Growth and Timing of Puberty: Reciprocal Effects

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Abstract. Based on the analysis of the pubertal growth spurt and final height in different pathological conditions, this paper provides evidence that variations in age at onset of puberty have a major influence on the subsequent acceleration of the growth rate but a minor impact on final height. A reciprocal effect of the growth rate on the timing of onset of puberty is also suggested by a number of clinical observations.

Introduction

Puberty and growth are two processes linked by mutual interactions mediated through different endocrine or paracrine factors at different anatomic levels. The purpose of this paper is to analyze the relationship between growth and timing of puberty. We will describe some physiological and pathological conditions providing evidence that age at onset of puberty affects growth and, also, that growth can influence the timing of onset of puberty.

Influence of Age at Onset of Puberty on the Pubertal Growth Spurt

During exposure to sex steroids, there is an acceleration of the rate of growth resulting from their synergistic action with growth hormone (GH) [1]. As shown in table 1, this acceleration is negatively correlated with age at exposure to sex steroids in several conditions: the physiological variants of the tempo of growth and puberty [2, 3]; central precocious puberty beginning at different ages; girls with Turner syndrome starting estrogen

Modulation of Growth by the Timing of Onset of Puberty

The pubertal growth spurt and final height are two distinct growth issues to be considered separately. The pubertal spurt results from an acceleration of the growth rate followed by a reduction. The capacity to accelerate growth during puberty can be reflected by the peak height velocity or maximal growth rate attained. However, the total pubertal height gain is a better index of the impact of puberty on growth since it takes into account not only the rate of growth but also the possible variations in duration of puberty [1].

Table 1. Conditions showing the reduction of growth capacity with age

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treatment at bone ages ranging from 8 to 14 years [1], and hypopituitary patients beginning spontaneous or sex-steroid-induced puberty at bone ages ranging from 10 to 15 years [4, 5]. The age-related reduction of growth response to sex steroids can be seen in patients with cen-
tral precocious puberty (fig. 1) as well as in hypopituitary boys and girls (fig. 2c, f). Interestingly, the pubertal height gain is markedly reduced in girls entering puberty at 13 years of bone age or later while a greater pubertal height gain is observed in boys at similar bone ages. This discrepancy can be related to the physiologically earlier occurrence of pubertal growth in girls than in boys.

In the absence of sex steroids, the rate of growth also shows a reduction with age which can be observed in several conditions (table 1): central precocious puberty during suppression of sex steroids by a gonadotropin-releasing hormone (GnRH) agonist therapy (fig. 1) [6]; girls with Turner syndrome either untreated [7] or treated using GH [8] and prepubertal hypopituitary pa-
tients treated using GH [9]. Thus, the capacity to re-
spond to different growth-promoting agents such as GH and sex steroids decreases steadily with age.

Using mathematical models of growth, it has been shown that the age-related reduction of the childhood component of the pubertal spurt is a major reason why pubertal growth decreases in amplitude with age [10]. A second reason why the puberal growth spurt declines with age is a reduced duration of pubertal growth. We observed a shortened duration of pubertal growth in GH-treated hypopituitary patients of both sexes begin-
ning puberty at late bone ages [4, 5]. Others reported similar findings [11–13]. This phenomenon may have biased a study where GH-treated patients treated with cypotrope were compared to untreated patients [12]. Since bone age at onset of puberty was 2 years less in the treated group than in the untreated patients, this age dis-

ference may have contributed to the longer duration of pubertal growth which could not result from cypotrope therapy. In girls, a reduction of the mean growth rate was also observed following onset of puberty at late bone ages [5].

**Influence of Age on Onset of Puberty on Final Height**

From the early observations of untreated patients with precocious puberty, it was shown that final height was reduced by 10–15% as a result of a 40% reduction of the total period of postnatal growth [1]. As shown in fig-
ure 3a, the pubertal component (part above the childhood component) of the growth spurt seen in precocious puberty is similar to that seen normally. The height lost by those patients is represented by the childhood compo-
nent of the pubertal growth spurt which is determined by the prepubertal growth rate. The relatively greater im-

portance of this prepubertal growth rate in younger sub-
jects contributes to the height loss in sexual precocity. In contrast, delayed onset of puberty results in a minor height gain because the pubertal component of the spurt shows a reduced duration while the childhood compo-
nent of the spurt is reduced as well due to the progressive decline in prepubertal growth rate with age (fig. 3b).

Therefore, the height gain resulting from late onset of puberty is not significantly greater than the pubertal component of the spurt which would have occurred at normal ages. This accounts for the absence of increase in final height following a delayed onset of puberty.

Recent studies of final height in different conditions have confirmed that a possible increase in adult height resulting from late onset of puberty was a misconception. Final height is not significantly affected by physi-
ological differences in tempo of sexual maturation [3]. While Tanaka et al. [14] reported a significant positive correlation between adult height and age at peak height velocity, this correlation would only account for a 5-cm difference in height resulting from a 5-year difference in age at onset of puberty. In patients with hypogonado-
tropic hypogonadism, adult height is also very close to the 50th percentile [15, 16]. Theastic impression of tall stature in those patients may result from the changes in body proportion with a relative increase of the lower seg-
ment and a reduced spinal growth due to the absence of.
 Possible Modulation of the Timing of Onset of Puberty by Growth

While the growth rate is evidently affected by the timing of onset of puberty, the reverse relation should be considered as well. A number of conditions (table 2) are consistent with a possible role of growth in modulating the timing of onset of puberty since increased growth rate can precede early onset of puberty [27–31] while a reduced growth rate can precede late onset of puberty as well. This concept warrants further studies based on clinical conditions and animal models to establish whether and how the growth rate can impinge upon the biological clock driving onset of puberty.

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References


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