

Age-dependent effect of high caffeine exposure on bone and reproductive organ

Opinion

Previously coffee or tea was the major sources of caffeine, and recently energy drinks are becoming popular.¹ Indeed, 28 to 34% of adolescents and young adults have been reported as regular consumers of energy drinks.² Most of energy drinks contain 3 to 5 times greater than those in usual soft drinks³ and some of them contains up to 505mg of caffeine per one serving.⁴ Although there is no exact safe dose of caffeine, less than 100 mg/day and 400mg/day for adolescents³ and healthy adults, respectively, is considered safe.⁵ Given that the reports of average consumption of energy drinks among adolescents and young adults and caffeine contents in energy drink, they are easily in danger of exposing above their recommended dose.⁶ It has been reported that maternal caffeine exposures increase fetal loss and low birth weight,³ as well as lower testosterone levels in male human offspring.⁷ Similar to the prenatal exposure, peripubertal caffeine exposure also reduced testis growth and serum testosterone levels in the animal study.⁸ Since development of the sex accessory organs are stimulated by increased testosterone during the puberty,⁹ reduced androgen production may contribute to decreased weights of sex organ by caffeine exposure during the puberty. On the other hand, caffeine has well known as a risk factor, which could cause the loss of bone minerals leading to increased risk of osteoporosis and fracture in human adults.^{10,11} Animal studies using pregnant or adult rats have demonstrated that chronic caffeine exposure caused negative impacts on bone mineral accretion.^{10,12} or fetal longitudinal bone growth.¹² Likewise, animal studies demonstrated that peripubertal caffeine exposure significantly impairs bone growth in length as well as bone mineral density.¹³ Growth rate of long bones seems to be different in each region, but rapid growth of long bones in most regions occurs between 20 to 40 days of age in the rat,¹⁴ which is corresponding to pubertal growth spurt in human. Hence, caffeine exposure could be particularly harmful more in children and adolescents than in adults based on the studies using immature rats. Because of the increasing concern of the potential adverse effects of caffeine intake in adolescent and young adult, caffeine effect during young adult also needs to be known for the comparison with the puberty. As compared with the adolescent, adulthood period occurs growth no longer in bone and sexual organs. Therefore, it could be expected that responses to the caffeine exposure in adults cannot be the same as those in adolescents. However, whether the effect of caffeine during puberty and young adult is different or not, and what the underlying mechanisms of age-dependent caffeine effect have not been observed. Based on our preliminary animal study, caffeine causes decrease in bone mineral density which can trigger osteoporosis rather than adverse effect on bone growth in length or sexual organ growth (unpublished data). In detail, caffeine caused significantly decreased bone mineral content in both immature and young adult groups, while significant reduction of bone mineral density was found mainly in immature rats (unpublished data). According to our preliminary results, although caffeine exposure during prepubertal period seems to be more susceptible on bone growth, high dose of caffeine exposure still can adversely affect young adults by reducing the bone mineral contents.

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Conclusion

Previously it has been demonstrated that caffeine exposure during peripubertal period interfered with the growth of long bone and testis.¹⁵ However, little is known about age-dependent effects of caffeine exposure on long bones and reproductive organs. To compare the difference in responses to caffeine exposure by age, immature rats in a rapid growing stage and young adult rats still being in a maturational developing stage were evaluated (unpublished data). Caffeine induced profound shortening and lightening in long bones along with the significantly decreased bone mineral density in immature animals whereas no difference was found in young adult animals. Effect of caffeine on reproductive system revealed a significant reduction in size and weight of testes in immature group while young adult group had profound decrease in sex accessory organs such as epididymis, seminal vesicle, and prostate. These clearly indicate that negative impacts of caffeine on the growth of long bone and reproductive organs are different by age in the male rat. Therefore, the adverse effect of caffeine exposure in peri-pubertal period is more critical for bone development and reproductive organs than in young adult. However, high dose of caffeine exposure still can adversely affect sex accessory organs during young adult period, suggesting differential effects of caffeine on skeletal and reproductive system by age.

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Conflict of interest

Author declares that there is no conflict of interest.

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