

Growth charts of Egyptian children with Down syndrome (0–36 months)

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بطاقات نمو الأطفال المصريين المصابين بمتلازمة داون: دراسة للحالات والشواهد
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الخلاصة: تصف هذه الدراسة للحالات والشواهد، منحنيات للنمو وسرعة النمو والطول ومحيط الرأس لـ 350 من الأطفال المصريين المصابين بمتلازمة داون (188 من الذكور و162 من الإناث) ممن تتراوح أعمارهم بين ساعة الولادة و36 شهراً. وقد لوحظ لدى المصابين بمتلازمة داون متغيرات نمو أقل مما لدى الأطفال الأسوياء الشواهد خلال السنوات الثلاث الأولى من حياتهم. ويعاني الأطفال المصابون بمتلازمة داون من نقص أكبر بوضوح في الوزن ولاسيما لدى الإناث منهم إذا توافقت ذلك بمرض قلبي خلقي (لدى 90 حالة) وذلك بالمقارنة بأقرانهم من غير المصابين بمرض قلبي خلقي. وخلال السنتين الأوليين كانت سرعة النمو بالنسبة للوزن ومحيط الرأس أعلى لدى الذكور. لقد كان لدى الذكور المصابين بمتلازمة داون سرعة في الطول أعلى بقليل مما لدى الشواهد خلال السنوات الثلاث الأولى من العمر.

ABSTRACT A study established growth and growth velocity curves for weight, length and head circumference in 350 Egyptian Down syndrome children (188 males and 162 females) from 0–36 months. Down syndrome children had poorer growth variables than normal healthy children through the first 3 years of life. Down syndrome children with associated congenital heart disease (90 cases) had significantly lower weight, especially in girls, compared with those without heart disease. In the first 2 years, growth velocity for weight and head circumference were higher in Down syndrome females than males, while growth velocity for length was higher in males. Down syndrome boys had slightly higher velocity of length than normal children in the first 3 years of life.

Les courbes de croissance des enfants égyptiens atteints du syndrome de Down (âgés de 0 à 6 mois)

RESUME Une étude a permis d'établir les courbes de croissance et de vitesse de croissance pour le poids, la taille et le périmètre crânien chez 350 enfants égyptiens, âgés de 0 à 36 mois, qui étaient atteints du syndrome de Down (188 garçons et 162 filles). Ces enfants avaient des variables de croissance inférieures à celles des enfants normaux en bonne santé pendant les trois premières années de la vie. Les enfants atteints du syndrome de Down qui présentaient une cardiopathie congénitale associée (90 cas) avaient un poids significativement plus faible, particulièrement les filles, que ceux ne présentant pas de cardiopathie. Au cours des deux premières années, la vitesse de croissance pour le poids et le périmètre crânien était plus élevée chez les filles atteintes du syndrome de Down que chez les garçons, tandis que la vitesse de croissance staturale était plus élevée chez les garçons. Les garçons atteints du syndrome de Down avaient une vitesse de croissance staturale légèrement plus élevée que les enfants normaux au cours des trois premières années de la vie.

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Introduction

Down syndrome (trisomy 21) is the most prevalent unbalanced chromosomal aberration seen in live births, with an incidence of 1 per 600 live births or 1 per 150 conceptions [1]. It results in moderate to severe mental retardation, high risk of congenital heart disease and other multiple malformations and/or various medical problems. These congenital malformations have a consistent effect on physical development [2]. Growth retardation is one of the cardinal features of Down syndrome, characterized by deficient prenatal growth, i.e. reduced by 0.5–1.5 standard deviations (SD) from normal control mean values, and extending postnatally through the end of growing at 3–5 years of age [3]. Progressive de-institutionalization of Down syndrome children and their integration into the community, with improved medical and psychological follow-up, have greatly changed their lives and lengthened their life span [4,5].

Although growth is influenced by biological and environmental factors, racial variations certainly have a major role. The publication of growth charts specifically for children with Down syndrome in various populations, e.g. American, Sicilian, Dutch and French [3,6–8], has drawn attention to the importance of constructing growth charts for Egyptian Down syndrome children. The potential benefits of growth charts include: growth monitoring to detect any deviation in growth patterns, evaluating the efficacy of measures aimed at promoting growth, providing reassurance to parents, evaluating the results of clinical research or intervention for individual patients and, finally, comparing their growth with that of the normal population.

This study aimed to establish growth curves for Egyptian children with Down

syndrome aged 0–36 months to investigate and characterize their size, monitor their growth and evaluate the effect of congenital heart disease on their growth pattern. The present study provides reference data (growth charts) for weight, length and head circumference for Egyptian children with Down syndrome covering the age range 0–36 months based on cross-sectional and longitudinal data.

Methods

The study was carried out between January 1999 and July 2001. The data for this study were based on 1700 observations of 350 Down syndrome children: 188 boys (53.7%) and 162 girls (46.3%) aged 0–36 months with free trisomy 21. All were cases referred to the Human Genetics Clinic at the National Research Centre for diagnosis, genetic counselling and/or attendance at early intervention and stimulation programmes. The data represent an unselected, therefore presumably unbiased, sample of children with Down syndrome in Egypt. The Down syndrome children were divided into 2 groups: group 1 was 260 children without congenital heart disease (143 males and 117 females) and group 2 was 90 children with congenital heart disease (45 males and 45 females).

Each patient underwent pedigree analysis, meticulous clinical examination and basic anthropometric measurements. Chromosomal analysis by G-banding technique, complete thyroid profile and electrocardiographic (ECG) examination were done in all patients. Patients with mosaic 21 or translocation and those with malabsorption, hypothyroidism or severe congenital heart disease were excluded. Down syndrome patients with associated mild and moderate congenital heart disease were included in

the study. Children with mild congenital heart disease had a single cardiac defect without pulmonary vascular involvement and did not require medication or surgery. Those with moderate congenital heart disease had more complex cardiac defects, often requiring digitals, while severe congenital heart disease consisted of serious anatomic heart lesions, e.g. tetralogy of Fallot. All studied Down syndrome children lived with their family members.

Growth measurements (weight, length, head circumference) were taken at 3-monthly intervals. Measurements were taken by trained physicians and a second person assisted in alignment and immobilization of the child during the measurements. Length was measured to the nearest millimetre using a recumbent length board infant measuring table. The weight was assessed by a sensitive balance scale to the nearest gram. Head circumference was measured to the nearest millimetre by a non-stretchable plastic tape taking the maximum occipitofrontal diameter. The recorded measurements for weight, length and head circumference represent a combination of cross-sectional and longitudinal data.

The data for Down syndrome children were compared with data obtained from measurements on normal healthy Egyptian children (2735 girls and 3315 boys) from birth to 36 months visiting Cairo hospitals over 1996–2000 (Egyptian growth charts, published by the Faculty of Medicine, Cairo University and the National Research Centre, Cairo, Egypt).

Growth curves for weight, length and head circumference comparing male and female Down syndrome cases (group 1) with normal children were plotted using polynomial curves. Baker and his co-workers found that polynomial curves adequately represent the growth pattern [9].

Growth velocities for weight, length and head circumference were calculated for 6-monthly intervals for group 1. The mean value for each age interval was subtracted from that for the subsequent age interval. Growth velocities for Down syndrome cases were compared with the growth velocities of normal children.

Statistical analysis of data was carried out, using SPSS software, version 6. Based on age and sex, the data were divided into monthly intervals since birth until 36 months. Descriptive statistics and percentiles (3rd, 50th, 97th) were estimated for weight, length and head circumference for each sex for group 1. Means and standard deviations were calculated for group 2. Student *t*-test was used to compare the mean of weight, length and head circumference at all age intervals between the 2 sexes, and between the 2 groups and the normal population. *P* values < 0.05 were considered significant.

Results

At birth, all Down syndrome children in the study showed lower mean anthropometric values than that of the normal children. For weight, length and head circumference the values were: -1.6 SD, -2.2 SD and -1.8 SD for boys, and -1.7 SD, -2.8 SD and -3.5 SD for girls respectively (Table 1).

Of the 90 Down syndrome patients with associated congenital heart disease (group 2), common atrioventricular canal was the most common congenital heart disease seen in 34.4% of our sample (31 cases), followed by ventricular septal defect in 26.7% (24 cases) and multiple cardiac anomalies in 13.3% (12 cases). These Down syndrome patients with congenital heart disease had significantly lower weight, especially in girls, than those with-

Table 1 Mean anthropometric measurements for Down syndrome children at birth compared with normal children

| Variable | Males | | | Females | | |
|-------------------------|--------------------|------|-------------|--------------------|------|-------------|
| | Down syndrome Mean | SD | Normal Mean | Down syndrome Mean | SD | Normal Mean |
| Weight (kg) | 2.97 | -1.6 | 3.90 | 2.86 | -1.7 | 3.80 |
| Length (cm) | 49.3 | -2.2 | 54.0 | 48.1 | -2.8 | 53.3 |
| Head circumference (cm) | 34.8 | -1.8 | 36.6 | 32.7 | -3.5 | 36.5 |

n = total number of children.

out congenital heart disease ($P = 0.02$) (Table 2).

In comparison with the normal population, patients with Down syndrome in group 1 and group 2 showed lower values of weight, length and head circumference. In boys of group 1, the mean weight, length and head circumference were reduced by 1.5 SD, 1.6 SD and 1.8 SD below the mean of the normal boys respectively. The girls showed a reduction of 1.6 SD, 1.7 SD and 1.8 SD below the mean of normal girls for weight, length and head circumference. Down syndrome boys of

group 2 showed mean values reduced by 2.8 SD, 2.2 SD and 1.8 SD for weight, length and head circumference respectively; the girls had reductions of 2.8 SD, 2.9 SD and 1.9 SD respectively.

Males and females of group 2 had significantly lower mean weight versus group 1 patients ($P = 0.03$ and $P = 0.02$ respectively). They also had lower values for mean length and head circumference but these were not statistically significant compared with group 1 (Table 2).

In all age stages, Down syndrome boys of group 1 and group 2 showed higher val-

Table 2 Mean anthropometric measurements for male and female Down syndrome children with and without congenital heart disease

| Variable | Down syndrome males | | | Down syndrome females | | |
|-------------------------|------------------------------------|--------------------------------|----------------|------------------------------------|--------------------------------|----------------|
| | No heart disease (<i>n</i> = 143) | Heart disease (<i>n</i> = 45) | <i>P</i> value | No heart disease (<i>n</i> = 117) | Heart disease (<i>n</i> = 45) | <i>P</i> value |
| Weight (kg) | 9.3 | 7.8 | 0.03* | 8.6 | 7.1 | 0.02* |
| Length (cm) | 73.8 | 71.9 | 0.50 | 70.8 | 68.5 | 0.30 |
| Head circumference (cm) | 43.7 | 42.0 | 0.06 | 42.1 | 41.3 | 0.40 |

n = total number of children.

* $P < 0.05$.

ues for weight, length and head circumference when compared with girls (Table 2). However, these values did not reach statistical significance.

Growth charts at the 3rd, 50th, and 97th percentiles from 0–36 months for male and female Down syndrome patients (group 1) were constructed and compared

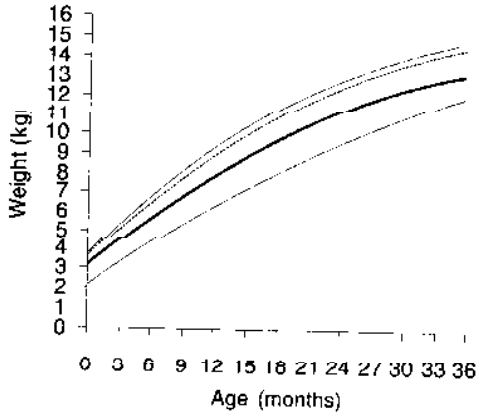


Figure 1 Weight growth charts (0–36 months) for males with Down syndrome (solid lines) compared with 50th percentile of normal Egyptian males (dotted line)

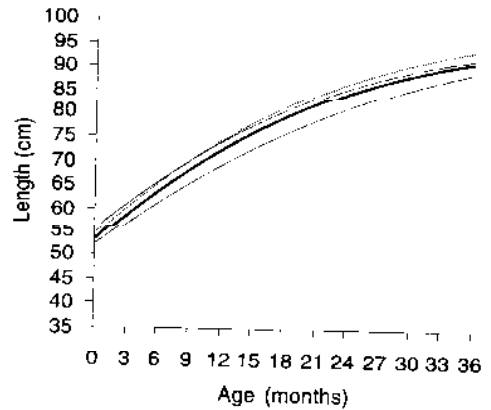


Figure 3 Length growth charts (0–36 months) for males with Down syndrome (solid lines) compared with 50th percentile of normal Egyptian males (dotted line)

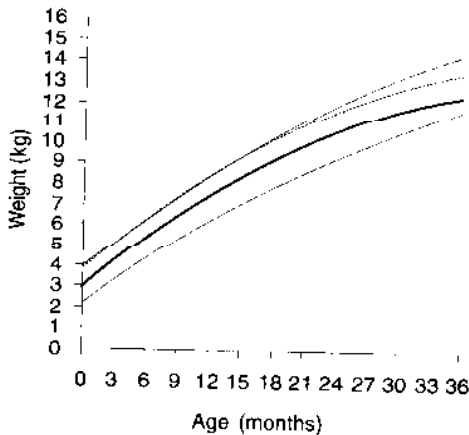


Figure 2 Weight growth charts (0–36 months) for females with Down syndrome (solid lines) compared with 50th percentile of normal Egyptian females (dotted line)

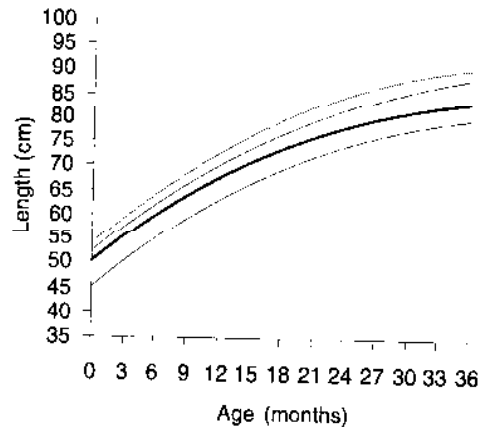


Figure 4 Length growth charts (0–36 months) for females with Down syndrome (solid lines) compared with 50th percentile of normal Egyptian females (dotted line)

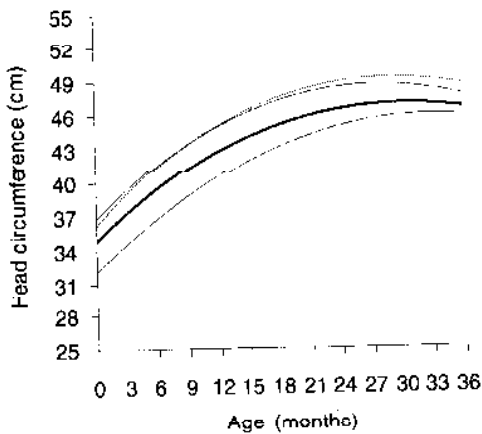


Figure 5 Head circumference growth charts (0–36 months) for males with Down syndrome (solid lines) compared with 50th percentile of normal Egyptian males (dotted line)

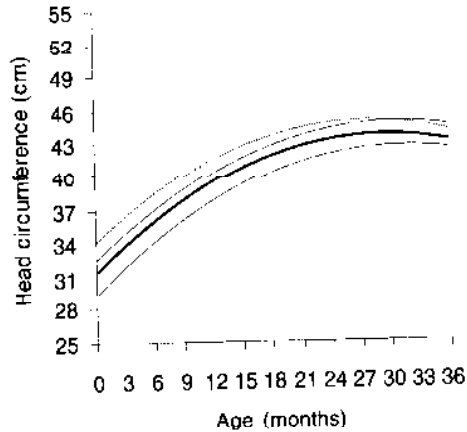


Figure 6 Head circumference charts (0–36 months) for females with Down syndrome (solid line) compared with 50th percentile of normal Egyptian females (dotted line)

with the 50th percentile for the normal group (Figures 1–6).

Growth velocity for Down syndrome girls (calculated for 6 monthly intervals) showed higher values of weight and head circumference versus Down syndrome boys. However, both sexes reached the same values by the end of the third year. Growth velocity of weight for Down syndrome cases was higher than the normal children until the 12 and 18 months of life in girls and boys respectively. Then it became lower until 24 and 33 months for girls and boys respectively (Figures 7 and 8).

Velocity of length for Down syndrome girls was lower than the normal group; however, the greatest deficiency was between 15 and 33 months (Figure 10). On the other hand, Down syndrome boys showed velocity of length slightly higher than the normal population at all age intervals (Figure 9).

Velocity of head circumference for Down syndrome girls showed higher val-

ues than the normal group until age 12 months. Then it was lower until 24 months and, after that it showed higher values than the normal population. A similar trend was seen in Down syndrome boys (Figures 11 and 12).

Discussion

We have produced the first growth charts relevant to children with Down syndrome in Egypt from birth until 3 years old in both sexes. Current data indicate that growth patterns of children with Down syndrome differ from those of normal children during the first 3 years of life.

At birth, the growth pattern of Egyptian children with Down syndrome ranged from -1.6 to -3.5 below the mean of the normal population. The same tendency was reported in French babies with Down syndrome at birth [8]. On the other hand, growth reduction by 0.5 – 1.5 SD from nor-

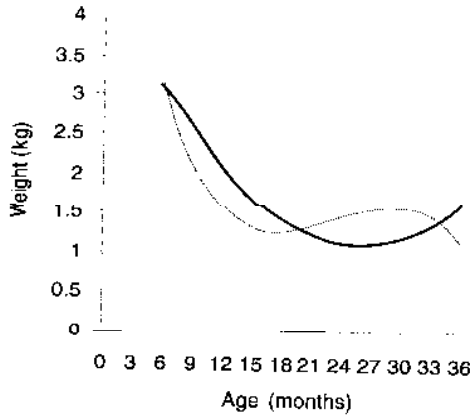


Figure 7 Weight velocity curves for males with Down syndrome (solid line) compared with normal Egyptian males (dotted line)

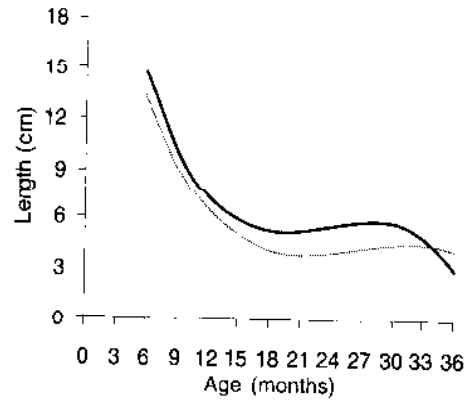


Figure 9 Length velocity curve for males with Down syndrome (solid line) compared with normal Egyptian males (dotted line)

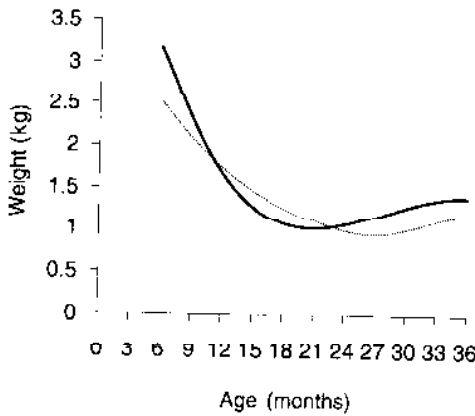


Figure 8 Weight velocity curve for females with Down syndrome (solid line) compared with normal Egyptian females (dotted line)

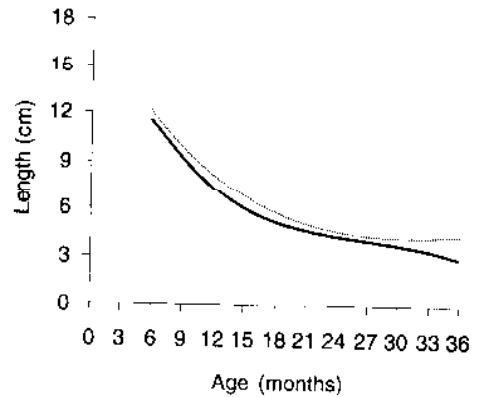


Figure 10 Length velocity curve for females with Down syndrome (solid line) compared with normal Egyptian females (dotted line)

mal control means was reported in American children [3]. This could be due to racial variations. However, our results confirm that the growth retardation started prenatally and was more severe in cases with

Down syndrome with congenital heart disease, which was the same observation of Wessels et al. [10].

All through the first 3 years of life, growth charts showed that male and fe-

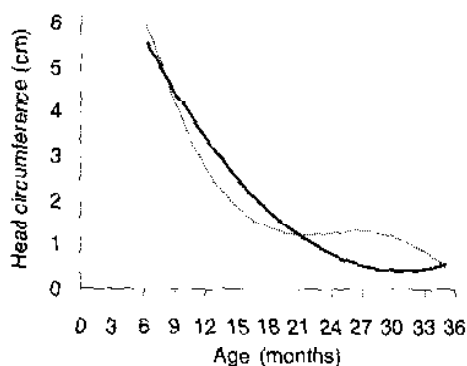


Figure 11 Head circumference velocity curve for males with Down syndrome (solid line) compared with normal Egyptian males (dotted line)

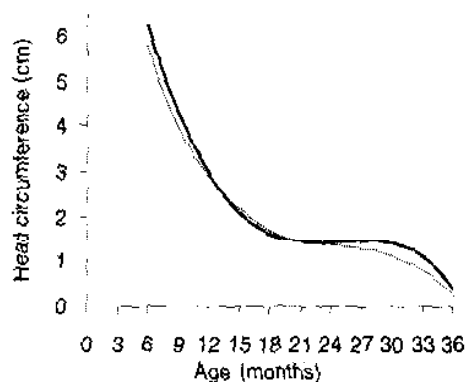


Figure 12 Head circumference velocity curve for females with Down syndrome (solid line) compared with normal Egyptian females (dotted line)

male patients with Down syndrome had lower growth parameters compared with normal children. Similar results have been documented by other researchers [3,6-8,11], which demonstrate the growth retardation effect of trisomy 21. Further analysis of the current growth charts revealed that growth impairment in Down syndrome is not severe and that children with Down syndrome are less likely than normal children to remain at a given percentile level.

The growth retardation ranged from -1.5 to -1.8 SD in Down syndrome children without congenital heart disease and -1.8 to -2.9 SD in Down syndrome children with congenital heart disease compared with a group of normal children from 1 to 36 months. These results demonstrate a trend toward better growth in Down syndrome children without cardiac anomaly and add weight to the effect of mild to moderate congenital heart disease on the growth retardation seen in Down syn-

drome patients having cardiac anomalies. Both boys and girls with congenital heart disease showed significant weight reduction compared with Down syndrome children without cardiac anomalies ($P = 0.03$ and $P = 0.02$ respectively). However, values of length and head circumference did not reach the statistical significance. It seems likely, therefore, that the influence of congenital heart disease in our sample affected weight more than the other parameters. These results are in concordance with those reported before [3,12].

At all age stages, Down syndrome boys, either with or without congenital heart disease, showed higher growth parameters than girls. However, no statistical significance between the 2 sexes was noted. This is in agreement with the American, Sicilian, Swedish and English Down syndrome growth charts showing significantly higher length and head circumference in boys versus girls [3,4,6,13,14].

Most published data showed deficient growth velocity all through the first 3 years of life but these authors did not comment on sex differences in growth velocity [3,8,12]. Interestingly, our results demonstrated higher growth velocity in children with Down syndrome versus normal children during the first 12–18 month of life, showing higher values in girls than boys (except for length). While during the 2nd year of life reduced growth velocity was equal in both sexes, by the 36th month of life growth velocity of Down syndrome patients reached values slightly lower than the normal population. The increased growth velocity, especially during the 1st year of life, could be due to the great care that our patients were receiving from their families, and the proper nutritional and medical consultations applied to their lifestyle. All our patients lived with their families and most of them were breastfed during the first 12–

18 months of their life. This finding highlights the important role of home care and breastfeeding and their effect on growth. Leonard and his co-workers attributed a similar observation to emotional support of the family and increased nutritional adequacy [15].

In conclusion, growth charts at all percentiles showed reduced patterns of growth in Down syndrome compared with normal children. The correct use of growth charts specific for Down syndrome can help highlight a physical developmental delay and suggest the need to look for concomitant diseases affecting growth. In addition, comparing our growth velocity with other results emphasizes the importance of breastfeeding and de-institutionalization during the early years of life. Our data also confirm the negative influence of congenital heart disease on growth patterns, especially on weight gain.

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