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Effects of physical training and calcium intake on bone mineral density of students with mental retardation

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A R T I C L E   I N F O

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A B S T R A C T

The purpose of this study was to investigate the effects of physical training and calcium intake on bone mineral density (BMD) of students with mental retardation. Forty mentally retarded boys (age 7–10 years old) were randomly assigned to four groups (no differences in age, BMD, calcium intake and physical activity): training groups with or without calcium supplementation (Tr+Ca+ and Tr+Ca−) and nontraining groups with or without calcium supplementation (Tr−Ca+ and Tr−Ca−). The intervention involved 45 min of physical training performed 3 sessions a week and/or the addition of dietary calcium-rich food using enriched cow milk with vitamin D containing 230 mg calcium per serving, over 6 months. Paired-samples *t*-test and ANOVA analysis was used to determine the main and combined effects of training and calcium on BMD. All groups showed greater femoral neck BMD after 6 months. The increase in femoral neck BMD in the Tr+Ca+ group was 10% greater than increase in the Tr+Ca− group (not significant). Apparently, the effect of training was greater than calcium intake because the Tr+Ca− group achieved 4% greater BMD than Tr−Ca+ group (not significant). In this study, both training groups had greater BMD than the control group (Tr−Ca−) ($P < 0.05$).

In these participants with inadequate calcium intakes, additional exercise and calcium supplementation resulted in a 6–20% greater increase in BMD than controls at the loaded site (femoral neck). These results help to provide more evidence for public health organizations to deal with both exercise and nutrition issues in children for the achievement of peak BMD.

1. Introduction

Even though genetic predisposition determines up to 80% of peak bone mass density (BMD) (Anderson, 2000), environmental factors like nutrition and physical activity play important roles in obtaining maximum BMD (Davies, Evans, & Gregory, 2005). During childhood bone mineral density (BMD) increases until peak bone mass is reached. Peak bone mass and subsequent bone losses are important determinants of osteoporosis later in life (Boot, De Ridder, Pols, Krenning, & De Muinck Keizer-Schrama, 1997). It is essential to know which factors influence BMD in childhood. The risk of osteoporosis fractures in elderly increases progressively as BMD declines and reduction of 1 SD in the BMD of the femoral neck is associated with a doubling of the risk of hip fractures (Cummings et al., 1993).

Several studies have shown that physical activity has a positive effect on bone mass during growth and even during adolescence (Courteix et al., 1998; Fuchs, Bauer, & Snow, 2001; Jones & Dwyer, 1998; Lehtonen-Veromaa et al., 2000;

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Macdonald, Kontulainen, Khan, & Mckay, 2007; Mackelvie, Mckay, Petit, Moran, & Khan, 2002; Mckay et al., 2005; Scerpella, Davenport, Morganti, Kanaley, & Johnson, 2001; Wang et al., 2003; Welch, Turner, Devareddy, Arjmandi, & Weaver, 2008; Yung et al., 2005). However, details regarding the nature and the magnitude of this relationship are still unclear (Hind & Burrows, 2007). Some studies have shown that exercise influences bone modeling locally at the regions being loaded. Furthermore, numerous studies have shown that higher calcium intakes increase bone mass more during intervention compared to controls (Bass et al., 2007; Courteix et al., 1998; Courteix, Jaffré, Lespessailles, & Benhamou, 2005; Iuliano-Burns, Saxon, Naughton, Gibbons, & Bass, 2003; Mølgaard, Thomsen, & Michaelsen, 2001; Rowlands, Ingledew, Powell, & Eston, 2004; Specker & Binkley, 2003; Vicente-Rodríguez et al., 2008). Calcium deficiency also leads to a reduction in bone mass by increasing bone resorption to preserve the level of ionised calcium in the extracellular fluid. Dietary calcium deficiency may also be a major cause of rickets in children in developing countries (Ondrak & Morgan, 2007). In a study by Goulding et al. (2004) children who avoid drinking cow's milk were at an increased risk for pre-pubertal bone fractures (Sanders et al., 2009).

Although there are improvements in BMD through physical activity and calcium intake, these effects do not significantly influence organizations that are responsible for public health. According to a report by the Iranian Ministry of Health, over 17% of women and 5.9% of men in Iran are suffering from osteoporosis. The risk of osteoporosis fractures in the elderly is compounded by the risk of fall and by the risk of fractures as a consequence of the fall. According to studies carried out by EMRC, under the supervision of Larijani (head of EMRC), in Iran only 60% of the recommended daily allowance of calcium and 15% of the recommended daily allowance of vitamin D is consumed (Goulding et al., 2004). As per Greer, Krebs, and the Committee on Nutrition (2006), the recommended daily calcium intake is 1000 mg/day for adults, 800 mg/day for children and 1200 mg/day for elderly people (Hashemipour et al., 2004).

Interactive effects of physical activity and calcium supplements have been investigated in different studies. In these studies the beneficial effects of the two aforementioned factors are synergistic. It is believed that exercise produces region-specific effects, whereas higher calcium intake produces generalized effects (works systemically) in addition to the benefits of exercise (Greer et al., 2006; Vicente-Rodríguez et al., 2008). Moreover, in reference to a 1-year study by Chevalley, Bonjour, Ferrari, Hans, and Rizzoli (2004) of pre-pubertal boys, calcium enriched food increased BMD at several appendicular skeleton sites, but not at the lumbar spine, and this without any bone size change (French, Fulkerson, & Story, 2000). There are several reasons to suggest that the pre-pubertal years are the best stage of growth and when the skeleton is most responsive to exercise. One reason is that the pre-pubertal growth is relatively sex hormones independent. Another reason is that, in a study by Bass et al. (1998), the residual benefits of exercise before puberty and maintained into adulthood has been illustrated (Chevalley et al., 2004). Moreover, according to Lee et al. (2005), generalized low bone mass of girls with adolescent idiopathic scoliosis is related to inadequate calcium intake and weight-bearing exercise in pre-pubertal period (Bass et al., 1998). Although most of the studies approve of the positive effects of calcium intake and weight-bearing exercise on BMD, other investigations have resulted in no significant intervention (exercise or calcium intake) effects for total or local bone mass content or density (French et al., 2005; Lee et al., 2005) and all of these research are done in normal persons without any consideration to mentally retarded subjects. Thus, more research is needed to identify the optimal dosage of physical activity and calcium-rich dietary behavior change required to optimize bone mass gains in children and adults. The aim of this study was to assess the effects of physical training and calcium supplementation on BMD of the femoral neck in students with mental retardation.

2. Materials and methods

In this study, we conducted a 6 months, randomized control trial (RCT) in 40 boy students with mental retardation aged 7–10 who were from schools for mentally retarded persons in Tehran and volunteered to take part in this study. The participants were randomly divided into either a training and calcium (Tr+Ex+) group, only training (Tr+Ex−) group, only calcium (Tr−Ca+) group, and control (Tr−Ex−) group.

Parents of the study children completed a life style questionnaire, which included items relating to previous and current medical status, use of medications, current and past physical activity and past injuries. At baseline, there were no differences according to physical status, nutrition and calcium intake across groups. None of the participants were known to have any illnesses or to take medication known to affect bone metabolism and structure.

BMDs (g/cm^2) of the right proximal femoral neck were evaluated by dual-energy X-ray absorptiometry. Based on adult scans the precision of femoral neck bone measurement was 99%. Standard positioning protocol and software were used to complete and analyze the scans. The inter-operator reliability scans at site were collected during each data collection period. BMD reliability was high ($r = 0.98$) and bias was approximately 1%.

For the subjects of training and calcium (Tr+Ex+) group and only training group (Tr+Ex−) group, we organized various 45 min physical training including running, hopping, galloping and skipping 3 sessions a week for 6 months. The program was conducted under the control of a trained physical educator. These physical trainings were simple and many children enjoyed doing them. For the participants in the training and calcium (Tr+Ex+) group and calcium only (Tr−Ex+) group, we considered 2000 cm^3 enriched cow milk with vitamin D, which provided the participants with additional 230 mg calcium per day. Participants were required to consume one food product per day. Parents were completely aware of the intervention and written informed consent was obtained from the children and their parents. They were asked to actively participate in the study. Children and their parents were encouraged to take the interventions really seriously and not to forget the