

JCY Cheng 鄭振耀
JTF Lau 劉德輝
S Ho 何陳雪鸚
X Guo 郭 霞

Nutrition and physical activity as possible factors affecting bone mineral status in adolescent idiopathic scoliosis: cross-sectional and case-control studies

Key Messages

1. Calcium intake and physical activity, in particular weight-bearing physical activity, were significantly associated with bone mineral density in girls with adolescent idiopathic scoliosis (AIS) at the age of 14 years.
2. Insufficient weight-bearing exercise appeared to be a risk factor for AIS in this population. However, girls with AIS may be less inclined to exercise than those without such deformity.
3. Patients with AIS had low calcium intake and insufficient intake of plant foods, especially fruits and vegetables.

Introduction

Adolescent idiopathic scoliosis (AIS) is a serious deformity of the spine affecting mostly girls at the age of 10 to 16 years, with a prevalence of 3 to 4% among adolescents in Hong Kong.¹ A majority of such patients have generalised low bone mineral density (BMD),^{2,4} although it is unclear whether calcium intake and physical exercise are related to the BMD of these patients.

Objectives

The primary objective of the study was to understand the relationship between the two lifestyle factors (calcium intake and weight-bearing physical activity) and BMD in adolescent girls with AIS. The secondary objective was to study the relationship between these two lifestyle factors (calcium intake and physical activity) and the occurrence of AIS.

Methods

This study was conducted from January 2000 to December 2001.

Study design and subjects

To achieve the primary objective, a cross-sectional study was undertaken to investigate the association between dietary calcium intake, physical activity, and BMD in girls with AIS. A total of 596 newly diagnosed patients with this condition were recruited. To achieve the secondary objective, an age-matched case-control study was carried out, and involved recruiting 234 healthy, age-matched girls as controls, which gave rise to 234 case-control pairs. Patients with AIS aged 11 to 16 years were recruited from the Scoliosis Clinic at the Prince of Wales Hospital, while the age-matched healthy controls were recruited from three schools in Shatin.

Outcomes measurements

Weight, height, arm span, and leg length were measured by standard methods. Pubertal growth during adolescence (in terms of breast development) was examined by Tanner's staging. Calcium and other nutrient intakes were assessed by a food frequency questionnaire consisting of more than 200 food items. Daily weight-bearing physical activity was assessed by a physical activity questionnaire. Weight-bearing exercises were categorised into high or moderate impact types. Areal bone mineral density (aBMD) of the lumbar spine and proximal neck of femur were evaluated by dual-energy X-ray absorptiometry. Volumetric bone mineral density (vBMD) of the distal radius and tibia were evaluated by peripheral quantitative computed tomography.⁵⁻⁷

Statistical analysis

Univariate analysis was used to examine the relation between the BMD and independent variables. Multivariate analysis was used to identify variables that predicted the variation of BMD after controlling for confounding factors. To achieve the secondary objective, conditional logistic regression analysis was

Hong Kong Med J 2007;13(Suppl 3):S33-5

The Chinese University of Hong Kong,
Shatin, Hong Kong;
Department of Orthopaedics and
Traumatology
JCY Cheng, X Guo
Centre for Clinical Trials and Epidemiology
JTF Lau
Department of Community and Family
Medicine
S Ho

HSRF project number: 921024

Principal applicant and corresponding author:
Prof Jack CY Cheng
Department of Orthopaedics and
Traumatology, Prince of Wales Hospital,
Shatin, NT, Hong Kong SAR, China
Tel: (852) 2632 2727
Fax: (852) 2649 3248
E-mail: jackcheng@cuhk.edu.hk

used to determine risk factors contributing to the occurrence of AIS in the age-matched case-control study. The level of significance was set to a P value of ≤ 0.05 .

Results

A total of 596 girls (age range, 11-16 years) with AIS participated in the cross-sectional study on the association of BMD with calcium intake and weight-bearing physical activity. Whereas, the case-control study to determine the contribution of calcium intake and physical activity to the occurrence of AIS was based on 234 age-matched pairs (each consisting of an AIS patient and a healthy control).

Calcium intake and general nutritional status of adolescent idiopathic scoliosis patients

The median calcium intake of AIS girls was 517.7 mg/d, which reached only 50% of the Chinese "dietary reference intake (DRI) of 1000 mg/d".⁸ The low calcium intake was associated with lower consumption of milk and milk products. Dietary intakes of energy (the energy equivalent calculated from dietary intake questionnaire data), protein, cholesterol, vitamin C, phosphorus, iron, and zinc were adequate. The percentages of energy intake derived from protein, fat, and carbohydrate were within the reference range. However, intakes of dietary fibre and folate (the basic vegetable- and fruit-based nutrients) were less than 50% of the DRI. Among girls with AIS, intakes of dietary fibre, vitamin C, and folate were significantly lower than in the controls ($P < 0.04$), which may reflect the lower consumption of whole grain cereals, vegetables, and fruits in the former group.

Calcium intake and bone mineral density

There was a significant correlation between calcium intake and vBMD at the distal radius ($P = 0.009$) in the older (15-16 years) age-group. There was no other statistically significant correlation between calcium intake and BMD at all assessed skeletal sites of subjects aged 11 to 16 years. At early puberty (breast stage 3), calcium intake was significantly correlated with aBMD measured at the lumbar spine ($P = 0.004$), greater trochanter ($P = 0.018$), and Ward's triangle ($P = 0.039$) of the proximal femur.

Physical activity

Patients with AIS spent on average 1.6 hours per day on weight-bearing activities. Average time spent on weight-bearing physical activities was highest at the age of 13 years (1.9 h/d) and lowest at 14 years (0.16 h/d). Overall, weight-bearing activity was significantly correlated with BMD at all sites except for vBMD at the distal radius in AIS patients at all ages ($P > 0.05$), whereas significant correlations between high-impact physical activity were found for lumbar spinal BMD ($P = 0.001$) and distal tibial BMD ($P < 0.014$). At the age of 11 to 13 years, there was no significant correlation between weight-bearing physical activities and BMD at all skeletal sites. At the age of 14 years, there were more

significant correlations between weight-bearing physical activity (especially high-impact type) and BMD measured at various skeletal sites ($P < 0.05$).

Multivariate analysis

Multiple regression analysis confirmed that calcium intake, weight-bearing exercise, age, and weight were significant independent predictors affecting the variation of BMD. However, height only predicted the variation of vBMD in AIS patients. Multivariate analysis also revealed that calcium intake was a moderate determinant of the variation of BMD, which was in contrast to the relationship with physical activity in AIS patients.

Case-control analysis

The case-control study showed that high-impact weight-bearing activity was negatively associated with the occurrence of AIS.

Discussion

This study is the first of its type to investigate the relationship between calcium intake and physical activity on BMD of AIS patients and helps to elucidate the special role of these factors on the accretion of bone mineral mass in adolescent girls with AIS. It is also the first study to investigate lifestyle factors associated with AIS in a Chinese population.

Part 1 addressed the primary objective. It found that calcium intake and physical activity (particularly weight-bearing) was significantly associated with BMD in 14-year-old girls with AIS. Part 2 (the case-control study) addressed the secondary objective. It found that insufficient weight-bearing exercise appeared to be a risk factor for AIS in this population. However, this inference must be interpreted cautiously, since AIS girls with spinal deformity may tend to exercise less than their peers. Thus, a cause-effect relationship cannot be established from these results. Another important finding was that AIS patients had low intake of calcium and of plant foods (particularly vegetables and fruits).

For future study, an intervention programme should be set up to investigate the role of calcium supplementation and structured physical training as a means of alleviating osteopenia. If necessary, health education and lifestyle interventional programmes (nutrition and physical exercise) could then be devised to improve the nutritional and BMD status of such vulnerable subjects at the critical period of peri-pubertal growth.

Policy implications from the present study

These study outcomes provide scientific data to international organisations with a special interest in AIS research and care. Orthopaedic surgeons need to be aware of the fact that lifestyle factors such as poor dietary calcium and inadequate weight-bearing physical activity could be associated with

osteopenia in AIS patients. Osteopenia has been proven in another study by our group to be a prognostic factor for the progression of AIS.⁹ The prevention and treatment of generalised osteopenia might help to curtail the progression of AIS. Further research could be helpful to address this hypothesis.

The current study findings also provide useful information to the local health authority on the need to emphasise relevant health education. The results show that in general, the present dietary intake of Hong Kong adolescent girls was inadequate to meet the increasing demands of rapid pubertal growth. The current cross-sectional study can serve as a baseline for further longitudinal follow-up investigations to define the dynamic change of BMD in AIS patients. Further research may clarify whether low BMD in AIS patients can be corrected by providing additional supplementation of calcium and/or physical exercises. If osteopenia and its related complications were preventable and have a direct effect on scoliosis progression, the health care cost saving from the treatment of this deformity and its short-term and long-term complications could be substantial.

Acknowledgements

This study was supported by the Health Services Research Fund (#921024). We would like to thank the patients and their parents; the Heads of school, students and parents from Sha Tin Methodist College, Christ College, Shatin, and Leung Kui Kau Lutheran Primary School (AM), Shatin.

We also thank Prof PC Leung and Prof EMC Lau from the Jockey Club Centre of Osteoporosis Care and Control, The Chinese University of Hong Kong, for their generous support on the project fieldwork.

References

1. Public Health and Epidemiology Bulletin, Appendix 1: Vol 6, No.2. Hong Kong: Department of Health; 1997.
2. Cook SD, Harding AF, Morgan EL, et al. Trabecular bone mineral density in idiopathic scoliosis. *J Pediatr Orthop* 1987;7:168-74.
3. Cheng JC, Guo X. Osteopenia in adolescent idiopathic scoliosis. A primary problem or secondary to the spinal deformity? *Spine* 1997;22:1716-21.
4. Cheng JC, Qin L, Cheung CS, et al. Generalized low areal and volumetric bone mineral density in adolescent idiopathic scoliosis. *J Bone Miner Res* 2000;15:1587-95.
5. Lee WT, Cheung AY, Lau J, Lee SK, Qin L, Cheng JC. Bone densitometry: which skeletal sites are best predicted by bone mass determinants. *J Bone Miner Metab* 2004;22:447-55.
6. Lee WT, Cheung SK, Cheng JC. Higher calcium intakes are found in idiopathic scoliotic adolescent girls with generalised osteopenia. Proceedings of the 5th Annual Nutrition Symposium; 2001 Nov 10; Hong Kong: Centre of Nutritional Studies, School of Public Health, The Chinese University of Hong Kong; 2001:15.
7. Lee WT, Cheung SK, Cheng JC. Bone mineral density (BMD) and calcium intake in patients with adolescent idiopathic scoliosis. Proceedings of the Joint Annual Scientific Meeting; 2001 Oct 13. Hong Kong: The Hong Kong Paediatric Society and Hong Kong Paediatric Nurses Association; 2001:4.
8. Chinese Nutrition Society. Chinese Dietary Reference Intakes. Beijing: Chinese Light Industry Press; 2000.
9. Hung VW, Qin L, Cheung CS, et al. Osteopenia: a new prognostic factor of curve progression in adolescent idiopathic scoliosis. *J Bone Joint Surg Am* 2005;87:2709-16.