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# Effects of calcium and training on the development of bone density in children with Down syndrome

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ABSTRACT

In this study we examined the effects of physical training and calcium intake on the development of bone mineral density (BMD) in children with Down syndrome (DS). A total of 48 children with DS (age 7–12 years old) matched for age and BMD were assigned to four groups exercise and calcium intake ($Ex^+Ca^+$), calcium intake-no-exercise ($Ex^-Ca^+$), exercise no-calcium intake ($Ex^+Ca^-$) and non-exercise-no-calcium intake ($Ex^-Ca^-$). The training protocol included 45 min of weight bearing exercise performed 3 sessions per week in addition to dietary calcium rich food intake of enriched cow milk with vitamin D containing 200 mg calcium per serving or no enriched dietary supplement for a duration of 4 months. Data analysis was performed on data by using *t*-test, one-way ANOVA analysis and Tukey post hoc tests to determine the main and combined effects of training and calcium regiment on BMD. All groups showed greater femoral neck BMD after 4 months. The increase in femoral neck BMD in the $Ex^+Ca^+$ group was 5.96% greater than the $Ex^+Ca^-$ group ($p < 0.01$). The effect of training was greater than calcium intake alone. The $Ex^+Ca^-$ group achieved 3.52% greater BMD than $Ex^-Ca^+$ group ($p < 0.01$). In this study, all the experimental groups had greater BMD than the no-calcium-no-exercise group that served as the control group ($p < 0.01$). It was concluded that additional weight bearing exercise and calcium supplementation resulted in a greater increase in BMD in children with DS.



## 1. Introduction

The physical growth process can be disrupted by malnutrition and developmental disabilities such as Down syndrome at any time (Gallahue, Ozmun, & Doodway, 2011; Piek, 2006). Malnutrition can serve as a mediating condition for certain diseases that affect physical growth. For example, lack of vitamin D in a diet can result in rickets, a softening and deformity of the bones that occurs as a result of lime salts in newly formed bones (Gallahue et al., 2011). In addition, physical training does increase bone mineral density which make for stronger, less brittle bones (Hemayattalab, 2010). Training stress within the limits of the particular individual is beneficial to the bones. Inactivity, on the other hand, has harmful effects on bone growth and may result in growth retardation (Gallahue et al., 2011).

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Bone mineral density acquisition during childhood and adolescence is very important for adult bone mass and skeletal health (Rizzoli, Bianchi, Garabedian, McKay, & Moreno, 2010). Even though genetic predisposition determines up to 80% of peak bone mass (Anderson, 2000), environmental factors like nutrition and physical activity play important roles in obtaining maximum BMD (Davies, Evans, & Gregory, 2005). During childhood BMD increases until peak bone mass is reached. Peak bone mass and subsequent bone losses are important determinants of osteoporosis later in life (Rizzoli et al., 2010). 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 (Macdonald, Kontulainen, Khan, & Mckay, 2007; Mckay et al., 2005; 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 greatly during the intervention period compared with un-supplemental controls (Bass et al., 2007; Courteix, Jaffré, Lespessailles, & Benhamou, 2005; Rowlands, Ingledew, Powell, & Eston, 2004; Vicente-Rodríguez et al., 2008). Calcium deficiency also leads to a reduction in bone mass by increasing bone desorption to preserve the level of ionized calcium in the extracellular fluid. Dietary calcium deficiency may also be a major cause of rickets in children in developing countries (Ondrak Kristin & Morgan Don, 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 (Hashemipour et al., 2004). The results of one study showed that only 60% of the recommended daily allowance of calcium and 15% of the recommended daily allowance of vitamin D is consumed in Iran (Hashemipour et al., 2004). Greer and Krebs (2006) claim that the recommended daily calcium intake is 1000 mg/day for adults, 800 mg/day for children and 1200 mg/day for elderly people (Greer & Krebs, 2006).

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 & Krebs, 2006; Vicente-Rodríguez et al., 2008). Moreover, the results of a 1-year study performed on pre-pubertal boys (Chevalley, Bonjour, Ferrari, Hans, & Rizzoli, 2004) showed that calcium enriched food increased BMD at several appendicular skeletons sites, but not at the lumbar spine, and this without any bone size change (French, Fulkerson, & Story, 2000). There are several reasons to assume that the pre-pubertal period is the optimal stage of growth. This is the time that the skeleton is most responsive to exercise. One reason is that the pre-pubertal growth is relatively sex hormones independent. Another reason is the findings reported by Bass et al. (1998) who demonstrated that the residual benefits of exercise before puberty was maintained till adulthood (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).

There are evidences that show individuals suffering from DS have lower bone density compared with those who have normal developmental and intellectual conditions (Babtista, Varela, & Sardinha, 2005) or even other disorders except DS (Angelopoulou et al., 2000). Despite the fact that the majorities of studies confirm the positive effects of calcium intake and weight-bearing exercise on BMD, however, there are some conflicting reports that do not confirm such effects (exercise or calcium intake) in regard to the total or local bone density changes (French et al., 2005; Lee et al., 2005). Moreover, it needs to be added that all of these research findings are related to healthy participants who show no developmental disorders. Thus, more research is needed to identify the optimal dosage of calcium-rich dietary intake plus physical activity to optimize bone mass gains in children and adults, particularly in children with DS. This research was designed to examine the effect of a weight-bearing exercise program combined with calcium-rich dietary intake on children suffering from Down syndrome.

## 2. Methods

In this randomized clinical trial (RCT), children with Down syndrome (DS) voluntarily participated in an exercise and calcium-enriched supplementation program. A total of 48 participants with DS (age 7–12 years old) matched for age and BMD were assigned to four groups of exercise and calcium intake ($Ex^+Ca^+$), calcium intake-no-exercise ($Ex^-Ca^+$), exercise no-calcium intake ($Ex^+Ca^-$) and non-exercise-no-calcium intake ($Ex^-Ca^-$).

The training protocol included 45 min of weight bearing exercise performed 3 sessions per week in addition to a dietary calcium rich food intake of enriched cow milk with vitamin D containing 200 mg calcium per serving or no enriched dietary supplement for a duration of 4 months. The parents of participants completed a human consent form in addition to a life style questionnaire for their children, 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. BMDs ($g/cm^2$) of the right proximal femoral neck were