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Feasibility of quantitative ultrasound measurement of the heel bone in people with intellectual disabilities

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ABSTRACT

Low bone mineral density (BMD) and fractures are common in people with intellectual disabilities (ID). Reduced mobility in case of motor impairment and the use of anti-epileptic drugs contribute to the development of low BMD. Quantitative ultrasound (QUS) measurement of the heel bone is a non-invasive and radiation-free method for measuring bone status that can be used outside the hospital. QUS might be used for screening purposes to identify people with intellectual disability with poor bone status, who are in need of supplementary examination and treatment.

To investigate feasibility of QUS in this group, QUS of the heel bone was performed on-site in 151 people with ID living in residential care.

Measurements were successfully performed in at least one foot in 94.7%, were interpretable (resulting in a stiffness index) in 91.6%, and induced barely or no stress in 90.4% of the study population. Measurements generally took less than 10 min. In 93 persons bone status of both feet had been measured. The "mean percentage of the absolute difference" between outcomes of both feet was 15.5% (±15.3% SD, range 0–76.5%).

Ultrasound measurement of the heel bone is a feasible and non-stressful method for measuring bone status in people with ID. Since the mean difference between outcomes of the left and right foot were large, measurement of both feet is recommended to prevent inaccurate interpretation.

1. Introduction

People with Intellectual Disabilities (ID) are prone to developing osteoporosis or low bone mineral density (BMD). In people with ID low BMD often develops at an earlier age than in the general population (Henderson, Kairalla, Barrington, Abbas, & Stevenson, 2005; Zacharin, 2004). Increased frequencies of low BMD are present in persons with any degree of ID (Center, Beange, & McElduff, 1998; Henderson et al., 2002; Jaffe & Timell, 2003; Jaffe, Timell, & Gulanski, 2001; King, Levin, Schmidt, Oestreich, & Heubi, 2003). In the Netherlands the prevalence of low BMD is 5.2% in males and 16.6% in women in the general population over 55 years of age (Elders et al., 2005; Woltman & den Hoed, 2010). In comparison, the prevalence of low BMD was 20% in young adult males with mild to moderate ID (Center et al., 1998) and even 77% in children with ID and moderate to severe cerebral palsy (CP) (Henderson et al., 2002). Important determinants of low BMD in people with ID are limited ambulancy and anticonvulsant drug use (Henderson, Kairalla, Abbas, & Stevenson, 2004; Henderson et al., 2002;

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Jaffe, Timell, Elolia, & Thatcher, 2005). Due to the increasing lifespan of people with ID (Coppus et al., 2008; Patja, Iivanainen, Vesala, Oksanen, & Ruoppila, 2000; Strauss, Shavelle, Reynolds, Rosenbloom, & Day, 2007), the prevalence of low bone mineral density may increase even further in the nearby future.

A reduced BMD in combination with an increased risk of falling, e.g. due to motor or visual impairment, causes an increased fracture incidence in people with ID compared to that of the general population (Lohiya, Crinella, Tan-Figueroa, Caires, & Lohiya, 1999; Stevenson et al., 2006). In high risk groups, such as older women and people with impaired mobility, bone status should therefore be assessed to determine fracture risk.

In large-scale screening studies in the general population, quantitative ultrasound measurement of the bone (QUS) has been used to identify people at risk for developing osteoporosis and fractures (Hollaender et al., 2009; Khaw et al., 2004). Advantages of QUS are its non-invasiveness, lack of radiation and its portability. Bone status can be measured outside the hospital (Baroncelli, 2008; Kauppi et al., 2009; Lenora, Gerdhem, Obrant, & Ivaska, 2009) and QUS can be applied to different parts of the extremities, such as the heel bone, radius, tibia or finger. However, the calcaneus or heel bone is the most commonly used site of measurement (Brunader & Shelton, 2002; Gluer, 1997; McDevitt & Ahmed, 2007).

Earlier studies in the general population have shown that QUS results can vary between the left and right foot.(Bayer & Kutilek, 1997; Oral, Yaliman, & Sindel, 2004) In most people the right foot is dominant and therefore may have a higher bone density than the non-dominant foot. As a result larger studies frequently opt for measurement of the left foot (Hollaender et al., 2009), so that the lowest value of bone density is measured. It is however unknown whether differences in QUS results between the feet present in a similar way in people with ID. Foot dominance is more difficult to determine and might be less pronounced in people with ID, resulting in less obvious left and right differences. On the other hand hemiplegia or other unilateral disrupting factors that are known to influence bone density (Demirbag, Ozdemir, Kokino, & Berkarda, 2005), are more frequently present in people with ID and might lead to increased differences between QUS results of the feet.

The variables measured with QUS are speed of sound (SOS), a variable related to velocity of the ultrasound signal, and broadband ultrasound attenuation (BUA), a variable reflecting the weakening of the ultrasound signal while travelling through the bone (Baroncelli, 2008). Both variables, but in particular BUA, are found to be predictive of fracture risk, independent of BMD as measured with dual energy X-ray absorptiometry (DXA) (Gluer et al., 1996; Khaw et al., 2004). This can be explained by the fact that QUS variables also depend on bone structure and composition besides bone density (Brunader & Shelton, 2002). Some QUS devices provide additional variables like a stiffness index (SI) or quantitative ultrasound index (QUI) which are parameters derived from linear combinations of BUA and SOS.

Since measurement can be performed on the spot, QUS seems a promising method for screening bone status in people with ID. Although several studies have applied QUS to determine bone quality in people with ID, we have found no studies specifically determining its usability, applicability and side effects in this group (Aspray et al., 1998; Hartman, Brik, Tamir, Merrick, & Shamir, 2004; Jaffe et al., 2005; Jekovec-Vrhovsek, Kocijancic, & Prezelj, 2005; Wilmshurst, Ward, Adams, Langton, & Mughal, 1996) Therefore, we determined whether ultrasound measurement of the heel bone is a feasible method for determining bone status in people with ID. While in the literature the definition of feasibility strongly depends on the diagnostic method or intervention that is used, we defined feasibility by number of successful recordings, interpretability of the outcome and acceptability by the client.

2. Materials and methods

2.1. Study protocol and population

From November 2007 until January 2008, a device for measuring bone status with QUS was available for feasibility testing at ASVZ, a residential facility for people with ID. During that period, physicians providing medical care for this group were invited to refer patients for examination of bone status. No inclusion or exclusion criteria were applied. A total number of 151 persons with ID were referred with a mean ($\pm$SD) age of 47.0 ± 18.1 yr (range 3 months–84 years) of whom eight were children (<19 years). Measurements were done after informed consent of parents or legal representatives. Consent for measurement of bone status was obtained by the care giving physician; therefore we are not aware of the percentage of people who refused to participate. This study was part of a larger project on the prevalence and risk factors of osteoporosis, and its study protocol has been approved by the Institutional Review Board. The feasibility outcome measures were analyzed anonymously

After referral, age and gender were noted on a registration form. Referred children were assessed as well, although paediatric reference values for BMD were unavailable.

The level of intellectual disability (ID) was retrieved from the patient files and scored as mild, moderate, severe or profound. Mobility was assessed according to the Gross Motor Function Classification System (GMFCS), a 5 level classification system that is widely used for children with CP and describes gross motor function on the basis of self-initiated movement. (Rosenbaum, Palisano, Bartlett, Galuppi, & Russell, 2008). GMFCS levels are distinguished according to functional limitations, the need for assistive mobility devices (walkers, crutches, canes) or wheeled mobility and, to a lesser extent, quality of movement (Palisano et al., 1997). Children in level 1 walk without limitations in all settings, whereas children in level 5 have severe limitations in head and trunk control, and in self-mobility. Children in level 4 may walk for short distances with physical assistance of an adult at home but rely more on wheeled mobility (pushed by an adult or operate a powered chair) outdoors, at school and in the community (Hanna et al., 2009{Palisano, 1997 #252}). The diagnosis ‘severe