

Indoor Rowing For Bone Health

By Andrew Hamilton BSc Hons MRSC

Indoor rowing is deservedly regarded as a superb method of building cardiovascular fitness and all round muscular endurance, which is great news for anybody wishing to get and stay fit. However, as we become an increasingly ageing population, it's more important than ever that the exercise we do confers us with health as well as fitness benefits. The bad news is that modern Western societies are facing an unprecedented epidemic of osteoporosis, a bone disease that wreaks havoc in the lives of those it affects. The good news is that new research demonstrates that indoor rowing could be the perfect way to maintain bone health. Andrew Hamilton explains...

WHAT IS OSTEOPOROSIS?

Osteoporosis is a disease that affects mainly (but not exclusively) older people in which bones gradually become more fragile and likely to break. These broken bones are also known as fractures and typically occur in the hip, spine, and wrist. Osteoporosis is often known as the 'silent crippler' because it often progresses painlessly and unnoticed, until a bone actually breaks. Although any bone can be affected, fractures of the hip and spine are particularly problematical because they can produce a number of long-term complications including loss of ability to walk and permanent disability, loss of height, severe back pain, deformity and even death.

HOW DOES OSTEOPOROSIS AFFECT BONES?

The term 'osteoporosis' quite literally means 'porous bones'. Contrary to popular belief, bone is not 'dead' or 'inert' material. It is alive and constantly changing. Old, worn out bone is broken down by cells called osteoclasts and replaced by bone building cells, called osteoblasts. This process of constant renewal is called bone turnover. Although the precise mechanisms are poorly understood, osteoporosis affects this process of renewal; the hallmark of osteoporosis is a reduction in skeletal mass caused by an imbalance between bone resorption and bone formation. This results in reduced bone mineral density (BMD).

If you were to look at the interior of your bones under a microscope (see below), you would see that they are comprised of a thick outer shell and a strong inner 'mesh like structure', which is filled with collagen (protein), calcium salts and other minerals. This mesh structure looks a bit like honeycomb, with blood vessels and bone marrow in the spaces between the actual bony structure. Osteoporosis occurs when these spaces become bigger, making the structure fragile and liable to break easily. Unfortunately, once the bone has become 'porous', the mesh like structure cannot be regenerated back to its original dense form (although it can be made stronger – more later).

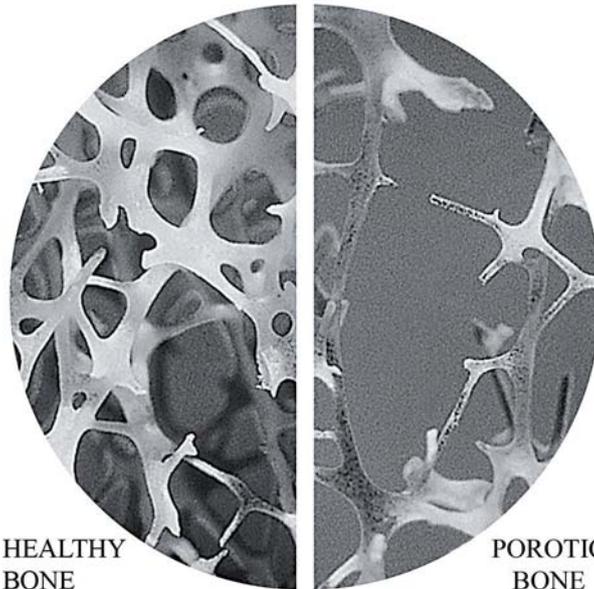


Image courtesy of International Osteoporosis Foundation (www.osteofound.org)

OSTEOPOROSIS FACT AND FIGURES

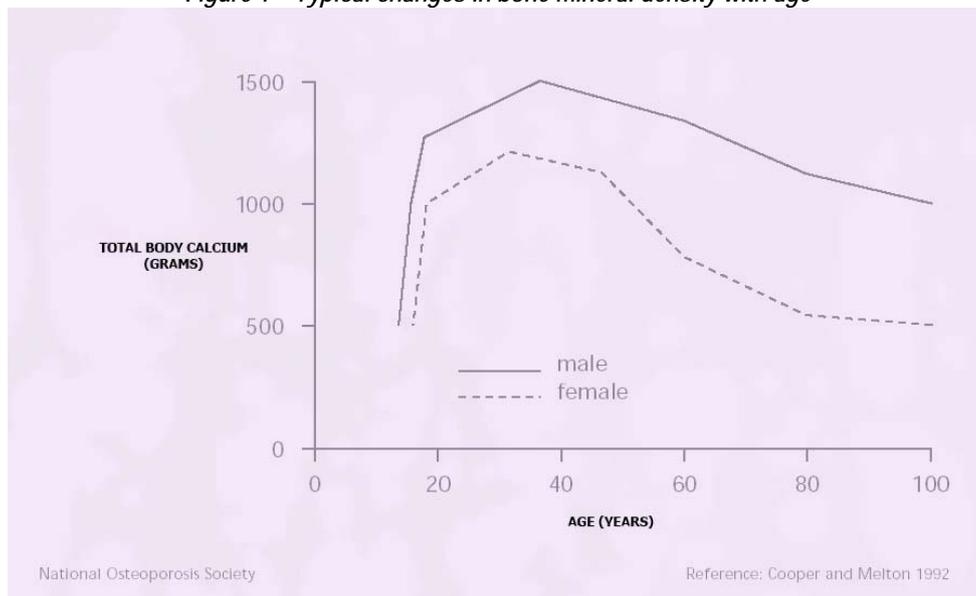
Despite a relative low profile in the media, the facts and figures on osteoporosis are quite shocking:

- *An estimated 3 million people in the UK suffer from osteoporosis;*
- *One in two women and one in five men will suffer a fracture after the age of 50¹;*
- *The lifetime risk of fracture in women at age 50 years is greater than the risk of breast cancer or cardiovascular disease²;*
- *On the basis of current trends, hip fracture rates in the UK will increase from approximately 46,000 per year in 1985 to 117,000 per year in 2016³;*
- *Hip fractures cause more than 1150 premature deaths each month⁴;*
- *A woman who sustains one or more vertebral fractures will have a 4.4 fold higher mortality rate than a woman who has no vertebral fractures⁵;*

Moreover, the consequences of osteoporosis place a huge financial burden on the healthcare system. For example, the combined cost of hospital and social care for hip fracture patients alone amounts to more than £1.73 billion per year in the UK⁶, similar to the £1.75 billion that coronary heart disease costs the NHS each year. The rising incidence of osteoporosis means that the cost of treating osteoporotic fractures in post-menopausal women is now predicted to increase to more than £2.1 billion by 2020⁷, while the total cost of all fractures each year in the UK is currently the same as the predicted cost of London's 2012 Olympics!

The costs of osteoporosis are not just financial however. A hip or spine fracture often leads to extended or even permanent pain, immobility and/or disability, requiring continuing medical treatment. The impact on lifestyle can be devastating; during the first 12 months after a hip fracture more than half of people who could walk unaided prior to the fracture will subsequently be unable to walk independently, while 55% of patients will require assistance at home and a third will experience difficulty sleeping due to pain⁸. Indeed, research has shown that 80% of older women would rather die than experience the reduced quality of life that inevitably follows a serious hip fracture and subsequent admission to a nursing home⁹.

Figure 1 – Typical changes in bone mineral density with age



Graphic courtesy of National Osteoporosis Society (www.nos.org.uk)

WHAT CAUSES OSTEOPOROSIS?

Although we don't yet fully understand the disease process, there are a number of factors that are known to increase the risk of developing osteoporosis. These include:

- **Genetic makeup** - Twin and family studies suggest that osteoporosis has a large genetic component^{10,11};
- **Poor nutrition** – there is a wealth of evidence to suggest that diets low in calcium (the main bone mineral) and vitamin D (which stimulates calcium uptake into body tissues) are associated with an increased risk of developing osteoporosis in later life;
- **Lack of exercise** – being physically inactive is a major risk factor for developing osteoporosis. This is because vigorous physical activity is very effective at stimulating the uptake of calcium into bones, thereby helping to build bone mass in earlier years, and reducing the loss of bone mass in later years¹²;
- **Alcohol and smoking** - An alcohol intake of more than 2 units per day increases the risk of an osteoporotic fracture¹³, while smokers also have a significantly increased risk of having a fracture¹⁴;
- **Menopausal changes in women** - During the menopause the ovaries produce lower levels of the female hormone estrogen, which is essential for bone health. After the menopause the rate of bone loss accelerates, increasing the risk of osteoporosis¹⁵.

The good news is that while you can't change your genetic makeup or age, you *can* considerably reduce your risk of developing osteoporosis by improving your lifestyle. If you are not already, one of the most powerful ways to do this is to become much more physically active.

ROLE OF EXERCISE IN OSTEOPOROSIS PREVENTION

When you're physically active, mechanical loads are transmitted to the bones in two ways; through *gravitational forces* (ie the weight-bearing loading transmitted through bones) and through *muscular pull* (the forces transmitted by muscles to bones they're attached to when you contract those muscles). These effects however are localised; if you want to build bone strength in your femur (main thigh bone), you need to exercise in way that either stresses the femur with gravitational or muscular contraction forces, or even better, both! This explains why for example, in 'one-handed' sports such as tennis, the bone mineral density (BMD) in the dominant arm is much higher than in the other arm.

Research has shown that the higher the muscular and impact load (gravitational) forces, the higher the BMD produced; so for example, gymnasts whose sport requires high loadings and impacts tend to have higher BMDs than endurance runners¹⁶. By contrast, research suggests that those who participate in sports with plenty of muscular motion, but without substantial loading (eg swimming) do not achieve the high BMDs of sports with higher loading¹⁷. There's also evidence that activities that develop strength (such as weight training) are particularly effective at producing high BMDs in the hip and spine^{18,19}.

Muscle strength and muscle mass also appear to be an important determinant of BMD. Studies have shown that the strength of hip abductor muscles is a strong predictor of hip BMD in both pre and post-menopausal women (more strength = higher BMD)²⁰. There are two likely reasons why this is so; larger, stronger muscles are able to exert more loading forces on the bones they attach to; secondly, larger muscle masses are associated with higher body weight, which thus increases the gravitational loading on bones.

GROUND REACTION FORCE IN EXERCISE

To stimulate bone strengthening, any exercise must load the bones significantly more than the normal activities of daily living. In particular, the concept of a 'Ground Reaction Force' (GRF) has become a popular way to assess the potential benefit of a particular mode of exercise. The term GRF commonly describes the forces that are produced in the bones when we decelerate a limb, for example footstrike during running or walking, or landing after a gymnastics jump.

These deceleration forces can temporarily far exceed the normal forces experienced by our bones when we're motionless. For example, GRFs at the lumbar spine during weight training can exceed 5-6 times body weight²¹, while GRFs of 10-12 times body weight have been observed in gymnasts²². Although there are a number of ways of producing sufficient force within bones to stimulate strengthening, the notion of working against gravity and using decelerative forces created by impact (eg by walking or jogging) as the most efficient way to strengthen bones has rapidly gained currency among health professionals. However, the reality is not quite so straightforward as we shall see; walking alone has *not* been shown to be an effective way of arresting BMD loss in post-menopausal women²³.

INDOOR ROWING AND BONE HEALTH

Before we discuss the role of indoor rowing in helping to prevent osteoporosis, let's just recap on what we've already learnt:

- The higher the loading on the bones during exercise, the greater the potential for bone strengthening;
- Loading can arise from both muscular pull and gravitational forces;
- The more muscles involved in loading the better, because more bones will be affected (remember the loading effect via muscles is localised to the bones to which they're attached);
- High loadings can arise from strong muscular pull, from large deceleration forces during impact, or a combination of the two;
- Higher muscle mass favourably affects BMD (through increased ability to generate muscular pull and higher body weight, which increases GRFs during impact activities).

The generally accepted consensus among many health professionals is that high-impact weight-bearing exercise (which produces high GRFs via deceleration) is the best exercise for bones, while low impact exercise such as rowing, cycling, swimming etc. is not nearly as effective. However,

while a number of studies have indicated that swimming is less effective than weight-bearing exercise for increasing/maintaining BMD, this is a gross over-simplification.

If you consider the checklist above, it's clear that the physiological demands of indoor rowing are very much in line with those required to build bone density:

- Rowing requires muscular strength and power in addition to endurance; this means that large amounts of muscular loading via muscular pull are generated during rowing;
- Rowing works a large number of muscles, which means that many bones are loaded;
- Rowing develops lean muscle mass, which is positively correlated to BMD;
- Rowing generates large forces in the spine – excellent for building BMD in the vertebrae (more later).

Yes, it lacks the impact-generating forces associated with running, but that isn't necessarily a disadvantage.

WHAT DOES THE RESEARCH SAY?

To properly assess the efficacy of rowing for bone health, we need to consult the scientific literature, and the good news for would-be indoor rowers is that rowing appears to offer very substantial benefits. Some of the research studies carried out in the last 15 years, which provide positive evidence for the bone health benefits of rowing include:

- A study carried out on male rowers, triathletes and sedentary subjects (controls), which found that rowers had significantly higher BMD in the spine and total BMD than the triathletes (whose sport includes high-impact generating running) and of course the sedentary controls²⁴. The researchers concluded that this was most likely due the increased lean muscle mass and strength induced by the rowing training;
- A study on the effects of an 18-month rowing program on 14 adolescent female rowers and 10 matched controls, which found that the accretion of BMD in the lumbar spine area was significantly greater (over 6% higher) in the rowers compared to the controls²⁵.
- A study on 14 female rowers and matched controls, which found that not only did the rowers have higher BMD in the lumbar spine, but also that during a 6-minute race on the Concept 2 Indoor Rower, the muscular pull forces generated in the region of L4-L5 were equivalent to 4.6 times body weight²⁶. Interestingly, these forces compare favourably with those during weight training, which is widely considered as one of the very best bone building exercises;
- An 11-month study on thirty-nine women aged 60-74 years, which compared the effects of joint-reaction forces (JRF - muscular pull generated through weight training and rowing) on BMD with those of ground reaction forces (GRF - impact activities; walking, jogging and stair climbing) and with sedentary controls²⁷. The BMD of the whole body, lumbar spine, proximal femur, and distal forearm was assessed five times at approximately 3-month intervals. The results showed that compared to the controls, the GRF and JRF exercise programs resulted in significant and similar increases in BMD of the whole body, lumbar spine, and Ward's triangle region of the proximal femur. The researchers also found that the JRF exercise program (but not the GRF) produced increases in lean body mass and strength. This is interesting because research has also shown that higher levels of muscular strength are associated with a reduced risk of falls (and therefore fracture) in the elderly²⁸.

THE IMPACT OF IMPACT EXERCISE

As we've seen, you don't necessarily need impact-generated forces to help increase bone density. Because of its strength demands, a properly constructed rowing program is more than capable of producing the beneficial bone health effects described above. And that's good news because the kind of exercise that generates impact forces (*eg* jogging, running, skipping etc.) has a major drawback; that impact is also transmitted through the joints, which places additional stresses and strains on the joints, especially the joint cartilage.

While this is not a problem for the average 25-year old with healthy joints, it could be a very great problem for an older person whose joints may be already affected by arthritis or other degenerative conditions. Indeed, given that maintaining BMD becomes ever more important with increasing age, the very people who stand to gain from impact exercise are the same group who are potentially most adversely affected by it.

Moreover, because bone building requires regular exercise over a period of months and years to produce a really significant effect, the cumulative effects of high-impact exercise over such an extended period could be quite severe.

But there's good news here too as new research on 60 rowers, cross-country runners, swimmers and sedentary controls has indicated that indoor rowing can offer the best of both worlds to the older person; large bone building benefits with low stresses on the joints²⁹.

In the study, the researchers looked at urinary levels of two compounds following exercise. NTx is a bone reabsorption marker; higher levels mean the body is actively taking up the nutrients required to build bone. CTx-II on the other hand is cartilage stress marker; higher levels indicate more that the cartilage in joints has been subjected to more stress.

The study compared the post-exercise levels of NT-x and CTx-II in the rowers, cross-country runners and swimmers, and also compared these levels with those from a control group who were inactive. The results were as follows:

- The bone building marker NTx was highest of all in the rowers, and higher in rowers and runners than in the swimmers or controls;
- The cartilage degradation marker CTx-II was significantly higher in runners than in rowers, swimmers or the controls;

The researchers concluded that although running (traditionally regarded as one of the best bone building exercises) produced more bone growth stimulus than swimming, it did so at the cost of the high levels of cartilage stress. Rowing on the other hand seemed to offer the best compromise of the all – the highest amount of bone growth stimulation without the degree of cartilage stress produced by running!

CONCLUSION

Osteoporosis is a serious and growing health problem, which will affect many people as they enter the later years of their life. A healthy lifestyle can play a major role in reducing the risk of osteoporosis and one of the most powerful ways to achieve this is by ongoing, regular physical exercise sustained throughout mid and later life. There's a common misconception that only weight bearing and impact type exercise can effectively build bone, but this is not true. Any exercise that loads the bones sufficiently can increase bone mass.

Numerous scientific studies have confirmed that rowing fulfills this criterion and is an effective means of building BMD. Moreover, it offers other benefits; it's especially effective at building spinal BMD, it helps increase lean body mass, which is also associated with increased BMD and also

develops muscular strength and power, which may help to reduce the risk of falls in the elderly. A further advantage is that rowing is kind to joints and cartilage, which is another advantage for the older person. No one exercise can ever be perfect, but rowing is probably as close as it gets!

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NB – If you have already been diagnosed with osteoporosis, you should seek medical advice before commencing a rowing program.

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