

Neuro-endocrinology

18 BRIEFINGS

PUBERTY: MIND AND BODY

SUMMARY

Puberty is the attainment of fertility – the ability to reproduce. It occurs because our brains begin to secrete one key hormone, gonadotrophin releasing hormone. This causes the pituitary gland to induce maturation of the testis and the ovary, which then produce sex steroid hormones and mature sperm and eggs. We should be concerned that the age at which puberty begins is decreasing in many countries. Puberty starts when adequate growth and energy storage has occurred, so the earlier age of puberty may reflect recent increases in adolescent obesity resulting from more sedentary lifestyles.

Increased activity of GnRH neurons in the brain (green) underlies all aspects of puberty, resulting in reproductive maturation and sexual awareness.

Puberty – its all in the mind!

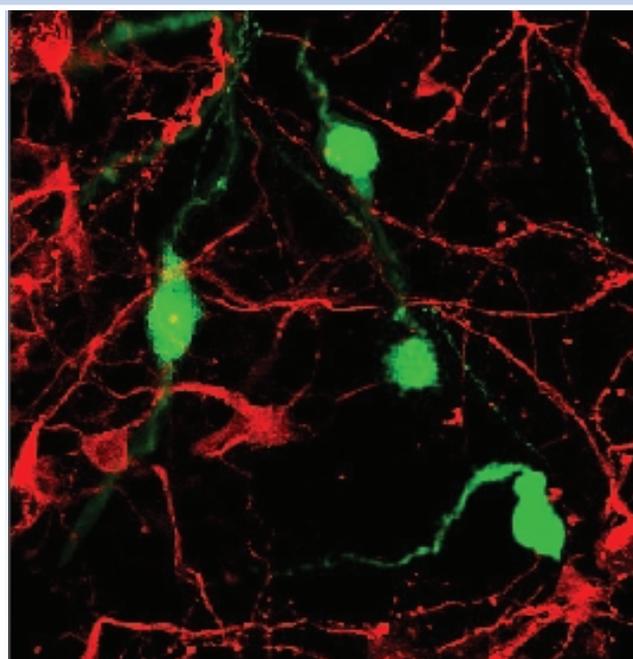
The many outward signs of puberty, for example development of the breasts and external genitalia, growth of body hair and deepening of the male voice, reflect increased activity of the gonads: testes and ovaries. At puberty, these organs are responding to increases in secretion of gonadotrophin hormones from the pituitary gland, and this in turn results from the increased activity of a tiny group of specialised nerve cells in the brain. Remarkably, there are less than two thousand of these neurons in the human brain, so only 1 in every 100 million cells in the human brain is concerned with

stimulating the pituitary gland to induce puberty. These cells do this by secreting a small hormone, gonadotrophin releasing hormone (GnRH), which stimulates the production and release of gonadotrophin hormones. This tiny number of GnRH-producing neurons, holds the key to puberty. If, during brain development, the GnRH neurons fail to arrive at their correct location, the individual will never go through puberty without medical treatment – a situation known as Kallmann's syndrome. Remarkably, the GnRH system is transiently activated during the first months of human postnatal life, at least in boys. The intriguing questions are why does this GnRH system that develops so

early in life then go into a protracted period of quiescence, and why does it subsequently reactivate to cause puberty?

Timing is everything

Both the age at which puberty begins in children, and the length of time that the process takes to complete, vary enormously between individuals. Although 'puberty' is often considered to begin earlier in girls than boys, compar-



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ing the external features of puberty between the sexes is like comparing apples and pears. The underlying hormonal changes begin at quite a similar age. It is really the acceleration of growth velocity resulting in increased height and the transition from lean skeletal growth to fat deposition that occurs earlier in girls than boys. Most information about the timing of puberty in the population at large is for girls, as breast development and onset of menstruation (periods) are more overt and recordable than changes in penis and testicle size in boys. In Europe, the age of menarche (first period) is thought to have increased from around 14 years in the Middle Ages to around 17 years by the start of the 19th century, but since then has declined markedly to about 13 years in most industrial countries. A very recent study of over 17000 adolescent girls in the USA provided clear evidence that the age of menarche is continuing to fall, particularly amongst African-American girls, where the average age of menarche was found to be 12.2 years. The study also found that the age of earlier markers of puberty such as breast development and pubic hair growth was falling in all girls irrespective of race.

Food, fat and fertility

Why is the age of puberty decreasing? The decreasing age over the last two centuries is widely attributed to improved nutrition and health, but could this explain why the age is decreasing in the last two decades? It is clear that the storage of energy reserves as fat and the availability of metabolic fuels are a key determinant in the ability of mammals to reproduce effectively, as the costs of

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supporting pregnancy and lactation are high for mammals. The brain can measure the availability of metabolic fuels, and so determine whether to initiate reproduction. One important signal is the hormone leptin produced by white fat cells. If fat reserves are low, leptin production is low and reproductive activity is arrested. Puberty will not begin unless adequate metabolic fuels are available, so we might consider the leptin levels to act as a ‘gate’ for puberty. Leptin is not a unique ‘trigger’ for puberty, as there are many other factors which signal energy metabolism to the brain, including insulin, glucose and fatty acids. As modern lifestyles are becoming increasingly sedentary, it is little surprise that the prevalence of being overweight or obese is increasing in childhood, particularly in the USA. Perhaps this increased availability of metabolic fuels and fat reserves is opening the puberty ‘gate’ earlier in adolescents.

Environmental estrogens?

Production of estrogens at puberty is not only important for sexual development in girls, but also in boys. Indeed, a genetic loss of estrogen receptors can result in infertility in male mammals. It has been suggested that increased exposure to environmental estrogens which interfere with the body’s own estrogen receptors may be affecting the time of puberty. Chemicals with

weak estrogen-like activity are used in the manufacture of many materials including plastics to which we may not have been exposed in previous years. Likewise, plant derived estrogens are found in food such as soya-based products which would not have formed part of a ‘western’ diet in the past. However, although high doses of environmental estrogens have been shown to disrupt reproductive function in experimental rodents, there is no direct proof that humans are exposed to sufficient levels to affect puberty.

Given that the neuroendocrine mechanism underlying puberty develops before birth, perhaps we should be studying whether altered nutrition of the pregnant mother or her exposure to environmental estrogens could be affecting the developing fetus, and thereby influencing the timing of puberty in later life. More research quickly please!

Author:

Dr Fran Ebling
School of Biomedical Sciences
University of Nottingham Medical School
Queen’s Medical Centre
Nottingham, UK

Editor:

Dr R John Bicknell
Laboratory of Neuroendocrinology
The Babraham Institute
Cambridge CB2 4AT UK
john.bicknell@bbsrc.ac.uk

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