tone, and craniofacial alterations that affect many systems including bone.\textsuperscript{10} Because of the increased life expectancy today of DS patients, the acquisition of a good PBM may represent an important factor in the prevention of osteoporosis, bone fragility, and related fractures in these patients.\textsuperscript{11}

Several studies have reported that DS patients have a lower level of bone mass than their peers without DS, but it is unclear whether this is due to specific effects of chromosome 21 genes or their lifestyle factors (Table 2).\textsuperscript{12,13}

Gonzalez-Aguero et al report lower values of bone mineral density (BMD) in children with DS with respect to unaffected siblings. Moreover, the differences in the observed sexual dimorphism indicate a non-standard bone development in this specific population.\textsuperscript{10} However, McKelvey et al measured BMD by dual-energy X-ray absorptiometry (DXA) in a group of 30 patients with DS and revealed that 53.3\% showed a BMD $\leq -2$ SDS. The authors also demonstrated that both bone formation and resorption were suppressed in DS compared with controls, indicating low bone formation and decreased bone turnover as the primary causes of the low bone mass observed in these patients.\textsuperscript{13} Wu compared BMD by DXA between preadolescent boys with and without DS and confirmed that patients with DS have lower BMD and bone mineral content (BMC), also suggesting that the pelvis may be the first site to show bone impairment in DS.\textsuperscript{14} These results were partially confirmed by peripheral quantitative computed tomography (pQCT) where a higher volumetric bone mineral density (vBMD) was observed in determined skeletal sites.\textsuperscript{15} Nevertheless, adolescents with DS have a higher risk of suffering bone fractures due to a decreased bone resistance to load bending or torsion.\textsuperscript{15}

In DS, factors possibly related to low bone mass are hypotonia, low amounts of physical activity, poor calcium and vitamin D intake, celiac disease, and hormonal factors.\textsuperscript{16} Hypotonia not only is a characteristic of DS, but it represents a limit to physical activity.\textsuperscript{17} However, some authors studying the effect of physical activity alone or of increase of calcium intake alone did not demonstrate a significant effect on BMD. On the contrary, studies carried out on patients with DS who received an increase of calcium intake and who were subjected to a specific program of physical activity have shown that these two elements have a beneficial synergistic effect on BMD.\textsuperscript{18} Moreover, hypovitaminosis D seems to be very frequent in DS, in particular in subjects with obesity and autoimmune diseases.\textsuperscript{19} DS patients with obesity and autoimmune diseases could require higher cholecalciferol supplementation.\textsuperscript{19} Nevertheless, no data about vitamin D intake and BMD are reported in DS.

Finally, adolescents with DS in the high physical activity tertile showed lower risk of developing future osteoporosis by having a higher BMD Z-score at the hip; this demonstrates the importance of accumulated minutes of physical activity on bone health in adolescents with DS.\textsuperscript{17}

Nevertheless, other authors demonstrated that one year of training significantly increased BMC values at the lumbar spine and total hip and BMD values only at the lumbar spine, whereas changes in broadband ultrasound attenuation (BUA) and speed-of-sound (SOS) values were not evident following training but showed a lower bone improvement compared to that reported.\textsuperscript{20}

Thus, impaired bone mass and quality is a frequent characteristic of DS probably related to some skeletal segments compared to others. In these patients, many factors affect correct bone turnover and gain, and therefore a multidisciplinary approach that comprises constant physical activity and an optimal calcium and vitamin D intake is mandatory.

### Table 2. Mechanisms contributing to reduced bone mass in Down syndrome

- Down syndrome related mechanisms
- Hypotonia
- Low physical activity levels
- Low intake of calcium
- Low vitamin D levels
- Hormonal factors
- Autoimmune diseases

**TURNER SYNDROME**

Turner syndrome (TS) is the most common gonadal dysgenesis in females and occurs in about 1 per 2,000 liveborn females.\textsuperscript{21} This syndrome is due to the total