute of Technology, Cambridge, Massachusetts

Summary: The rapid dark adaptation test (after Thornton) has been shown to correlate with classical dark adaptation test results and vitamin A nutriture in adults. Using this test, 27 children in Guatemala (aged 5–12 years) and 18 children in Baltimore (aged 4 and 5 years) were studied. Plasma for vitamin A and zinc analysis was obtained from the Guatemalan children and dietary histories were obtained from the parents of the Baltimore children. All but two children (ages 4 and 5) were able to complete the study. For the Guatemalan group, the mean time to complete the test was 144 s, and for the Baltimore group, 171 s. Rapid dark adaptation test performance was significantly correlated to the dietary intake of vitamin A by a logarithmic model, $p < 0.05$. The rapid dark adaptation test appears to be acceptable for use in childhood populations and could complement biochemical determination of vitamin A and/or zinc in clinical settings, field surveys, and research. **Key Words:** Dark adaptation—Visual testing—Vitamin A deficiency—Zinc deficiency—Night blindness.

Night blindness occurs as an early symptom of Vitamin A deficiency. Recent evidence indicates that zinc deficiency can also cause night blindness (1,2). The corresponding clinical sign—impaired dark adaptation—can be quantified by formal dark adaptometry (3), but the procedure is tedious and is unlikely to be acceptable to most parents or to be tolerated by most children, especially young children. Sommer et al. have recently suggested that a culturally based history from the parents can elicit verification of night blindness (4); its applicability, however, may have cultural limitations.

Recently, a rapid procedure for assessing dark adaptation has been developed by Thornton (5) and validated for nutritional assessment of adults by Vinton and Russell (6). The procedure requires about 10 min and is interactive like a game. The present collaborative study was undertaken in Baltimore, MD and Guatemala City to determine the acceptability, quality of performance, and nutritional correlates of the rapid dark adaptation test (RDAT) in healthy, free-living children.

Address correspondence and reprint requests to Dr. Russell at USDA Human Nutrition Research Center, 15 Kneeland Street, Boston Massachusetts 02111.

MATERIALS AND METHODS

A total of 45 children, ranging from ages 4 to 13 years, participated in the combined series; 25 were male, 20 were female. Eighteen children (11 males and seven females; aged 4 and 5 years) in a day school setting were enrolled in Baltimore. Twenty-seven subjects (14 males and 13 females; aged 5–12 years) were studied in Guatemala at the Institute of Nutrition of Central America and Panama (INCAP). All children had normal ophthalmoscopic examination and a corrected visual acuity of at least 20/100.

The tests were modifications of the procedure of

Thornton (5). They were based on the retinal Purkinje shift, a physiological phenomenon whereby the sensitivity of the retina shifts from the red toward the blue end of the visual spectrum during the early phase of dark adaptation (5) and involves the timed, sequential separation of white, blue, and red disks from a black surface in dim illumination. Scoring is based on the total time taken to separate correctly the blue disks from the surface. A preliminary warm-up trial was allowed. In Guatemala, the numerical score was the arithmetic mean of the two best attempts among the three post–warm-up trials; in Baltimore, the time recorded was for a single valid (post–warm-up) trial. All tests were carried out in the morning.

In Guatemala, the procedure was identical to that originally described by Thornton (5) using poker chips, only the time of preadaption to light was 120 s at 45 cm from an X-ray view box. In the Baltimore series, the procedure was identical to the one used in adults (6). Special cone-matched red and blue Munsell color disks were used (wavelengths 605 and 475 μm, respectively), illumination was set to emit at the surface 6.8×10^3 candela/m^2 (6), and pretest retinal bleaching was accomplished by having the test subject stare at a lighted portable X-ray view box at 0.5 cm for 1 min. The young children were first instructed by the operator (EV) in the playroom to familiarize themselves with the procedure with a warm-up trial in full daylight. The darkroom was a play cave in the playroom, entered via a ladder.

In Baltimore, a food frequency history based on customary intake of vitamin A/carotene-rich foods and vitamin supplements was taken from parents by a registered dietitian. The vitamin A and provitamin A content of the diets were estimated using food tables (7). In 24 subjects in Guatemala, a 4-ml sample of whole blood was taken from an antecubital vein with a plastic syringe and anticoagulated with 0.05 ml of 20% potassium oxalate, using procedures to minimize trace-mineral contamination. Plasma zinc concentration was determined using a modification of the method of Sinha and Gabrieli (8). Vitamin A levels were measured by the method of Bessey et al. (9).

Data were analyzed using Pearson's correlation coefficient and computerized nonlinear regression models. As the procedures were not identical for both series, the absolute RDAT scores could not be combined or compared numerically.

RESULTS

All of the children in Guatemala were able to understand the instructions, manipulate the disks, and cooperate throughout the testing procedure. Of the 18 4- and 5-year-old children enrolled in Baltimore, 16 (89%) successfully performed the test. One Baltimore subject, a boy aged 5, played with the chips but did not comprehend the mission of the test; another, a girl aged 4, asked to be excused to return to the playroom.

Data are given in Table 1 and Fig. 1. For the Baltimore group, the geometric mean was 171 s; for the INCAP subjects, the geometric mean was 144 s. RDAT performance was significantly correlated with the dietary intake of vitamin A (Fig. 1): $r = 0.71$ by linear model; $r = 0.68$ by logarithmic model, $p < 0.05$. There was no correlation between the RDAT scores with either serum vitamin A or serum zinc among the Guatemalan children. None of the plasma zinc levels were below 70 μg/dl. One child had a plasma vitamin A concentration of 30.7 μg/dl.

DISCUSSION

Clinical signs of hypovitaminosis A cannot be used to detect early vitamin A deficiency. Moreover, serum vitamin A levels are uncertain indicators of deficiency in individual subjects because of the wide range of "borderline values" where vitamin A-dependent rod function may or may not be affected (3). Since night blindness may result from other nutrient deficiencies (i.e., zinc, vitamin C, riboflavin) (1,10), dark adaptation testing alone also cannot be employed to diagnose vitamin A deficiency. We have used the serum vitamin A value coupled with dark adaptation testing to diagnose vitamin A deficiency. We have found this combined approach to be useful in sick adults because of the higher serum vitamin A values which are necessary for the maintenance of normal rod function (3).

The RDAT, based on the Purkinje effect and involving the separation of colored disks, was developed and validated in adults (5,6). Vinton and Russell (6) showed a high correlation between RDAT scores and both rod-cone break times and final dark-adapted thresholds as determined by formal Goldmann-Weekers dark adaptometry. The present studies suggest that the RDAT is applicable in children as well, and that valid scores can be obtained in a high percentage of children even as young as 4

TABLE 1. *Age, sex, rapid dark adaptation score (RDAT), and nutritional data in 27 normal children in Guatemala*[a]

Subjects	Age (yr)	Sex	RDAT score (s)	Plasma zinc (μg/dl)	Plasma vitamin A (μg/dl)
CSC	5	F	122.5	87.8	32.3
WMO	6	F	87	97.4	40.9
CCM	6	F	207.5	98.0	38.7
CAG	6	M	151	102.0	40.9
MS	6	F	174.5	95.9	36.6
AYC	6	F	164	—	—
LEC	6	M	162.5	—	—
WP	7	M	178	83.9	33.4
DP	8	F	163.5	88.4	40.9
WOC	8	M	142.5	94.7	40.9
LMD	8	F	176.5	104.0	39.8
MVC	8	M	159	—	—
CAE	9	M	99	75.6	49.5
MS	9	M	130.5	96.3	38.7
PL	9	M	109.5	100.4	36.6
BS	9	M	137	100.0	51.7
CP	10	F	131	77.8	33.7
OMU	10	M	95.5	83.9	43.0
CMC	10	F	207	90.7	26.9
CYM	10	F	132.5	81.1	32.3
KD	11	F	122	86.5	48.4
BP	11	M	102.5	85.4	30.7
KRR	11	F	143	99.0	41.9
RGL	11	F	145.5	76.0	37.7
OOR	12	M	95.5	103.7	41.9
LTR	12	M	278.5	94.1	49.5
JRL	12	M	216	89.7	44.1

[a] Using a close approximation of the original test of Thornton (5).

years old. The test is acceptable in both Spanish-speaking and English-speaking cultural settings. The procedures differed between centers, but internal comparisons with adults at each institution are revealing. In Baltimore, the time to perform the test ranged from 101 to 300 s, compared to 93–284 s for healthy adults aged 20–39 years at the same center (6). In Guatemala, scores for children ranged from 87 to 278 s, compared to a range of 71–426 s for 75 healthy adults aged 13–39 years (unpublished data).

No significant correlations between RDAT scores and either plasma zinc or vitamin A levels were observed in the Guatemalan children. We would expect a correlation between impaired dark adaptation and serum vitamin A levels in vitamin A-malnourished children as shown previously in adults (6); but, as our subjects were healthy individuals, our results were not unanticipated. It was interesting and provocative that in the Baltimore series, again with normal children but of poor economic background, a gradation of RDAT scores with vitamin A intake was observed. Studies are now being carried out to evaluate the RDAT test in

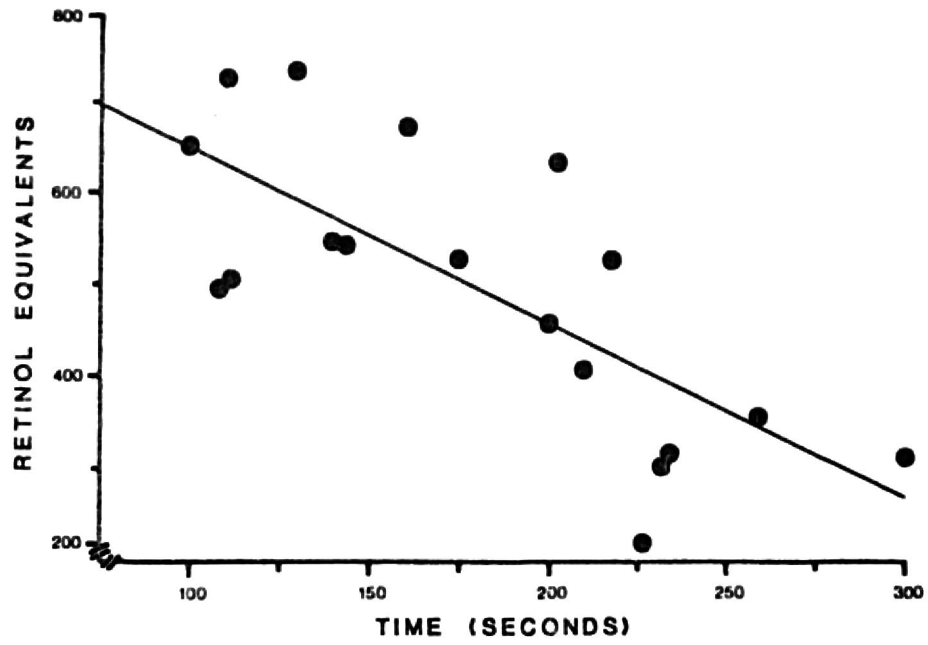

FIG. 1. Dietary intake of retinol equivalents plotted as a function of time to complete the rapid dark adaptation test (RDAT) in 16 Baltimore children ages 4 and 5.

children who are at high risk for vitamin A deficiency either because of poverty or because of disease. Correlations with serum vitamin A and serum zinc values will be determined from these studies.

The present study demonstrates the feasibility and acceptability of the RDAT in childhood populations. It may prove to be more quantitative as a screening test than the historical method introduced by Sommer et al. (4). The ten-state survey (11) found a high prevalence of low serum vitamin A levels in children of Mexican-American origin in southwestern United States. This was not the experience, however, when Chase et al. (12) reinvestigated vitamin A levels in Colorado. The RDAT could potentially complement biochemical determinations in the setting. Although the RDAT should not be used alone to diagnose vitamin A deficiency, it could potentially complement biochemical determinations in clinical settings, field surveys, and research.

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