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REFERENCES

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NUTRITION AND BONE HEALTH

Nutrition plays a major part in ensuring strong bone formation. Adequate intakes of calcium and vitamin D are essential, while physical activity helps to lower the risk of osteoporosis. Strategies to assist with bone formation should be implemented as early as possible.

Bone is made up of living tissue and consists of a protein matrix which contains deposits of calcium, magnesium, zinc and fluoride - with calcium being the most abundant. Bone has many functions, including the provision of a protective framework, which allows the attachment of muscle and tissues, storage of nutrients and energy and the production of blood cells that help fight infection.

Bone is constantly broken down and renewed throughout life. The process of renewal occurs at different rates, for example, throughout childhood and adolescence, bone formation is greater than bone resorption. In contrast, in adulthood, bone resorption occurs at a quicker rate than bone formation, resulting in decreased bone mineral density (BMD), by approximately 0.5% each year.¹

In women, bone loss is accelerated after menopause.² This is because the production of the hormone oestrogen, which has a protective effect on bone formation, ceases. Chronic bone loss leads to low BMD and the deterioration of bone tissue, resulting in osteoporosis.² Osteoporosis is a disease which affects millions of people worldwide. It is characterised by low bone mass and micro-architectural deterioration of bone tissue. In Europe, it is suggested that as many as 30 million people will be affected by osteoporosis by the year 2050.³ This number will continue to rise due to increased numbers in the ageing population, with huge cost implications

for the NHS. Treatment for osteoporosis includes medication and lifestyle interventions.

It cannot be denied that nutrition plays a huge role, with adequate intakes of calcium and vitamin D essential for strong bone formation, but additionally physical inactivity and smoking also increases osteoporosis risk.⁴ Therefore, it is essential to implement strategies as early as possible which can assist with bone formation to reduce osteoporosis risk in later life.

CALCIUM

Calcium is an essential mineral and one of the main bone-forming minerals in the body. Calcium has many functions within the body, most notably for the role it plays in ensuring bone health. An adequate supply at all stages of life is, therefore, necessary. Each day, we lose calcium through our skin, nails, hair, sweat, urine and faeces. Our bodies are unable to produce its own calcium, therefore we must source calcium from our diet. If we lack calcium in our diet, our body extracts calcium from our bones to meet demands, which, over a long period of time, can reduce BMD and increase osteoporosis risk.³ Many high quality studies and meta-analyses have concluded that calcium intake is a strong predictor of BMD.^{4,5}



Table 1: Recommended daily allowances: calcium

Group and age	Calcium (mg)
Infants <1yr	525
Children:	
1-3yrs	350
4-6yrs	450
7-10yrs	550
Adolescents: 11-18yrs	
Girls	800
Boys	1000
Adults	700
Pregnant women	700
Breastfeeding mums	1250
Post-menopausal women	1200
Osteoporosis	1000
Coeliac disease	1000
Inflammatory bowel disease:	
Those <55yrs	1000
Post-menopausal women and men >55yrs	1200

Source: COMA, 1991

In the UK, recommended daily allowances (RDAs) have been set to ensure we get adequate amounts of calcium to certify optimal bone health (see Table 1).⁶ Those at increased risk of calcium deficiency include; vegans, anyone following a lactose/milk protein-free diet, those who have already developed osteoporosis, or who present with coeliac disease, or malabsorptive conditions such as irritable bowel disease, those currently breastfeeding, or post-menopausal women.

It is well documented that dairy products, such as milk, yoghurt and cheese, are good sources of calcium. However, it should be acknowledged that there is a wide range of non-dairy and fortified foods on the market which contain high amounts of calcium and should, therefore, be included in the diet to meet calcium demands (see Table 2). However, remember that oxalates (found in spinach, rhubarb, sweet potatoes and walnuts) and phytates (found in wholegrains, seeds, nuts), hinder calcium absorption. Nevertheless, research has shown that soaking these foods or consuming with vitamin C-rich foods can reduce their anti-nutrient effect.⁷ For those unable to meet their RDA via diet, a daily calcium supplement can be beneficial and should be discussed with a GP.

VITAMIN D

It is well recognised that vitamin D also plays a huge role in bone protection - mainly due to increased calcium absorption and muscle support, which, in turn, reduces our risk of rickets, osteomalacia and falls. It should be highlighted that, even if you have a calcium-rich diet but inadequate vitamin D, calcium cannot be sufficiently absorbed, which may result in deficiency and subsequent bone loss.⁸

Vitamin D can be obtained from diet or sunlight. Around 90% of our requirement is synthesised in the skin - this is known as vitamin D3 (cholecalciferol) - with the remaining 10% coming from ingestion of foods - vitamin D2 (ergocalciferol).⁹ As the UK is placed quite far North of the equator, ultraviolet (UV) light is only strong enough to make vitamin D on exposed skin during the months of April to September. Furthermore, SPF 15+ blocks 99% of vitamin D synthesis. This means that for the other six months of the year, it was assumed that we got adequate vitamin D from our body's stores and from dietary sources, therefore, a recommended nutrient intake (RNI) was only established for those solely at risk of vitamin D deficiency, with no RNI been set for those aged 4-65 years 'living a normal life'.

Table 2: Calcium content in various foods

FOOD	PORTION SIZE	Calcium (mg)
DAIRY ALTERNATIVES		
Soya milk- enriched	1/3 pint (200ml)	178
Soya milk- not " "	1/3 pint (200ml)	26
Soya yoghurt- enriched	Small pot (125g)	150
Soya yoghurt- not " "	Small pot (125g)	18
Oat milk- enriched	1/3 pint (200ml)	240
Rice milk- enriched	1/3 pint (200ml)	130
Soya Cheese*	Matchbox size (30g)	400
First Quality Swedish	-	-
Glace ice-cream	100ml	120
Tofu*	Medium portion (100g)	100-500
CEREALS		
Cereals 'enriched'	Medium portion (30g)	135-360
White bread	1 slice (28g)	50
Wholemeal bread	1 slice (28g)	30
Chapatti	1 small (30g)	20
FISH		
Whitebait	Medium portion (80g)	688
Tinned pilchards	2 fish (110g)	275
Tinned sardines	½ can (60g)	300
Breaded scampi	10 pieces (150g)	315
Anchovies	Small tin (50g)	150
Tinned salmon	Medium portion (100g)	91

Source: Food Standards Agency, 2002

FOOD	PORTION SIZE	Calcium (mg)
NUTS/ SEEDS		
Tahini	1 teaspoon (19g)	130
Sesame seeds	1 tablespoon (12g)	80
Chick peas	1 tablespoon (35g)	56
Baked beans	2 tablespoons (80g)	42
Almonds	6 whole (13g)	31
Brazil nuts	3 whole (10g)	17
VEGETABLES		
Okra- stir fried	Medium portion (60g)	132
Curly Kale	Medium portion (60g)	90
Spinach-boiled	1 tablespoon (40g)	64
Broccoli	Medium portion (85g)	34
Cabbage	Medium portion (95g)	31
Watercress	Quarter of a bunch (20g)	34
FRUIT		
Orange juice- enriched	1 glass (160ml)	195
Orange juice- not " "	1 glass (160ml)	16
Orange	1 small (120g)	56
Dried figs	1 (20g)	50
Dried apricots	4 (32g)	23
Currents	1 tablespoon (25g)	23
Dried mixed fruit	1 tablespoon (25g)	18
EVEN WATER!		
Calcium enriched water	1 Litre	300
Hard water**	1 Litre	111
Bottled waters	1 Litre	40-70

People at risk of vitamin D deficiency include those with little exposure to sunlight, for example, babies, elderly people, those living in residential care, those who habitually cover their skin for religious beliefs, those with darker pigment skin and pregnant, or breastfeeding ladies due to increased calcium demands. Furthermore, certain types of liver and kidney disease can hinder production of vitamin D, as it needs to be activated by hydroxylation steps which occur in the liver and kidneys.

Dietary sources of vitamin D are mainly of animal origin, but there are few food sources which are naturally high in vitamin D. Given our geographical location and the lack of vitamin D-rich foods, it is, therefore, not surprising that evidence has emerged showing that many of the UK population have inadequate vitamin D status in the winter months. The National Diet and Nutrition Survey (NDNS) indicated that only 8% of adults aged 19-64 years had low vitamin D levels in July to September, compared with 39% in January to March. Likewise, 2% of children aged 4-10 years had low vitamin D levels in July to September, compared to 32% in January to March.¹⁰

These findings are further supported by a recent high quality report produced by the

Scientific Advisory Committee on Nutrition (SACN), *Vitamin D and Health*, which concluded that vitamin D stores in the UK are insufficient to maintain adequate vitamin D status.¹¹ This resulted in SACN proposing a new RNI of 10ug for all individuals aged four years+. The Department of Health now advise all UK individuals to take a 10ug vitamin D supplement during the winter months.

For those at risk of vitamin D deficiency, consideration should be made regarding supplementation all-year round. See pages 19-22 of this issue for more on vitamin D.

OTHER NUTRIENTS AND BONE HEALTH

While calcium and vitamin D have been the main focus of nutrition in bone health, much research has been undertaken to establish if other nutrients could play a beneficial impact and interesting results have been found.

Phosphorus

An essential bone forming element along with calcium, an adequate supply of phosphorus is required throughout life. Concerns have risen about the high content of phosphorus in Western diets, mainly due to

the large consumption of carbonated drinks.¹² Observational studies suggest that consuming high levels of phosphate is associated with lower BMD and increased fracture risk.¹³ However, this effect was also observed in those with low calcium diets, therefore, the issue may be due to the fact that these individuals are replacing milk with carbonated drinks rather than the phosphorus itself.¹²

Magnesium

This is involved in bone and mineral homeostasis. A small number of studies have shown that magnesium positively correlates with BMD, with low levels contributing towards osteopenia and osteoporosis.^{14,15} Other research has shown that increased intake of magnesium was associated with increased BMD at the hip and radius.¹⁵ However, in many of the studies undertaken, magnesium intake was not examined alone, but rather given in foods such as fruit and vegetables, which produce an alkaline environment resulting in a reduction of calcium excretion.^{15,24} Therefore, additional research should be undertaken to examine magnesium alone on bone health.

Protein

As we know, protein intake increases renal calcium excretion; therefore, high protein diets, which are common in the Western world, may have a detrimental impact on bone health. However, research has been conflicting, with some studies suggesting that protein intake is in fact beneficial for bone health.¹⁶ The Framingham Original cohort has demonstrated a link between low protein intake and increased bone loss and hip fractures in older adults.¹⁷ Another large research study has shown that total protein intake was not associated with hip fracture risk.¹⁸ Therefore, there is no firm evidence suggesting that high protein diets can negatively impact on bone.

B Vitamins

Extensive research has been carried out on this group of vitamins due to their possible impact on bone health. It is well established that B vitamins reduce homocysteine levels and research has shown that elevated homocysteine is a strong risk factor for hip fracture.¹⁹ Observational

studies have produced inconsistent results, with some research suggesting that a low level of B12 correlates with reduced BMD and that B12 preserves BMD and reduces fracture risk.²⁵ Many other studies, however, have found non-significant results, including trials which provided B12 supplementation.^{26,27}

Alcohol

Much evidence, including a high-quality systematic review, has suggested that moderate alcohol intake (<2 drinks per day) can offer protection from poor bone health due to its estrogenic effect, while intakes above this can have a negative impact and should, therefore, be avoided.^{20,21}

Prebiotics

These are classified as non-digestible food ingredients that, when consumed, bring about health benefits via the activity of beneficial micro-organisms. It is well known that prebiotics play an important role in inflammatory conditions. However, a recent high quality review has shown that the use of prebiotics increases calcium absorption in the lower intestines in both animal and human subjects.²² Similarly, a study in post-menopausal women showed that bone resorption was reduced with the ingestion of galacto-oligosaccharides.²³ The beneficial effect is thought to be due to alterations in gut microbiota composition in addition to altered intestinal pH.

CONCLUSION

To conclude, it is well known that diet plays a major role in bone health and in reducing diseases such as rickets and osteoporosis. There is no doubt that adequate amounts of calcium and vitamin D are required to ensure optimal bone health, with recent evidence suggesting that the full UK population should consider a 10µg vitamin D supplement during the winter months and those at high risk perhaps supplementing all-year round. Furthermore, there is interesting evidence around other nutrients such as magnesium and vitamin B12, although more robust research is required before recommendations can be made.