Bone Mineral Density in Adults With Down Syndrome, Intellectual Disability, and Nondisabled Adults

Justin R. Geijer, Heidi I. Stanish, Christopher C. Draheim, and Donald R. Dengel

Abstract

Individuals with intellectual disability (ID) or Down syndrome (DS) may be at greater risk of osteoporosis. The purpose of this study was to compare bone mineral density (BMD) of DS, ID, and non-intellectually disabled (NID) populations. In each group, 33 participants between the ages of 28 and 60 years were compared. BMD was measured with dual-energy x-ray absorptiometry (DXA) scans. BMD ($p < .0001$) between all groups was significantly different. Participants with DS had significantly lower BMD compared to NID participants. Individuals with ID had significantly lower BMD compared to NID subjects. Participants with DS had the lowest BMD of all groups. DS subjects display a greater risk for osteoporosis than ID subjects or control populations.

Key Words: physical activity; bone mineral density; Down syndrome

Introduction

Osteoporosis is a disease characterized by low bone mass and deterioration of bone tissue (World Health Organization [WHO], 1994). The incidence of bone fractures is significantly increased in people with osteoporosis, which is a major public health problem (WHO, 1994). Fractures to bones that limit ambulation, such as the hip or the spine, are particularly concerning because of the associated risk for morbidity and mortality (Franklin, Englund, Ingvarsson, & Lohmander, 2010; Robitaille et al., 2008). Bone mineral density (BMD) is an important correlate of bone health, and osteoporosis is defined as a BMD that is 2.5 standard deviations below peak bone mass (20-year-old, healthy, gender-matched average; WHO, 1994). BMD is most commonly measured by dual-energy x-ray absorptiometry (DXA; Prodigy, GE Medical, Madison, WI; software version 6.7) and is represented as the amount of mineral in one cubic centimeter of a given bone.

There is evidence to indicate that individuals with intellectual disabilities (ID), including Down syndrome (DS), have low BMD and increased prevalence of osteoporosis (Aspray et al., 1998; Center, Beange, & McElduff, 1998; Jaffe, Timell, Elolia, & Thatcher, 2005). Aspray et al. (1998) investigated the BMD of the heel of seven individuals with ID and found that all had BMD more than 2.5 standard deviations below the mean value for young adults without a disability. The BMD of the heel is directly related to impact on the heel typically caused by walking or other physical activities (Aspray et al., 1998), thus decreased physical activity in the individuals with ID compared with normal, healthy controls could account for a portion of the decrease in BMD. Center and colleagues (1998) reported that adults with ID and DS have lumbar spine BMD scores more than 2.0 standard deviations below age- and gender-matched norms. A comparison of femoral neck and lumbar spine BMD in adults with and without DS indicated significantly lower BMD at both sites in the participants with DS (Baptista, Varela, & Sardinha, 2004). Despite the compelling findings of previous research on BMD and osteoporosis in people with ID and DS, most studies only include BMD measurements at one or two sites. It has been suggested that total body BMD may be a more relevant outcome when examining overall bone structure (Franck & Munz, 2000).
Several behavioral, physiological, and genetic factors contribute to low BMD and osteoporosis, and may account for some of the differences that exist between people with and without ID. Specifically, physical activity, dietary calcium, vitamin D intake, smoking, family history, and menopause in women are all related to bone health (Franklin et al., 2010; Nordstrom, Nordstrom, & Lorentzon, 1997; Robitaille et al., 2008). It has been repeatedly shown that people with ID and DS do not engage in sufficient physical activity to achieve health benefits (Stanish, Temple, & Frey, 2006). Several investigations using objective measures have indicated that, in general, adults with ID and DS do not meet the minimum standards recommended for physical activity (Aspray et al., 1998; Draheim, Williams, & McCubbin, 2002b; Stanish & Draheim, 2005). People with ID are also known to consume low amounts of calcium and vitamin D, which may contribute to the low BMD observed in this population (Luke, Sutton, Schoeller, & Roizen, 1996; Molento, Smit, Mills, & Huskisson, 2000; Zubillaga et al., 2006). Although considerably more work is needed in this area, it appears that low levels of physical activity and poor dietary intake could place individuals with ID and DS at risk for osteoporosis.

It should be noted that the specific genetic implications of DS, such as altered collagen formations, may result in impaired bone development that may or may not be observed in individuals with ID from other causes (Hattori et al., 2000; Kola & Hertzog, 1997; Parsons, Ryan, Reeves, & Richtsmeier, 2007; Pozsonyi, Gibson, & Zarfas, 1964). Therefore, it is important to examine individuals with DS as a distinct group when conducting studies of bone health in people with ID. To our knowledge, no comparative studies have been conducted that investigate total body BMD among people with ID and DS.

The purpose of this study was to assess the BMD in adults with ID, with and without DS, and to investigate whether BMD is associated with physical activity levels. Further, we aimed to determine whether differences exist in the BMD among three groups: adults with DS, adults with ID without DS, and adults without a disability (NID). Based on previous research, it was hypothesized that: (a) the DS and ID groups would have lower BMD than the NID group; and (b) the DS group would have lower BMD than the ID group.

Method

Participants
A cross-sectional, comparative design was used to examine differences in BMD among the three groups of adults. Each group consisted of 33 adults matched on age, gender, and race. Specifically, 18 female and 15 male participants between 28–60 years of age composed each group and all participants were Caucasian. Participant demographics are presented in Table 1.

Adults with DS and ID were recruited to participate in the study through offices of Developmental Disabilities Services and Arc offices in a Midwestern state. To protect confidentiality of personal information, representatives of the service agencies performed an initial screening of individuals who expressed an interest in participating in the study. The care providers were asked to use medical records and their personal knowledge of an individual to confirm a diagnosis of DS and/or ID, and to identify eligible participants based upon each of the following inclusion criteria: (a) residing in a community setting (i.e., assistive living communities), (b) expressed interest in participating in the study, and (c) independent ambulation without need for an assistive device such as a walker or crutches. The comparison groups of adults without a disability were recruited through flyers and word of mouth from the same geographic area.

All participants signed a consent form and were compensated for their time with a $20 gift card. A parent or guardian provided consent for those adults with DS and ID who were not their own legal guardian or who could not read and/or understand the consent form. In these cases, the participant signed a simply-worded assent form that was read aloud to them. The care providers of participants with DS and ID were also compensated with a $20 gift card for their assistance with the study, such as transportation of the participants and facilitating communication between participants and study staff. The University’s Institutional Review Board for the Protection of Human Subjects approved all procedures and consent forms.

Measurement Protocol
On the day of the study visit, participants were asked to dress in clothes that did not contain any loose metal (i.e., zippers, snaps, buttons, or buckles) and to follow their typical eating habits. With participants dressed in lightweight clothing,
Body weight was measured to the nearest 0.5 kg on a digital scale. Height was measured to the nearest 0.5 cm using a stadiometer. Body mass index (BMI) was calculated by dividing the weight in kilograms by the height in meters squared.

BMD were measured with DXA. A DXA scanner uses x-ray beams to classify the tissues of the body as bone mass, muscle tissue, fat tissue, or water (Mazess, Barden, Bisek, & Hanson, 1990). During the DXA protocol, participants lay in a supine position on a table while the x-ray detector scanned the whole body. BMD measurements were obtained on the total body, arm, legs, pelvis, spine, and trunk. The DXA scan took approximately 20 minutes and the participant was required to lie still for about 10 minutes to obtain a clear scan. The radiation exposure during DXA scan has been reported to have no observable radiological or biological effect (Roux, 2003).

The NHANES III Physical Activity Survey was used to assess walking activity. Physical activity levels of persons with ID, determined by the NHANES III Physical Activity Survey, have previously been shown to be reliable (Stanish & Draheim, 2005) and associated with cardiovascular disease risk (Draheim, Williams, & McCubbin, 2002a). The survey included questions on frequency of participation in various physical activities, including walking, in the past month and the average duration of each bout of activity. A research assistant administered the physical activity survey through an interview with the participant and the participant’s direct caregiver who assisted with the questions as needed. All caregivers were close to the participant and were directly involved in their day-to-day lives so they could confirm the accuracy of responses. The interviewer answered any questions posed by participants and caregivers and provided clarification on any points of confusion. The interview took approximately 10–15 minutes.

While the NHANES III Physical Activity Survey assesses a wide variety of physical activity habits, walking has been established as a preferred and popular physical activity among individuals with ID and DS (Stanish & Draheim, 2005; Stanish, Temple, & Frey, 2006). Because walking is the most commonly reported weight-bearing physical activity in people with ID and DS, we focused our attention on walking activity for this study. The NHANES III questions on walking include average total weekly minutes of walking, average walking bouts per week, and average minutes per bout of walking. We also examined the total weekly minutes of physical activity in order to determine if an association existed with BMD.

### Statistical Analyses

All variables were screened for missing data, outliers, and normal distribution using statistical analysis software (SPSS 16.0, SPSS, Inc., Chicago, IL). Means and standard deviations of all variables were calculated for each group. An ANOVA was

<table>
<thead>
<tr>
<th>Table 1 Mean (± Standard Deviation) Participant Characteristics</th>
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<tbody>
<tr>
<td>Down Syndrome (DS) (n=33)</td>
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<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>Gender (M/F)</td>
</tr>
<tr>
<td>Age (yrs)</td>
</tr>
<tr>
<td>Height (cm)</td>
</tr>
<tr>
<td>Weight (kg)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
</tr>
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</table>

Note. Differing letters across rows denote significant differences between groups, i.e., group meana is significantly different (p < 0.05) from group meanb and (when applicable) group meanc. Values with identical letters are not significantly different.
used to determine mean differences in BMD at all of the measurement sites (head, spine, lumbar spine, hip, arms, and legs, and total body) between the three groups. Bonferroni adjustments were made post hoc. Independent t tests were utilized to identify group differences. Significance was designated at the 0.05 level. Correlations were made between BMD measures and physical activity measures.

**Results**

No significant differences between the three groups were found for age, gender, or BMI (Table 1). However, significant differences existed for height \( (p < .0001) \) and weight \( (p = .004) \). Post-hoc t tests revealed that participants with DS had significantly lower body weight than the ID \( (p = 0.004) \) and the NID comparison \( (p = 0.001) \) groups. Participants with DS were also significantly shorter than the ID \( (p < .0001) \) and NID \( (p < .0001) \) groups, and participants with ID were significantly shorter than participants in the NID group \( (p = .001) \).

There were significant differences in BMD \( (p < .0001) \) between the three groups (Table 2). Participants with DS had significantly lower BMD compared to NID participants at all measurement sites (Figure 1; total body, arms, legs, pelvis, spine, and trunk). Additionally, they had significantly lower BMD compared to participants with ID at all measurement sites with the exception of the legs. Participants with ID had significantly lower BMD compared to NID participants for total body, arm, leg, and pelvis. The mean total body z score for participants with DS was almost a full standard deviation below the norm, while the participants with ID were in the normal range. The NID control participants had a mean BMD that exceeded the normal range (Table 2).

Physical activity results are presented in Table 3. Total weekly minutes of physical activity was not significantly different between participants with DS and ID, however both the DS group \( (p = 0.037) \) and the ID group \( (p = 0.024) \) engaged in significantly fewer minutes than the NID group. None of the physical activity measures, including total minutes of physical activity, total minutes of walking per week, total bouts of walking per week, and average minutes per walking bout, were significantly different between the DS and ID groups. Total bouts of walking and total minutes of walking were significantly higher in the NID group than both the DS and ID groups. Total bouts of walking was found to be significantly correlated with total BMD in the DS group \( (p = 0.019) \); however, physical activity level did not significantly correlate with BMD in either the ID or the NID group.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Mean (± Standard Deviation) Bone Mineral Density Between Groups</th>
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</thead>
<tbody>
<tr>
<td>Down Syndrome (DS) ( (n=33) )</td>
<td>Intellectual Disability (ID) ( (n=33) )</td>
</tr>
<tr>
<td>BMD&lt;sub&gt;total&lt;/sub&gt;</td>
<td>1.10 ± 0.11&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>BMD&lt;sub&gt;Arm&lt;/sub&gt;</td>
<td>0.88 ± 0.11&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>BMD&lt;sub&gt;Legs&lt;/sub&gt;</td>
<td>1.21 ± 0.13&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>BMD&lt;sub&gt;Spine&lt;/sub&gt;</td>
<td>1.02 ± 0.11&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>BMD&lt;sub&gt;Trunk&lt;/sub&gt;</td>
<td>1.04 ± 0.13&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>BMD&lt;sub&gt;Legs&lt;/sub&gt;</td>
<td>1.21 ± 0.13&lt;sup&gt;a&lt;/sup&gt;</td>
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Note. Differing letters across rows denote significant differences between groups, i.e., group mean<sup>a</sup> is significantly different \( (p < 0.05) \) from group mean<sup>b</sup> and (when applicable) group mean<sup>c</sup>. Values with identical letters are not significantly different.
Discussion

The results of this study indicate that adults with ID, including DS, have significantly lower total body BMD compared to age-, gender-, and race-matched adults without an intellectual disability. Previous studies also report lower BMD in people with ID compared to individuals without a disability (Angelopoulou et al., 2000; Angelopoulou, Souftas, Sakadamis, & Mandroukas, 1999; Aspray et al., 1998; Center et al., 1998; Hemayattalab, 2010). However, earlier work only included measures of hip and lumbar spine BMD.

The participants with ID in our study did not have significant differences in BMD of the spine when compared to the NID comparison group, as reported in previous studies (Angelopoulou et al., 2000; Angelopoulou et al., 1999; Aspray et al., 1998; Center et al., 1998; Hemayattalab, 2010). However, these previous studies indicated differences of the lumbar spine, as opposed to the total spine. A measure of total spine is necessary when determining overall bone health in a group (Angelopoulou et al., 2000). Previous investigations have found that individuals with DS have significantly lower BMD of the spine, hip, and total body when compared to individuals without disabilities (Angelopoulou et al., 2000; Angelopoulou et al., 1999; Baptista et al., 2004; Sakadamis, Angelopoulou, Matziari, Papameletiou, & Souftas, 2002). The findings from this study support previous work, in that participants with DS had significantly lower BMD of the spine, hip, and total body when compared to the NID participants. However, participants with ID did not show reduced BMD of the spine when compared to the NID participants.

While it was expected that the NID participants would be the most physically active, and therefore have higher BMD measurements, this study did not find similar connections between the physical activity levels and BMD measurements of the DS and ID participants. The DS participants and ID participants of this study portrayed similar levels of physical activity, yet the DS participants had significantly lower BMD than the ID participants. There were no significant correlations between physical activity and BMD as seen previously (Aspray et al., 1998); however, the findings of this study may give credence to the theory that gene driven developmental issues in the cartilage of participants with DS exist (Hattori et al., 2000; Kola & Hertzog, 1997; Parsons et al., 2007; Pozsonyi et al., 1964). Abnormal cartilage maturation patterns may be responsible for decreased BMD as well as
diminished growth rates of individuals with DS (Garcia-Ramirez et al., 1998; Hattori et al., 2000; Kola & Hertzog, 1997; Parsons et al., 2007; Pozsonyi et al., 1964).

Lack of significant correlations between physical activity measures and BMD may also be attributable to the crude method of physical activity assessment. Future studies should utilize a more direct measurement of physical activity variables, such as physical activity monitors or pedometers. Comparison of individuals participating in formal exercise programs and those who are not actively involved could also be helpful in determining the true impact of physical activity on bone health.

We acknowledge the significant contribution of dietary intake, particularly vitamin D and calcium, to bone health. We aimed to examine the relationships between physical activity, BMD among adults with ID and DS, and we focused our measurements on these variables. However, future studies should include measures of diet in order to better understand bone health in people with disabilities.

In conclusion, adults with DS display a greater risk for osteoporosis compared to adults with ID and adults without disabilities. The significant deficit in BMD in the DS population, particularly with similar physical activity levels of the ID population, warrants further research. The increased risk for osteoporosis in DS and ID populations must be addressed clinically and academically.

### References


*Received 2/12/2013, accepted 3/13/2013.*

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