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Strong, steady and straight: UK consensus statement on physical activity and exercise for osteoporosis

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► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bjsports-2021-104634).

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Accepted 28 March 2022

To cite: Brooke-Wavell K, Skelton DA, Barker KL, *et al*. *Br J Sports Med* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/bjsports-2021-104634

ABSTRACT

Exercise and physical activity can improve bone strength and the risk of falls, which may offer benefits in the prevention and management of osteoporosis. However, uncertainty about the types of exercise that are safe and effective instigates lack of confidence in people with osteoporosis and health professionals. Existing guidelines leave some questions unresolved. This consensus statement aimed to determine the physical activity and exercise needed to optimise bone strength, reduce fall and fracture risk, improve posture and manage vertebral fracture symptoms, while minimising potential risks in people with osteoporosis. The scope of this statement was developed following stakeholder consultation. Meta-analyses were reviewed and where evidence was lacking, individual studies or expert opinion were used to develop recommendations. A multidisciplinary expert group reviewed evidence to make recommendations, by consensus when evidence was not available. Key recommendations are that people with osteoporosis should undertake (1) resistance and impact exercise to maximise bone strength; (2) activities to improve strength and balance to reduce falls; (3) spinal extension exercise to improve posture and potentially reduce risk of falls and vertebral fractures. For safety, we recommend avoiding postures involving a high degree of spinal flexion during exercise or daily life. People with vertebral fracture or multiple low trauma fractures should usually exercise only up to an impact equivalent to brisk walking. Those at risk of falls should start with targeted strength and balance training. Vertebral fracture symptoms may benefit from exercise to reduce pain, improve mobility and quality of life, ideally with specialist advice to encourage return to normal activities. Everyone with osteoporosis may benefit from guidance on adapting postures and movements. There is little evidence that physical activity is associated with significant harm, and the benefits, in general, outweigh the risks.

BACKGROUND

It is estimated that 137 million women and 21 million men have high osteoporotic fracture risk globally, with this prevalence expected to double in the next 40 years.[1] Fractures of the hip and spine can lead to loss of independence, disability and reduced life expectancy.[2] Vertebral fractures are associated with long-term pain and other physical and psychological symptoms,[3–5] whereas hip fractures are associated with increased morbidity and mortality.[6 7]

Current approaches to reduce fracture incidence include identifying people with significant fracture risk and prescribing pharmaceutical treatment, using education and support to promote adherence to medication, and developing falls prevention strategies especially for those who are older and frailer.[8 9] Additional preventive strategies include healthy eating with adequate calcium and vitamin D, not smoking or consuming excessive alcohol and being physically active in adolescence and young adulthood to maximise peak bone mass.[8 9]

Epidemiological and intervention studies provide evidence of a strong relationship between physical activity, exercise and bone health, with regular exercisers having a lower incidence of fracture.[10] Exercise can both increase bone mineral density (BMD) and reduce falls risk. However, there is still uncertainty about whether increasing volume and intensity of exercise, especially in later life or when bone strength is compromised, will improve bone strength, and importantly, what type or intensity of exercise intervention is most beneficial.

Osteoporotic fractures may be precipitated by a fall or with loading during activity. People with osteoporosis and health professionals are thus concerned that physical activity could increase fracture risk, although evidence to support these concerns is limited. Uncertainty persists about what is appropriate and safe in people with, or at risk of, osteoporosis, and may be accompanied by concerns about liability. As a result, people significantly reduce activity levels, limiting both function and enjoyment.[11] This may have important adverse implications for their bone health, falls and future fracture risk.

For the vast majority of adults and older adults, taking part in activities that promote muscle and bone strength is safe and will help to maintain or improve function, irrespective of age or health.[12–14] Providing authoritative and effective guidance may prompt an increase in physical activity and exercise. This will have wider beneficial effects on physical, social and psychological health[14 15] alongside physical literacy, including physical competence, knowledge and understanding, to engage in physical activities for life.[16]

There is no UK guidance on exercise and osteoporosis. Although there is international guidance on safe and effective exercise and physical activity for bone health, from the USA,[17] Australia[13] and Canada,[18] some key questions remain unanswered.

These include the appropriate intensity of exercise interventions for those with diagnosed osteoporosis, whether there are real harms from any particular types of exercises or activities, and whether or how to modify physical activity for specific 'fracture risk' groups.

OBJECTIVE

The objective of this consensus statement is to provide guidance on the role of exercise and physical activity in the prevention and management of osteoporosis.

The specific aims are to:

- Clarify the role of physical activity and exercise for optimising bone strength and reducing falls and fracture risk.
- Clarify the role of physical activity and exercise in managing the pain and symptoms of vertebral fracture.
- Review any safety issues of exercise for those with osteoporosis, to address fears of causing fractures (particularly in the spine) while engaging in exercise or day-to-day physical activities.
- Promote confidence and a positive approach so that people with osteoporosis do *more* rather than *less* exercise and physical activity.
- Ensure consistent advice for people with osteoporosis so that people can exercise safely and effectively.

The target population is people with osteoporosis, who have bone mineral density measured by dual X-ray absorptiometry in the osteoporotic range or a significant fracture risk based on a fracture risk assessment score, with or without fragility fracture. Separate consideration is made for those with vertebral or multiple low trauma fractures and for those who are living with frailty and are unsteady or experiencing falls. Physical activity includes any activity, whatever the purpose, that increases energy expenditure, while exercise is structured physical activity performed to enhance or maintain performance or health.

This document updates the principles underpinning previous guidance on exercise and physical activity and distils current research evidence for people with osteoporosis.[19] This guidance is developed for clinicians, including physiotherapists and exercise practitioners, as well as policy makers, and is designed to inform clinical practice and policy.

METHODS

Developing scope through stakeholder consultation

To determine the scope and content for the consensus statement, stakeholder consultations were undertaken in 2017. First, face-to-face stakeholder discussion groups were held. Two groups consisted of people with osteoporosis; both were recruited through the Royal Osteoporosis Society database of members in two UK areas of differing socioeconomic status (Camerton and Stoke-on-Trent). A further stakeholder group in Camerton involved exercise and health professionals, again recruited through local Royal Osteoporosis Society contacts and professional members. Discussions were facilitated by ZP, using a discussion guide (online supplemental appendix I), to explore perceptions of the importance and role of exercise, identify areas of uncertainty and to seek views on the provisional content framework for the consensus document. The discussions were audio-recorded, written field notes taken and a summary of the main discussion themes produced.

Second, an online/telephone survey was distributed to people affected by osteoporosis and interested health professionals recruited through Royal Osteoporosis Society members, healthcare professionals and social media channels. Participants provided 'free text' responses about what they felt were the key issues and uncertainties about exercise and osteoporosis (online supplemental appendix II). These were entered into a spreadsheet and structured according to categories and themes.

Refining scope through exercise expert consultation

A UK Expert Exercise Steering Group (EESG) consisting of 12 clinical and academic experts developed the consensus statement (online supplemental appendix III). This group included four physiotherapists, three rheumatologists, three academics and an osteoporosis specialist nurse; all but one of whom were female. Nine were clinically active with mean (SD) 18 (13) years of clinical experience, and ten were research active with 18 (11) years research experience. A wider UK Exercise Expert Working group (EEWG) consisted of a further 16 experts: nine physiotherapists, two patient representatives, two patient advocates, an exercise instructor, nurse and physiologist; 13 female and 3 male (online supplemental appendix III). Experts were selected to provide relevant clinical, research expertise and/or lived experience, often through contacts of the Royal Osteoporosis Society clinical and scientific advisory committees, or professional bodies (such as the Chartered Society of Physiotherapists).

The scope was refined by the EESG by teleconference and email, and evidence synthesised. The scope and evidence were then reviewed in a full day, face-to-face meeting of the EESG and EEWG in London in September 2017. A summary was circulated, with all members invited to comment.

Literature search strategy

The EESG identified several international osteoporosis and falls prevention guidance documents, meta-analyses and systematic reviews. These have synthesised the published evidence, agreed key principles and reported evidence[12 20–46] and consensus-based guidance.[12 13 17 18] The EESG agreed a pragmatic approach to review and update existing literature reviews and that a further systematic review of all the scientific and clinical evidence was not indicated. We thus repeated the searches conducted in previous systematic reviews of exercise and BMD[43]; falls[47] and outcomes after vertebral fracture.[44]

Limited literature was available on the adverse events and safety issues associated with physical activity and exercise for adults with osteoporosis and osteopenia so a systematic review was undertaken that has been published separately.[48]

Formulation of recommendations

Reviews of literature were circulated to the EESG and EEWG. It was agreed that, as there was inevitably limited evidence to answer some of the core questions, the statement would need to base some recommendations for best practice on agreed principles. It would also aim to provide some 'standard responses' to common questions to aid meaningful discussion between practitioners and the people they are treating or working with. Where appropriate, key statements or standard responses were agreed using discussion and modifying wording as needed to reach consensus across the EESG and EEWG, which was confirmed by email after each draft. Recommendations were made in each section based on either the evidence reviewed (marked E) or expert consensus (marked C) where limited or no research evidence was available and unanimous agreement across the EESG and EEWG was achieved.

The EESG then developed the draft statement and presented it for review by the EEWG at a second face-to-face meeting in London in March 2018. This involved more detailed discussion

of the wording. Final changes were approved by email with each member of EESG and EEWG providing confirmation that they agreed with the final principles and recommendations.

Consultation strategy

The draft statement was endorsed by the Royal Osteoporosis Society clinical and scientific committee. It was disseminated to stakeholders, including partnership organisations (online supplemental appendix IV). Public consultation was sought (through the Royal Osteoporosis Society website) from September to October 2018. Feedback was collated on a spreadsheet according to the strong, straight and steady themes. Any changes were initially reviewed by the editorial group (DAS, SL, EMC, KB-W) before being circulated for discussion/agreement by expert groups. An online meeting of the EESG was then held in October 2018 to review all changes.

RESULTS

Outcome of stakeholder consultation

Stakeholder meetings for those with, or at risk of, osteoporosis were attended by 27 people (25 postmenopausal women with osteoporosis with two of their spouses). The professionals' stakeholder meeting was attended by 13 health or exercise professionals (four physiotherapists, three osteoporosis specialist nurses, three Pilates instructors and three health professionals with osteoporosis).

The stakeholder group discussions identified that people with osteoporosis viewed exercise and physical activity as very important with wide-ranging benefits on health and well-being, and areas of frustration, about being given no, conflicting or negative 'don't do' exercise advice by health professionals. Areas of uncertainty, for both non-professionals and professionals alike included what exercise was 'best' and safe to improve specific and general bone and muscle strength, dependent on ability. People with osteoporosis wanted more specific information about exercise regimens to guide safe functional activity, and professionals wanted more information about how to tailor advice, dependent on patient characteristics.

A total of 880 stakeholders participated in the online survey. Of those who provided demographic information, >70% were aged between 56 and 75 years; 772 (94%) described their ethnic origin as 'white' and 782 (96%) said they were female. Most respondents were people with osteoporosis: 521 (61%) diagnosed from a bone density scan; 83 (10%) reported one spinal fracture and 114 (13%) reported more than one spinal fracture; 148 (17%) had other fragility fractures; 44 (5%) said they were less mobile and unaccustomed to regular exercise. One hundred and thirty-nine respondents (16%) were health professionals.

Of the respondents who provided specific queries, 44% wanted to know what exercise was effective for strengthening bones (including specific questions on type, intensity and duration, or site-specific exercise) and 38% wanted to know about the role of exercise in prevention or management of vertebral fractures. Over a third had questions about the safety of specific exercises, such as Pilates or yoga positions. Questions about equipment, including vibration platforms, were asked. There was substantial uncertainty about what exercise was effective or safe, from both health professionals and those with osteoporosis.

The preferred format for receiving information was leaflets (90%) online video clips (59%) and DVDs (36%).

Outcome of refining scope through exercise expert consultation

The EESG consideration of scope concluded that two key themes arose from stakeholder consultations: what exercise is effective in increasing bone strength, and what exercise is safe and appropriate for those with, or at risk of, vertebral fractures. Given that the majority of fractures result from a fall, the EESG added exercise for falls prevention as a further theme. User consultation in stakeholder discussion groups (as described above) was undertaken to identify acceptable terminology for these themes, resulting in the following:

- **Strong**: physical activity and exercise to benefit bone strength;
- **Steady**: physical activity and exercise to prevent falls;
- **Straight**: physical activity and exercise to reduce risk of vertebral fracture, improve posture and manage symptoms after vertebral fracture.

Under each theme recommendations were specified for:

- All people with osteoporosis. People with osteoporosis were defined here as someone with BMD in the osteoporosis range (a dual energy X ray absorptiometry (DXA) bone density scan measurement T-score <-2.5) **or** a significant fracture risk (based on fracture risk assessment) **with or without fragility** fractures (including vertebral).
- People with vertebral fractures or multiple low trauma fractures (the latter group may be at more significant risk of vertebral fracture during exercise).
- People living with frailty and unsteadiness or those experiencing falls.

Interventions of interest included exercise or other physical activity. Outcomes included BMD or other proxies of bone strength, falls, fracture incidence, spinal curvature/posture and pain related to vertebral fracture. Recommendations were intended to be applicable for community, primary and secondary care settings.

Literature search

The updated searches from previous systematic reviews of exercise and BMD,[43] falls[47] and outcomes after vertebral fracture[44] yielded 35, 19 and 3 new trials, respectively.

Safety of exercise in people with osteoporosis or fragility fractures

Information from three sources was reported: observational and case studies reporting circumstances of osteoporotic fracture; reports of exercise interventions in people with osteoporosis; adverse event reporting from exercise interventions to increase bone strength and to reduce falls risk.

A few case studies described instances of vertebral fractures during horse riding or during a golfing mid-swing stroke.[48] However, the majority of observational or non-randomised studies in people with osteoporosis did not report adverse events, apart from muscle soreness and joint discomfort.[44 48] There were some reports of vertebral fractures associated with end-range, sustained, repeated or loaded flexion exercises, including sit-ups[49] and some yoga positions involving extreme spinal flexion.[50] One study reported fractures associated with rolling from prone to supine and dropping a weight on a foot.[51]

In exercise interventions designed to increase BMD, many studies did not report whether there were adverse events. Of 62 trials, 11 reported fractures[48] over the course of the studies but rarely due to the intervention itself. Overall, 5.8% of intervention group participants sustained fractures compared with 9.6% of control group participants.[48] In particular, there was no evidence of symptomatic vertebral fracture in association with impact exercise or moderate to high-intensity muscle-strengthening exercise.[48] Closely supervised high-intensity

resistance and impact training in osteoporotic men and women was associated with few adverse effects and no vertebral fractures.[52 53] In a further study of strength, balance and daily moderate to vigorous physical activity in people with osteoporosis, adverse events (both falls and fractures) did not differ significantly between the control and the intervention groups.[54] These trials demonstrate that exercise can be conducted even in those who already have osteoporosis.

In studies on exercise for fall prevention, only 27 out of 108 trials reported adverse events and only one study reported a (pelvic stress) fracture.[21] There is some evidence that brisk walking increased fracture risk in a population already at risk of falls and fracture, who may therefore require strength and balance exercise to improve stability before embarking on brisk walking or fatiguing exercise.[47]

Overall, there is little evidence of harm, including fractures, occurring while exercising. Furthermore, cases that were identified comprised a mixture of people with and without osteoporosis (as defined by DXA). Exercise is therefore unlikely to cause a fracture (and specifically a vertebral fracture) and does not need to be adapted for those with osteoporosis according to fracture risk or low BMD (including osteoporosis or osteopenia determined by DXA).

Strong: physical activity and exercise to promote bone strength and prevent fractures

Research evidence underlying recommendations is summarised in online supplemental appendix V. This evidence was considered alongside previous guidance[12 13 17] and EESG consensus to agree recommendations (Box 1).

The combination of impact and progressive resistance training best promotes bone strength[43] as reflected in other national guidance.[12 13 17 18]

Resistance exercise is ideally supervised to ensure good technique and minimise injury risk,[13 18] with interventions starting with lower loads while correct technique is attained. For consistent gains, resistance exercise should be progressive—that is, loads gradually increased.[55] The ultimate intensity recommended previously was 8–12 repetitions maximum (RM)[18]—that is, the maximum weight that could be lifted 8–12 times or 8 repetitions at 80–85% 1 RM[13]—that is, 80–85% of the maximum load that could be lifted just once. Both recommend increasing to two to three sets. EESG consensus was that recommending an 8–12 RM was easier to implement outside a formal laboratory setting, although supervised progressive resistance training at higher intensity is likely to have greatest effects on BMD.

Resistance exercises involving major muscle groups should be used to load skeletal sites at risk of osteoporotic fracture, such as the spine, proximal femur and forearm. This may be achieved through one exercise each for legs, arms, chest, shoulders and back using exercise bands, weights or body weight,[18] or eight exercises targeting major muscle groups of the hip and spine, including weighted lunges, hip abduction/adduction, knee extension/flexion, plantar–dorsiflexion, back extension, reverse chest fly, and abdominal exercises[13] (while avoiding loaded spinal flexion). The latter recommendation could be replaced by fewer compound movements, such as squats and dead lifts. Such activities should be performed on two or three days of the week. While evidence relates to progressive resistance training, performed usually in a formal exercise setting or using specialist equipment, such activities are undertaken by only a small proportion of the population.[56] To enable activity, EESG consensus was that other sports or leisure activities that might promote muscle strength should also be encouraged, such as circuit training, rowing, Pilates or yoga, stair climbing, sit to stands, heavy housework or gardening and carrying shopping, although repeated or end-range flexion should be avoided in these activities (figure 1).

Weightbearing or impact activity includes running, jumping, aerobics, some forms of dancing and many ball games and sport. As it does not necessarily require specialist facilities or equipment, this can be more accessible for many people than resistance exercise. Previous guidance recommends aerobic exercise for 30 min per day, 5 days a week,[18] to comply with recommendations for other health outcomes, but this may not necessarily include exercise with sufficient gravitational loading to increase bone strength. Australian recommendations are more specific in suggesting impact exercise on 4–7 days per week, with each session including 50 jumps: 3–5 sets of 10–20 repetitions with 1–2 min rest between sets.[13] They recommended high intensity (>4 times body weight (BW)), which may be encountered

Box 1 Recommendations for exercise to promote bone strength

For all people with osteoporosis

- Muscle-strengthening physical activity and exercise is recommended on two or three days of the week to maintain bone strength. [E]
- For maximum benefit, muscle strengthening should include progressive muscle resistance training. In practice, this is the maximum that can be lifted 8–12 times (building up to three sets for each exercise). Lower intensity exercise ensuring good technique is recommended before increasing intensity levels. [E]
- All muscle groups should be targeted, including back muscles to promote bone strength in the spine. [C]
- Daily physical activity is recommended as a minimum, spread across the day and avoiding prolonged periods of sitting. [C]

In addition:

For people with osteoporosis who do not have vertebral fractures or multiple low-trauma fractures

- Moderate impact exercise is recommended on most days to promote bone strength (eg, stamping, jogging, low-level jumping, hopping) to include at least 50 impacts per session (jogs, hops etc). [C]
- Brief bursts of moderate impact physical activity should be considered: about 50 impacts (eg, 5 sets of 10) with reduced impact in between (eg, walk-jog). [C]

For people with osteoporosis who have vertebral fractures or multiple low trauma fractures

- Impact exercise on most days at a level up to brisk walking is recommended, aiming for 150 minutes over the week (20 min per day). This a precautionary measure because of theoretical (unproved) risks of further vertebral fracture in this group. [C]
- Individualised advice from a physiotherapist is recommended for both impact and progressive resistance training to ensure correct technique, at least at the start of a new programme of exercise or activity. [C]

For people with osteoporosis who are frail and/or less able to exercise

- Physical activity and exercise to help maintain bone strength should be adapted according to individual ability. [C]
- Strength and balance exercise to prevent falls will be needed for confidence and stability before physical activity levels are increased. In practice, falls prevention may be a priority. [C]

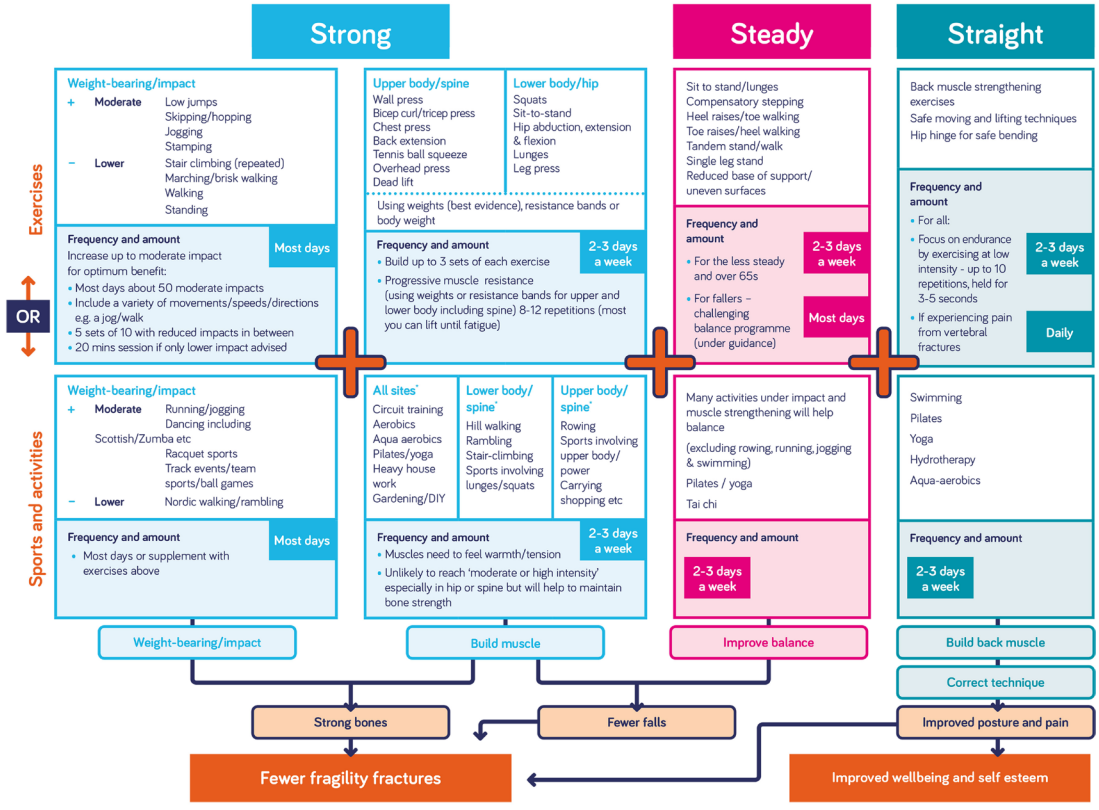

Figure 1 Summary of exercise recommendations (from Royal Osteoporosis Society).[63] Most research evidence is based on formal exercise. The suggested sports and activities include some with research evidence and some that may safely help engagement in activity and improve quality of life based on expert consensus.

in gymnastics or drop jumps) for those without osteoporosis, and 2–4 BW for those at moderate risk of osteoporosis. Because of the lack of evidence of greater benefit of the high versus moderate intensity, EESG consensus was to recommend moderate impact exercise, such as jumps, skipping, hopping, running, higher impact forms of dance such as Scottish dancing or Zumba, or ball sports (figure 1) but not very high impact exercise such as landing from height. Consistent with Australian guidance,[13] the recommended volume and frequency was ~50 moderate impacts interspersed with rest pauses, on most days.

People with vertebral fractures or multiple low trauma fractures, will have greater general bone fragility and a higher risk of further fracture. The expert group consensus was more cautious about moderate impact exercise in these people. A discussion about personal preferences and concerns is recommended to aid decisions about amending or excluding specific leisure or sports activities. An individualised progressive tailoring of intensity of both impact and muscle-strengthening exercise, under supervision, would often be appropriate. Gradually increasing impact up to 'moderate' could be appropriate depending on the number of vertebral fractures and symptoms experienced; other medical conditions, level of fitness or previous experience of moderate impact activity before the vertebral fracture need to be considered.

When starting an impact or muscle-strengthening programme, factors including general fitness, previous exercise and comorbidities should be considered in everyone. Building up gradually, employing good technique, and monitoring both progress and any adverse effects, is the best approach. Urinary incontinence may be a barrier to impact exercise so addressing stress incontinence may be a necessary step to being able to implement such an exercise programme. Learning best possible posture and correct technique is recommended as part of any progressive muscle resistance training. Balance and muscle strength training will be important for those at risk of falling before increasing to activities such as brisk walking.

Some sports and leisure activities involve an inherent risk of injurious impact, falling and fracture, such as contact sports, horse riding and skiing.[48] However, for those who practice these regularly, the benefits provided by the activity, including enjoyment and benefits to muscle and bone strength, are likely to outweigh the risks unless people have had multiple fragility fractures or painful spinal fractures. People with osteoporosis may need some reassurance to continue with activities they enjoy.

Steady: exercise and physical activity to prevent falls

Research evidence is summarised in online supplemental appendix V and recommendations in Box 2. Substantial evidence suggests that targeted strength and balance training can prevent falls.[21] Such specific exercise may be accessed by referral to a falls service for those who have experienced falls or are limiting activity though fear of falling.

Strength and balance training is recommended that is individualised, supervised by a health or exercise professional, highly challenging and conducted for 3 hours per week over at least 4 months, in line with previously published evidence.[21] The consensus opinion was that following such exercise, weight-bearing activities such as brisk walking could be introduced.

For people who are not eligible for a falls service, the consensus was that activities that improve balance and muscle strength,

Box 2 Recommendations for exercise to reduce falls

For all people with osteoporosis (particularly those aged 65 or who have poor balance)

- Physical activity or exercise to improve balance and muscle strength is recommended. [E]
- Balance and muscle strength exercise (including activities such as Tai Chi, dance, yoga and Pilates) are recommended at least twice a week to reduce the risk of falls especially in older age. [C]

For people with osteoporosis who are already having falls

- People who fall repeatedly or have started to avoid activity as a result of concern about falling, should be referred to a local falls service. [C]
- Exercise interventions to prevent falls should be tailored to suit the individual to ensure that they challenge balance without increasing falls risk. [E]
- Specific and highly challenging balance and muscle-strengthening exercises, supervised by a trained health or exercise professional, are recommended. [E]
- Highly challenging balance and muscle strength training for 3 hours a week over at least 4 months is recommended—this could be around 25 min/day or 3×1 hour sessions a week. [E]
- The Otago or Falls Management Exercise (FaME) programmes are recommended. [E]
- Gradual progression from strength and balance exercises to higher impact exercise (such as brisk walking) is recommended for the frailer older adult to prevent an increase in falls risk. [C]
- Exercise to strengthen back muscles and improve posture should be considered to reduce falls risk. [C]
- Advice about reducing falls risk should be communicated in a positive way to be relevant and effective. [E]

such as Tai Chi, dance, yoga or Pilates could be conducted, at least twice a week in line with physical activity guidance.

As kyphosis may increase fall risk, consensus was that exercise to strengthen back muscle (particularly of spinal extensors) and improve posture should also be recommended to reduce falls risk.

How professionals communicate the benefits of falls prevention exercise is important. Most people do not perceive themselves as fallers or as frail. People need to be motivated to take part in falls prevention exercise using appropriate language, such as 'maintaining independence' and 'reducing the risk of fractures' rather than 'fall prevention'. Emphasising the importance of balance to feel confident and be able to enjoy other activities may also be useful.[57]

Straight: modifying physical activity and exercise to reduce risk of vertebral fracture, improve posture and manage symptoms after vertebral fracture

Given the limited evidence about how to reduce risk of vertebral fracture during activity, and the role of exercise in improving kyphosis and managing vertebral fracture (online supplemental appendix V), recommendations (Box 3) are consensus rather than evidence based and take into account previous consensus statements.

The risks of exercise were found to be relatively low[6] and the benefits of exercise to health and well-being are substantial,[12–14]

Box 3 Recommendations to reduce risk of vertebral fracture, improve posture and manage symptoms of vertebral fracture

For all people with osteoporosis

- A positive and reassuring approach is recommended to reduce fear, enhance confidence and control - 'how to' rather than 'don't do', especially as most people with osteoporosis are unlikely to experience a vertebral fracture during these activities. [C]
- Exercises to improve muscle strength in the back are recommended to improve posture and support the spine. Aim for exercises repeated 3–5 times and held for 3–5 s at least twice a week. [C]
- Safe techniques for day-to-day moving and lifting are: [C]
  'Think straight'—a straight upper back (and keeping the neck in line with the spine) is the key principle for all movements that involve bending and lifting.
  However, recognising the natural curves in the back, flexibility and function remain important and should be encouraged.
  Safe lifting techniques are recommended rather than instructions such as 'don't lift' or 'only lift up to a specific weight'.
  The 'hip hinge' is a simple technique for safe bending that facilitates this and can be practised and integrated into all day-to-day movements.
  Always move in a smooth, controlled way within a comfortable range. Rotation (twisting) movements should be safe if performed smoothly and comfortably.
  Engage abdominal muscles during movements.
- Movements or exercise that involve sustained, repeated or end-range flexion should be modified or avoided. [C]
- Any exercise that causes the back to curve excessively especially with an added load should be modified or avoided. [C]
- People who are experienced, demonstrate flexibility in the spine and can manage the moves comfortably and smoothly, should be advised that they can continue with these activities as long as they are fit enough to manage them with ease. As a precaution, alternatives to exercises such as the 'roll down 'and 'curl up' in Pilates should be considered. [C]
- Correct form and technique is important [C]

For people with osteoporosis with vertebral fracture

- Prompt moving and lifting advice is recommended soon after painful vertebral fractures to reduce fear and maintain mobility and function. [C]
- A referral to a physiotherapist will be helpful although some advice will also be important as soon as possible after a painful fracture. [C]
- Daily exercises to strengthen back muscles (with a focus on endurance by exercising at low intensity), reduce muscle spasm, relieve pain, improve flexibility, and promote best possible posture are recommended with a referral to a physiotherapist for tailored advice. Aim for repeated exercise 3–5 times and held for 3–5 s. [C]
- Maintaining physical activity and exercise is recommended to address pain and improve well-being. [C]
- Professionals should explain how exercise interventions may help with back pain as people are fearful that exercise will make pain worse. [C]

Continued

Box 3 Continued

- Yoga and Pilates and similar exercise programmes should be considered to help with posture and pain through teaching form, alignment and muscle strength and relaxation. [C] Classes should, if possible, by led by an instructor who has been trained to work with older individuals or those with osteoporosis and can amend exercises according to ability and range of movement.
- Breathing and pelvic floor exercises are recommended to help with other symptoms that may be exacerbated by severe spinal kyphosis. [C]
- Hydrotherapy should be considered to help improve quality of life. [C]

so it is recommended that the emphasis is on being able to continue rather than prohibit exercise.

As reduced kyphosis may benefit pain, falls and vertebral fracture risk, exercises to improve posture (particularly by increasing the strength of spinal extensors) are recommended. Exercise can improve back extensor strength and posture, to counter the expected neuromuscular changes linked to weaker, less fatigue-resistant, muscles, combined with deficits due to spinal pathology that exacerbate back muscle weakness and postural deformity in people with osteoporosis.[58] Improvements in back extensor muscle function are likely to underpin the improvements observed in standing balance.[59] Different trials have used varying frequency and intensity of exercise. Overall, the consensus from the trials is that the initial dose and progression needs to be tailored to the individual to provide safe but incremental challenge and that the higher the dose and the longer the duration of the intervention the greater change observed, particularly in people over 70 years old.[60]

Avoiding activities that may provide excessive spinal load or flexion is a pragmatic approach to limit potential triggers of vertebral fracture, and more detailed strategies are supplied in previous guidance.[18]

People with pain following vertebral fracture may benefit from exercise to improve symptoms as well as helping to maintain usual activity. While such exercise should be delivered with expert advice, it is important that those with limited access to physiotherapy still have opportunity to benefit, so yoga or Pilates classes with an instructor with an understanding of appropriate exercise and movement for patients with vertebral fracture may be an alternative. Hydrotherapy improved quality of life[61] so may be appropriate for improving vertebral fracture symptoms as those affected may find water-based exercise more comfortable, although it may not benefit bone strength.

Responses to consultation

A total of 155 comments were received. Minor changes were made in response to this feedback. In 2020/2021, the final updated statement was again reviewed and updated by the EESG to confirm that recommendations were still consistent with more recent evidence.

To support implementation, a range of resources were developed, which are available on the Royal Osteoporosis Society website: infographics and quick guide for health professionals[62 63] as well as fact sheets and videos for the public.[64]

DISCUSSION

Health professionals and people with osteoporosis had substantial uncertainty about the efficacy and safety of exercise for those with osteoporosis. However, evidence synthesis confirmed that physical activity and exercise have multiple potential benefits for those with osteoporosis: it may modestly benefit bone strength; improve muscle strength and balance and hence reduce falls risk and reduce kyphosis, which may benefit pain, self-esteem and risk of falls and fractures. Physical activity has a range of other health benefits. We conducted an updated and more thorough analysis of adverse events (particularly fractures) reported during exercise: harms have not been consistently reported, and although a small number of fractures have been reported during exercise, the benefits outweigh the risks. The level of evidence for people who have existing fractures is lower unfortunately; there is inconsistent evidence that exercise could benefit pain, physical function and quality of life. Many of our recommendations for this group are thus based on consensus rather than evidence.

We recommend several overarching principles. Physical activity and exercise have an important role in promoting bone strength, reducing falls risk and managing vertebral fracture symptoms, so they should be part of a broad approach that includes other lifestyle changes, combined with pharmaceutical treatment where appropriate. People with osteoporosis should be encouraged to do more rather than less. This requires professionals to adopt a positive and encouraging approach, focusing on ‘how to’ messages rather than ‘don’t do’. Although specific types or exercise may be most effective, even a minimal level of activity should provide some benefit. The evidence indicates that physical activity and exercise is not associated with significant harm, including vertebral fracture; in general, the benefits of physical activity outweigh the risks. Professionals should avoid restricting physical activity or exercise unnecessarily according to BMD or fracture thresholds as this may discourage exercise or activities that promote bone and other health benefits. Finally, people with painful vertebral fractures need clear and prompt guidance on how to adapt movements involved with day-to-day living, including how exercises can help with posture and pain. Anyone with osteoporosis may benefit from guidance on amending some postures and movements to care for their back. Supporting resources were produced.[62–64]

Bone strength

A combination of high load resistance exercise or weight-bearing exercise with impact appears the most effective for bone strength. Moderate impact exercise may be more effective but lower impact (equivalent to brisk walking) was advised in those with vertebral fractures or multiple low trauma fractures. Several recent reviews confirmed the efficacy of resistance exercise[65–67]; one reported no benefit but was selective in the studies included.[68] Consistent with previous guidance, we recommend that resistance exercise should progress to high intensity. Although some recent meta-analyses did not detect greater benefits from high than lower load resistance exercise,[66 67 69] some of the interventions classified as high intensity were of more moderate loading, and substantial heterogeneity meant that it was not possible to detect significant differences according to intensity.[66 67] One recent meta-analysis confirmed that high-intensity training was more effective than moderate intensity at the lumbar spine.[70]

Falls risk

A high proportion of fractures result from falls, and we recommend strength and balance training to reduce fall incidence, based on a large body of evidence. Exercise is effective in preventing fall-related injuries in people with osteoporosis,[71] and in the broader population, participants randomised to exercise interventions had 26% fewer injurious falls, and 16% fewer fractures, than those randomised to control groups.[72] This highlights that although health practitioners and people with osteoporosis may be concerned about vertebral fractures sustained during exercise that can directly be attributed to the exercise, it is important to balance this concern with the injuries prevented by exercise despite it being much harder to directly attribute an injury to not exercising.

Vertebral fracture prevention and management

We follow previous guidance in recommending safe lifting strategies and in particular avoiding loaded flexion or end of range movements, both during everyday life and exercise such as Pilates or yoga. We also recommend exercise to strengthen spine muscles, that may reduce pain and reduce kyphosis which may further reduce risks of falls and fractures.

Our recommendations for people with vertebral fracture are to undertake strength and balance training, although keep impact exercise to an intensity no more than brisk walking unless under instruction with personalised advice. Exercises to strengthen the spine muscles should be conducted and symptoms may also benefit from pelvic floor exercise or hydrotherapy. Given the limited evidence, these recommendations are consensus based. An updated Cochrane review on exercise after vertebral fracture found that evidence was still sparse and findings variable; no further studies had reported adverse events.[45] Recent findings continue to be mixed; a home-based exercise intervention produced only modest improvements in physical function and no change in quality of life, pain or kyphosis in women with vertebral fracture; authors ascribed this to poor adherence to home-based exercise.[73] A shorter resistance and balance training intervention improved strength, balance and fear of falling, which may reduce falls risk and increasing confidence to remain active.[74] There is thus no later evidence that would affect the recommendations and the level of evidence about exercise in those with vertebral fracture is still low.

Exercise and pharmaceutical treatment

The level of evidence and magnitude of benefit from exercise is substantially lower than that for osteoporosis medication,[8] with much less funding to exercise studies. Thus, exercise should be viewed as an adjunct rather than an alternative to pharmaceutical treatment where this is indicated. However, people with osteoporosis are keen to contribute to management of their osteoporosis with lifestyle approaches/exercise, and inactivity will increase the risk of falls and many other health conditions, so it is important to consider exercise even when pharmaceutical treatment is used.

Strengths and limitations

The evidence reviewed was primarily composed of targeted exercise interventions, often conducted in a laboratory or clinic. Although such well-controlled interventions are informative about the parameters of exercise that are effective, they may be less available to many people with osteoporosis (although a fall prevention exercise programme should be available to those at risk of falls). We took the pragmatic decision to recommend some types of exercise available in the community that seemed likely to provide the necessary training stimulus (figure 1), although the type and intensity of such exercise may be much more variable. Even if such exercise is less effective it may at least postpone inactivity-related decline.

This statement provides updated evidence consideration and application to the UK setting. Limitations to the process include that the stakeholder groups were predominantly white and female, although advice and access to exercise is needed for all populations. Furthermore, we have no health economic evaluation. Limitations to the strength of recommendations arise due to limited evidence available in some areas, including lack of studies with fracture as primary outcome, inconsistent reporting of adverse effects of exercise and limited number of interventions in men, ethnic minority groups and people with osteoporosis (although recent findings from LIFTMOR studies suggest that principles developed in theoretical studies and broader populations apply to those with osteoporosis). A further limitation is that many individual trials have small sample sizes, and so we are reliant on meta-analyses of data pooled from multiple studies. This may cause problems with exercise interventions: heterogeneity may arise through different types of exercise interventions, intensity, frequency and volume of exercise or population characteristics, such as age, health status and habitual activity. Even within one exercise mode, such as resistance training, differences in exercise intensity, or velocity of contraction, could affect efficacy. Furthermore, selection of studies for meta-analyses has differed in search strategies, inclusion and exclusion criteria and classifications of exercise, sometimes producing conflicting findings. We have not formally rated the quality of the reviews in our analysis. Given the highly localised effects of exercise on bone, the efficacy at specific skeletal sites may vary depending on the precise exercises used. Finally, most studies focused on BMD, but localised adaptations in bone mean that such changes may not parallel changes in bone strength.

Implementation

This consensus statement provides clear consistent advice for people living with osteoporosis and health professionals working with them about the evidence for, and safety of, exercise (see online supplemental appendix VI for further UK-specific guidance), supported by resources.[62–64] To ensure effective implementation of the strong, steady and straight exercise approaches, the factors that act as both facilitators and barriers to implementation need consideration. These include appropriate and timely identification and management of people living with osteoporosis by primary and secondary care providers; provision of exercise interventions that conform to evidence-based requirements and the complexity of providing multiple exercise programmes for different long-term conditions in the context of limited resources; and uptake and adherence to exercise interventions (short-term and long-term). Osteoporosis exercise programmes, like other exercise programmes for older people and those with long-term conditions, need to be more than a prescribed set of exercises. They need to consider education and physical literacy, support and goal setting, motivation strategies, behaviour change techniques and take into consideration needs and preferences.[75 76] For effective implementation of the strong, steady and straight exercise approaches an infrastructure for measuring and monitoring quality assurance and improvement is needed, to ensure ongoing fidelity (the right populations targeted by the right professionals, dose, frequency, intensity, challenge, resistance, etc.). We need to demonstrate impact to justify investment

in osteoporosis programmes. This is increasingly important as the impact of COVID-19 and increased prevention and rehabilitation needs have the potential to jeopardise the offer of exercise for osteoporosis.

CONCLUSIONS

Key recommendations are that people with osteoporosis should undertake resistance and impact exercise to maximise bone strength; should take part in activities to improve strength and balance to reduce falls and undertake spinal extension exercise to improve posture, and potentially reduce pain levels caused by vertebral fractures, risk of falls and vertebral fracture. Although we recommend avoiding postures involving a high degree of spinal flexion (especially weighted) during exercise or daily life, and that people with vertebral fracture or multiple low trauma fractures should only exercise up to an impact equivalent to brisk walking, there is limited evidence of harms from exercise. People with vertebral fractures may benefit from exercise to reduce pain, improve mobility and quality of life, ideally with advice from a physiotherapist. Most importantly, inactivity should be avoided, physical activity encouraged and reassurance provided to counter the fear of moving that could detrimentally affect bone strength and health/quality of life more broadly.

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Funding Development of this statement was facilitated by funding by the Royal Osteoporosis Society, UK.

Competing interests KB-W, KB; EMC, SDB, SA, ZP, KRR, RML, JHT, KAW, JW and SL have no competing interests to declare. DAS is a director of Later Life Training, a not-for-profit organisation that provides training and qualifications to health and fitness professionals working with frailer older people.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

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Strong, Steady and Straight: UK consensus statement on physical activity and exercise for osteoporosis.

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SUPPLEMENTARY MATERIAL

CONTENTS:

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Appendix I: Discussion guides for Stakeholder Groups

1. Question guide for stakeholder groups with patients
   - Introductions, what are your experiences of osteoporosis and fracture?
   - What does the term exercise mean to you? How is it different from physical activity?
   - Do you think exercise is important in osteoporosis?
   - Have any of you started a new exercise since your fracture/since you have been diagnosed. Tell us about this
   - What would make you feel more confident to undertake exercise
   - What are your concerns relating to exercise

Show Strong Straight & Steady powerpoint
   - What do you think about the headings strong, straight and steady and what do you think they mean?
   - Does this include the important questions?
   - Do you think advice should be different for different groups of people? If so – who?

2. Question guide for stakeholder groups with health and exercise professionals
   - Introductions
   - What are you experiences of discussing exercise with patients with OP and fracture?
   - What uncertainties do you have about advising patients about exercise?
   - What does the term exercise mean to you – or your patients. How is it different from physical activity

Show Strong Straight & Steady powerpoint
   - What do you think about the headings strong, straight and steady and what do you think they mean?
   - Does this include the important questions?
   - Do you think advice should be different for different groups of people? If so – who?
   - Who should have an assessment before exercise and who should do the assessment?

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Appendix II: Online Survey

The National Osteoporosis Society is working with experts in the field to create a UK Expert Statement on how exercise and physical activity can help to improve bone strength - what exercise is needed and what is safe. Although information and advice is available, we know there are uncertainties and unanswered questions that need addressing so that people with osteoporosis can get the information they need.

If you are either a health professional, working with people with osteoporosis, or you have the condition or are at risk, we would love to hear your views.

1. Do you have a questions or issues about exercise and osteoporosis that you would like the experts to address in their Expert Statement ? Please explain in the box below.
   An example might be ' Will brisk walking strengthen the bones in my back' or 'Is jogging helpful and safe to strengthen my hip bones, if I've got low bone density'

2. Are you interested in this subject as : (please tick all that apply)

   - a health professional
   - someone with low bone density - not in the osteoporosis range someone with osteoporosis (diagnosed on a bone density scan) someone with osteoporosis who has had one spinal fracture someone who has had more than one spinal fracture
   - someone with osteoporosis - you aren't sure if you've had spinal fractures someone with osteoporosis who has broken other bones after a simple fall someone 'at risk' of fractures and advised to take an osteoporosis drug treatment someone with risk factors for osteoporosis
   - someone who isn't very mobile or used to exercise
   - Other (please specify)

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3. The charity plans to produce new and improved information resources on exercise and osteoporosis. Would you, or your patients, use the following :

- printed material, such as fact sheets, that could be ordered or downloaded from our website video clips on our website
- a DVD
- Other (please specify)

4. How old are you (please only answer Q 4- 6 if you are interested for yourself) :

- 0 - 35
- 36 - 45
- 46 - 55
- 56 - 65
- 66 - 75
- 76 - 85
- 86 or over

5. What gender are you :

- male
- female
- other

6. How would you describe your ethnic origin :

- White
- Asian or Asian British (including Chinese)
- Black/African/Caribbean/Black British
- Mixed/multiple ethnic groups
- I prefer not to say
- Other (please specify)

Thank you for your help.

We cannot provide you will a personal reply from this survey. If you would like to discuss your own situation or get more information please contact our helpline 0808 800 0035 or nurses@nos.org.uk . If you would like more information about the Strong,Straight and Steady project, please email s.leyland@nos.org.uk.

Appendix III: Composition of Exercise Expert Steering Group and Exercise Expert Working Group

Expert Exercise Steering Group

CHAIR: Professor Dawn Skelton, Professor in Ageing and Health, Glasgow Caledonian University

Coordinator and project lead: Sarah Leyland, Osteoporosis Nurse Consultant, Royal Osteoporosis Society

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Professor Emma Clark, Professor of Clinical Musculoskeletal Epidemiology, University of Bristol, and Consultant Rheumatologist, North Bristol NHS Trust

Rachel Lewis, Clinical Specialist Physiotherapist in Rheumatology, North Bristol NHS Trust

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Professor Kate Ward, Professor of Global Musculoskeletal Health, MRC Lifecourse Epidemiology Centre, University of Southampton

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Exercise Expert Working Group

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Sarah Legg, Senior Physiotherapist, Rheumatology at the Royal National Hospital For Rheumatic Diseases, Bath

Dr Katie Robinson, Research Physiotherapist at the School of Medicine, University of Nottingham

Yvonne Sadler, Public/patient representative

Ruth Sawtell, Public/patient representative

Christina Scorringe, Clinical Specialist Rheumatology Physiotherapist and Clinical Rheumatology Lead at Northwick Park Hospital, London

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Appendix IV: stakeholder organisations

British Association of Sport and Exercise Sciences

British Geriatrics Society

Bone Research Society

Chartered Institute for the Management of Sport and Physical Activity

Chartered Society of Physiotherapy

Orthopaedic Trauma Society

Register of Exercise Professionals

Society for Endocrinology

PD:Approval

The Physiological Society

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Appendix V: Summary of research evidence informing recommendations

Strong: Physical activity and exercise to promote bone strength and prevent fractures

Research Evidence

Observational studies suggest that day-to-day participation in physical activity reduces the risk of fracture. Age-adjusted risk of hip fractures is up to 40% lower in the most active compared with the least active adults [1]. This may be mediated through lower risk of falls and/or higher bone strength. The strongest evidence is for a reduction in the risk of hip fracture. For example, an evidence synthesis of 13 prospective cohort studies of men and women aged >35 followed up for 4-35 years identified a 38-45% reduced risk of hip fracture with higher levels of physical activity participation [2]. Similar results are seen in papers published since [3–6]. There is less evidence for the association between day-to-day physical activity and the risk of non-hip fractures, with contradictory results varying by age, functional status, physical activity, population studied and fracture type. It is hard to make conclusions on the type or intensity of the day-to-day activity that is associated with a reduction in fractures. Walking is one of the most prevalent forms of exercise and many studies suggest that those who walk for exercise have lower risk of hip fracture [3,6–8]; although this finding may reflect the increased fracture risk of the inactive reference group. A recent review suggests walking has to be part of a multicomponent intervention to potentially reduce risk of fractures [9] . An important caveat to these observational findings is that they may be confounded by factors such as health or socioeconomic status.

Randomised controlled trials allow more robust evidence regarding effectiveness of specific exercise interventions. Unfortunately, there are no adequately powered bone health randomised controlled trials with fracture as an endpoint [10] The first adequately powered falls prevention screening study, with more than 9000 people, did not show a reduction in fractures but the exercise programme employed was unlikely to influence BMD, only balance [11]. To allow comparison of specific exercise characteristics that may reduce fracture risk it is thus necessary to examine research on risk factors for fracture, such as bone mineral density or fall incidence.

A large number of randomised, controlled trials have examined the influence of different exercise interventions on bone mineral density (BMD), with most evidence in women and white populations. These have been summarized in systematic reviews and meta-analyses [10,12–33], and in previous international guidance [34–36]. It is important to highlight that BMD is just one determinant of bone strength. Exercise may also influence bone strength through BMD independent mechanisms, such as through changing the distribution of bone (bone geometry or microarchitecture) and the bone material properties [37]. There are fewer studies available with these outcome measures available at sites susceptible to fracture although a recent review concluded that novel or very intense activities can stimulate adaptations to loaded bones such as increased cortical thickness or periosteal diameter [38].

Type and intensity of exercise

As bone responds to forces applied through muscular contraction or impact forces [39], exercise can be categorized according to whether it generates impact (ground

reaction) forces through weightbearing exercise, or applied load in resistance (joint reaction) exercise.

Resistance exercise

Resistance or joint reaction exercise involves work against an external load, which may be provided by free weights, weights machine, resistance band or body weight. Resistance exercise intensity may be described as a proportion of repetition maximum (1RM): the maximum load that can be lifted for the specified number of lifts before fatigue. The Cochrane review demonstrated that high-force non weightbearing exercise (>70% and usually 80%1RM) benefitted spine and femoral neck BMD, whilst low-force non weightbearing exercise (e.g. low load, high repetition strength training 40-60% 1RM) had no significant effect [26]. Other meta-analyses of resistance training alone in postmenopausal women showed benefits that did not reach statistical significance, but combined interventions of variable intensities, as well as exercises targeting different muscle groups and hence loading different skeletal sites [13,23]. Resistance training alone benefitted BMD at hip and spine sites in men [24].

Animal studies and consequent theoretical models suggest that dynamic exercise is more effective than static or isometric exercise [40,41]. Although some modest benefits to BMD have been reported with other forms of exercise that often involve static poses or slower movements, such as Tai Chi, yoga and Pilates [42,43], evidence is limited and weak [44–46]. These exercise modes may have some benefits (and risks) to outcomes other than BMD however, as discussed later.

Weightbearing/impact exercise

Weightbearing exercise involves the skeleton bearing the body weight during dynamic movement involving impact with the ground, and resultant ground reaction forces. Examples include walking, running, dancing, jumping and many weightbearing sports. The intensity of impact exercise is often defined by the magnitude of ground reaction forces sustained (although it is important to note that this does not include the concomitant muscle generated forces acting on bone). As the magnitude of forces will vary proportionately with body weight, impact forces may be expressed in multiples of body weight (BW).

According to a Cochrane review [26], high force dynamic weightbearing exercise such as jumping, skipping, aerobic dance (activities typically generating ground reaction forces >2BW) benefitted BMD of the hip and trochanter, but not spine and femoral neck; although this grouping included also whole body vibration training, which may provide very low gravitational loading. High impact exercise also increased hip but not spine BMD in premenopausal women [12,15,22] and older men [47]. Odd impact protocols (i.e. involving multidirectional movements) increased BMD at lumbar spine and femoral neck in older adults [13]. Low force weightbearing activity such as walking and low impact aerobics (that may typically incur ground reaction forces of ~1-2BW) benefitted BMD at the spine but not hip sites [26], although no significant effects of low impact exercise were reported in a meta-analysis focussing on older adults [13] whilst walking alone produced modest benefits at the hip in some but not all meta-analyses [14,48,49]. One biomechanical analysis suggests that walking must be at brisk pace to stimulate improvements [50]. However, brisk walking may increase risk of falls in those with a high falls risk [51].

Aerobic exercise is recommended for its multiple health benefits by UK Chief Medical Officers [52], as well as international bodies [53]. Whilst aerobic exercise includes impact exercises such as running, some other types of aerobic exercise may provide substantial cardiorespiratory intensity but not provide adequate skeletal loading. Examples include swimming and cycling, which did not benefit BMD [30,54]; whilst water-based exercise was less effective than land-based exercise [20].

Moderate to high impact exercise thus seems to confer skeletal benefit, with possible benefit from low impact exercise such as walking, but not from exercise where gravitational loading is reduced, such as swimming. These findings from randomised controlled trials are supported by observational studies that provide ecological validity. Using accelerometry to objectively monitor physical activity, high, but not moderate or low acceleration activities, were associated with BMD [55–57]. As accelerations do not relate directly to ground reaction forces it is not possible to determine whether these relate to high impact (previously defined as >4BW [35]) or moderate impact (2-4BW) so there was no evidence as to whether high impact exercise was more effective than moderate impact.

Combination of resistance and weightbearing exercise

Meta-analytic findings are consistent that a combination of weightbearing and resistance exercise benefitted both spine and hip sites in premenopausal women [15], postmenopausal women [13,26,29,33] and men [24]. The recent LIFTMOR studies demonstrated substantial benefits from a programme involving high intensity progressive resistance training and impact exercise in men and women with osteoporosis, with net benefits at the spine ~4% and proximal femur ~2-3% [58,59].

Sedentary behaviour

Observations from population studies suggest that lower physical activity in later life increases the risk of hip fracture [1] and that less sitting is associated with higher BMD [60]. This suggests that avoiding sedentary behaviour and maintaining standing and weightbearing activities may have a protective role in maintaining BMD [61]. A recent systematic review of sedentary behaviour and bone health in older adults shows differing associations (mostly negative) of sedentary behaviour with BMD in men and women at different BMD sites and calls for more robust studies in this area [62]. In the context of an exercise intervention, gentle walking may not generate sufficient forces to improve BMD but maintaining such activity may be important for preventing inactivity related losses. For example, a study of men and women aged 49 - 83 identified that regular walking or cycling, reduced fracture risk by up to 23% relative to hardly ever walking or cycling [5]. A recent qualitative study suggests that people with osteoporosis are knowledgeable about the detrimental effects of sedentary behaviour and easily identify facilitators to breaking up long periods of sitting, including the use of technology [63].

Exercise frequency, duration or volume

Animal studies and consequent theoretical models suggest that relatively low volumes of loading that generates high strain rates in bone can stimulate gains in bone strength; that there is desensitisation after a limited number of loading cycles, and that insertion of rest pauses can increase effectiveness [40,64]. This is consistent with observational studies in humans showing that intermittent bursts (1-2 minutes) of moderate impact exercise may be more beneficial to maintain or improve BMD

than longer periods of low impact exercise [65]. With regard to frequency, physical activity and exercise on a day-to-day basis are associated with improved bone strength and a lower risk of hip fracture [1,66,67].

With regard to frequency of resistance exercise or combined exercise modes, the majority of studies that showed BMD improvements prescribed exercise on two or three days per week [26]. Post hoc analysis of one long-term controlled trial demonstrated that at least two sessions per week were necessary [68]. A recent randomised controlled trial of a combination of high intensity, progressive resistance training with impact exercise demonstrated that just two, 30-minute sessions per week were sufficient to increase BMD in women and men with osteoporosis [58,59].

Meta-analysis of randomised controlled trials has demonstrated that brief, high impact interventions (e.g. jumping) can increase hip BMD [12,15,22], and one study found that such exercise was most effective when performed daily, with significantly greater BMD response relative to exercise performed on just two days per week [69]. Finally, the most recent review of physical activity and osteoporosis prevention in people aged 65+ recommends multiple exercise types, including resistance exercise, for 60+ minutes, 2-3 times a week for 7+ months [25].

Site specificity

Loading stimulates very localised bone adaptation, with gains evident at only the loaded skeletal sites. Even within a single region of interest such as the femoral neck, a small overall benefit was associated with much larger localised increases in cortical and trabecular bone [70]. As such, it is important that exercise is targeted to apply loading to the skeletal sites susceptible to osteoporotic fracture, such as spine, proximal femur, and forearm, or multi-directional to load multiple sites.

At the spine, greatest benefits were observed from a combination of resistance and weightbearing activity [13,15,24–26,29]. Benefits were also observed from resistance training alone, although variability in response may arise from variation in the type or intensity of exercises incorporated [13,15,24–26,29]. Improving the strength of back muscles may also reduce the risk of vertebral fracture [71]. Impact exercise alone did not significantly benefit the spine [12,15,22].

At the proximal femur, benefits were observed from impact exercise alone [12,15,22] or in combination with resistance exercise [13,15,24,26,29]. Again, some benefits were also observed from resistance training alone, although variability in response may arise from variation in the type or intensity of exercises incorporated [13,15,24,26,29].

At the forearm, a recent meta-analysis suggests that both high and low intensity resistance training can benefit BMD although effects of impact exercise was unclear [72]. In addition, observational studies suggest that sports such as tennis that involve substantial loading of the forearm are associated with higher forearm BMD [72,73] and strength [74].

Other considerations

Some groups need specific advice. Those with eating disorders will need advice from a multidisciplinary eating disorders team [75,76] as excessive physical activity and exercise can contribute to energy deficiency and delay recovery. Similarly, elite

athletes with high training volumes may benefit from sports medicine advice as they are at increased risk of overuse injuries [77,78].

Frail or sarcopenic individuals are at a higher risk of fracture and less likely to undertake physical activity [79]. Low gait speed or muscle strength may reduce the ability to undertake higher intensity activity, although gains are still possible [80–82], even in osteosarcopenic individuals [83]. The evidence that frail older people can increase bone strength through exercise is weaker but two studies of 12 and 18 months duration have shown modest effects on spine and hip BMD [83]. As bone is lost rapidly during inactivity, preventing this inactivity-related loss and using exercise to maintain muscle function and promote independence should be a priority.

STEADY- exercise and physical activity to prevent falls

The contribution of falls to fractures

95% of non-vertebral fractures, and about 20% of vertebral fractures, occur following a fall [106]. Falls and injurious falls are a significant problem in older age, with a third of people over the age of 65 falling every year [106,107]. There is a difference in the prevalence of fractures at different sites as people age. Younger people who fall may put a hand out to try to break the fall; thus wrist fractures are more common in younger people. In older people, perhaps as result of slower reactions, hip fractures are more prevalent. Hip fractures are associated with increased mortality: 6.1% of hip fracture patients die within 30 days [108], rising to over 20% in the year following fracture[6]. Of those who survive, 30% have permanent disability, 40% are unable to walk independently and 80% are unable to carry out activities of daily living (ADLs) one year after the fracture [2].

Falls: causes and risk factors

Risk factors for falls include: having had a fall in the last year; poor strength; poor balance; poor posture; bad eyesight; poor foot health; continence and health issues such as Parkinson's disease; having had a stroke; and dementia [109]. In an ageing person, fear of falling and comorbidities can lead to a vicious spiral of inactivity. This in turn leads to a reduction in the ability to maintain an independent lifestyle and the potential for increased risk of injury [107].
Gait problems and use of walking aids, along with difficulties in everyday tasks and fear of falling almost double the risk of a fall [110]. Furthermore, people with vertebral fractures are more likely to have kyphosis or forward-flexed posture, which is associated with impaired balance [111] - 64% of people with kyphosis had had a fall in the previous year [112].

Falls risk, including problems with gait, muscle strength and balance, is modifiable with exercise [12]. Weight-bearing activities will help muscle strength and balance to some extent, although this can become more difficult in older age.

Fall prevention

There should be a health professional assessment for multiple risk factors for falls, and advice on appropriate interventions, including a specialist falls prevention exercise programme (with balance training) where available [107]. A multi-factorial

approach should include medication review, bone health risk factors, and general health assessment (e.g. eyesight, continence, foot health). Environmental factors may need to be considered to address other risk factors, such as better lighting and marking edges of stairs if eyesight is failing [113].

Research evidence

Observational evidence demonstrates that those who meet physical activity guidelines for health (150 min/week of moderate to vigorous physical activity) are less likely to fall or injure themselves [21,114]. Exercise also reduces fear of falling to some extent - at least immediately after the intervention [115]. A large number of randomised controlled trials of exercise interventions on fall incidence have been conducted, as summarised in recent meta-analyses [12].

Type and intensity of exercise

The majority of studies have used balance training, often combined with strength training, sometimes incorporating also walking to meet physical activity guidelines for other health benefits [12]. Balance training is defined as the transfer of bodyweight from one part of the body to another or challenges specific aspects of the balance systems (e.g. vestibular systems) and balance retraining is defined as the re-education of basic functional movement patterns to a wide variety of dynamic activities that target more sophisticated aspects of balance [116].

Overall, exercise interventions reduced the rate of falls by 23% in older people living in the community [12]. The most effective interventions incorporated highly challenging balance training for at least 3 hours per week which reduced rate of falls by 39% [55]. The level of challenge can be increased by reducing the base of support (e.g. standing with legs closer together, then on one leg), moving the centre of gravity (e.g. reaching, transferring weight) and reducing the support from arms [55]. Most research studies included supervised sessions with an instructor to participant ratio of <10 in the supervised sessions [55]. The Otago exercise programme and the FaME (PSI) programme are evidence-based and cost effective [113].

Tai Chi reduced risk of falls in people with mild deficits of strength and balance [12]. However, if it has to be significantly modified for those with poor balance to participate (e.g. seated versions or versions without weight transfer), it loses its ability to improve lower limb strength, balance and falls risk [117].

Not all exercise modalities reduce falls [12]. Walking alone does not reduce falls risk or improve strength or balance [118]. Brisk walking may even increase risk of falls and fractures in those with a falls history [119]. For the more severely frail or those with a history of injurious falls, gradual progression from strength and balance activities to brisk walking or activities that work on stamina or endurance, may avoid an increase in falls risk [103]. Interventions that do not challenge balance sufficiently (e.g. seated programmes) have shown little or no effect on falls rates in people who are already falling, despite improvements in known risk factors, such as strength. There is currently not enough evidence to recommend dancing as a falls prevention activity for individuals with a high falls risk [12,120], although it may have the potential to reduce future falls risk in a general population.

Frequency & amount of intervention

For someone with a history of falls, 3 hours a week of strength and balance training for at least 4 months (>50 hours total) is needed to effectively reduce falls [55]. The training must be ongoing, as the fall risk reduction quickly diminishes if exercise stops. However, interventions that have a component that works on stamina as well as strength and balance, with education, have been shown to significantly increase habitual physical activity outside of sessions even a year after the intervention finishes and this is protective on maintaining falls risk reduction [121,122].

Interventions that do not provide a sufficient dose have shown little or no effect on falls rates in people who are already falling [12].

Evidence specifically concerning people with osteoporosis

Strength and balance exercise reduced pain and improved balance and co-ordination, without any adverse events in people with osteoporosis [123]. Women with osteoporosis who had completed balance training, found that they perceived improved empowerment and self-efficacy after participation in balance training. They resumed activities they had stopped and became more active and independent in daily life using safety precautions and fall-prevention strategies [124].

A substantial proportion of people with osteoporosis are also at risk of falling, so integrating a falls screening programme into routine osteoporosis care is justified [125].

Straight: modifying physical activity and exercise to reduce risk of vertebral fracture, improve posture and manage symptoms after vertebral fracture.

There are over 40,000 vertebral fractures in women each year in the UK, costing £134 million in 2010, and it is projected that this will increase to nearly 50,000 by 2025 [127]. Vertebral fractures contribute to kyphosis and cause substantial pain and disability, substantially reducing quality of life. Conversely, kyphosis can increase risk of falls and vertebral fractures [128]. Kyphosis may contribute to back pain and increase the torque applied to the anterior of the vertebral body hence increasing risk of further vertebral fractures. Furthermore, pain or fear of future fractures can limit activity [129,130], which may contribute to further bone loss as well as other adverse health outcomes.

Physical activity and exercise could benefit vertebral fracture risk by improving bone strength but also by reducing kyphosis [131,132]. Improving back muscle strength may indirectly help reduce falls risk by reducing kyphosis, although the research evidence is limited [91,111]. Vertebral fractures can cause pain, loss of mobility and reduced quality of life and may also be related to reduced respiratory function and incontinence [3,4]. Physical activity may benefit many of these outcomes in people with existing vertebral fracture.

However, people with osteoporosis are so concerned that exercise or daily activities such as bending and lifting could apply excessive vertebral loading and precipitate fracture, that they may severely curtail their activities. It is thus important to consider potential adverse effects also; both to avoid activities that may increase risk and

adapt activities as necessary, but also to reassure people with osteoporosis so they can continue activities of lower risk [130].

Research evidence

Activity modification for prevention of vertebral fracture

Most vertebral fractures may occur as part of everyday living. However, the evidence in relation to *particular* day-to-day movements, or the effectiveness of activity modification to prevent fracture, is very limited. Previous guidance has thus been based largely on expert consensus [15,20,26,27]. Recommendations have been that people with vertebral fractures or osteoporosis avoid rapid, repetitive, weighted, end-of-range-of-motion movements, rotation or flexion of the spine during physical activity and exercise. This included lifting weights with a flexed spine, sit-ups and end of range yoga and Pilates postures, rapid or loaded twisting without adequate control in sports such as golf [15,20,26,27]

Kyphosis

There is some evidence that exercise can improve hyperkyphotic posture, with 8 of 11 studies reporting some improvement [31], although the studies were small and some of limited quality. The interventions that benefitted kyphosis included spinal extension exercises and yoga, delivered by a physiotherapist or trained instructor [31]. Recent trials of spinal extension exercise also benefitted kyphosis [131,133], whilst high intensity resistance and impact training in people with low BMD showed improvements to kyphosis as well as BMD [60,85].

Exercise in management of vertebral fracture

Recent Cochrane reviews evaluated exercise interventions in people with existing vertebral fracture [11,53]. In some, but not all individual trials, there were benefits to physical function, pain, and/or quality of life. Subsequent studies have also shown improvements in pain and physical function [134]. The recent UK-based PROVE trial showed that physiotherapist prescribed home exercise had some short term benefits on quality of life and back muscle endurance and kyphosis relative to provision of information only, but these were not sustained in the longer term [132].

Few studies in the Cochrane review had reported adverse events. An updated systematic review found few further adverse events reported in three subsequent trials [56]. In one trial that reported incident fracture, none were sustained during the exercise intervention and there were an equal number of vertebral fractures in the exercise and control group. Whilst the number of non-vertebral fractures was greater in the control group, this difference was not statistically significant [134]. The PROVE trial of over 600 participants reported no directly associated adverse events with exercise [132]. It should be highlighted that these interventions were usually led by trained physiotherapists although some included home exercises after checking of correct form.

A consistent finding in the reported trials has been of poor adherence to the exercise interventions and it is recommended that any exercise programme needs to include strategies to enhance long-term adherence [132,135]

Appendix VI: Implementation in a UK context

Implementation

This consensus statement provides clear consistent advice, which has previously been missing, for people living with osteoporosis and health professionals working with them about the evidence for, and safety of, exercise. To ensure effective implementation of the strong, steady, and straight exercise approaches, there are factors that act as both facilitators and barriers to implementation that need consideration. These include appropriate and timely identification and management of people living with osteoporosis by primary and secondary care providers; provision of exercise interventions that conform to evidence-based requirements and the complexity of providing multiple exercise programmes for different long-term conditions in the context of limited resources; and uptake and adherence to exercise interventions (short-term and long-term). Osteoporosis exercise programmes, like other falls and other exercise programmes for older people and those with long term conditions, need to be more than a prescribed set of exercises. They need to consider education and physical literacy, support and goal setting, motivation strategies, behaviour change techniques and take into consideration their needs and preferences [87,88].

As barriers, these factors lead to disparity and variation of services across the UK, and, therefore, inequity of access. For example, osteoporosis management in primary care is not always a key priority. Whilst osteoporosis indicators are included in the quality and outcomes framework this is to record information about management of patients who have sustained a fragility fracture; primary prevention is not included. Whilst primary care clinicians may offer lifestyle advice including advice on exercise and increasing physical activity, as part of their approach to treating osteoporosis [89], they may not refer onto bone strengthening exercise programmes; although it is likely referrals will be made for the sub group of people with osteoporosis who are at risk of falls. Nevertheless, the link between strong, steady, and straight exercise approaches in this consensus statement provides an opportunity for improvement through integrated falls prevention and bone health exercise pathways. For example, as osteoporosis is a musculoskeletal condition there is opportunity for first contact practitioners (FCPS) funded through the primary care direct enhanced service additional role reimbursement scheme (ARRS) [90] to lead on screening, assessment and management of osteoporosis, osteopenia and falls in primary care as part of an integrated care pathway. Systemic issues related to how exercise for osteoporosis is delivered could be addressed through FCP influence and leadership, with physiotherapists in such roles leading in the development and delivery of exercise programmes. This guidance will enable FCPs to replicate effective programmes in clinical practice.

The most recent UK Fracture Liaison Service database (FLS-DB) annual report [91] showed only five percent of non-hip fracture patients over 75 from participating services had started strength and balance training within 16 weeks of their fracture in 2018; and this was no improvement on the proportion referred in 2017 (also 5%). This is an improvement area for the FLS-DB beyond 2021 and with an increasing number of FLS-DB services being established/commissioned this should further improve screening and identification of those likely to benefit from exercise for

osteoporosis; and support more education and lifestyle change, over and above what is currently being realised, particularly regarding bone strengthening exercise.

The impact of COVID on exercise services and the influx of prevention and rehabilitation needs post-COVID has the potential to jeopardise the offer of exercise for conditions such as osteoporosis. Competition for resources may result in exercise interventions being deprioritised. Effective partnership working, perhaps incorporating direct messaging to people with osteoporosis, is particularly pertinent if we are to respond to the impact of COVID restrictions including interrupted or delayed access to osteoporosis services and/or reduced physical activity levels

For effective implementation of the strong, steady, and straight exercise approaches there is a need to build in infrastructure for measuring and monitoring for quality assurance and improvement - to ensure ongoing fidelity to original effective components (right populations targeted by right professionals, dose, frequency, intensity, challenge, resistance etc.); to demonstrate impact, and to justify investment in osteoporosis programmes. One possible solution to the barriers described might be a system wide infrastructure to support exercise referral, similar to the National Exercise Referral Scheme (NERS) in Wales [92]. This evidence-based scheme not only incorporates physical activity and behaviour change interventions, but it standardises exercise referral opportunities across all Welsh Local Authorities and Local Health Boards. The aim of the scheme is to reduce the inequalities in health by providing access to tailored and supervised physical activity whilst supporting partnership working across health and community services and between healthcare and exercise professionals. For such a scheme to work for osteoporosis, access to consistent education to train health and exercise professionals on benefits of exercise for osteoporosis and to demystify the risk of harm, especially in vertebral fracture, would be paramount.

This consensus statement has updated and consolidated previous guidance as well as placing it in a UK context. Key recommendations are that people with osteoporosis should undertake resistance and impact exercise to maximise bone strength; should take part in activities to improve strength and balance to reduce falls and undertake spinal extension exercise to improve posture, and potentially reduce pain levels caused by vertebral fractures, risk of falls and vertebral fracture. Although we recommend avoiding postures involving a high degree of spinal flexion (especially weighted) during exercise or daily life, and that people with vertebral fracture or multiple low trauma fractures should only exercise up to an impact equivalent to brisk walking, there is limited evidence of harms from exercise. People with vertebral fractures may benefit from exercise to reduce pain, improve mobility and quality of life, ideally with advice from a physiotherapist. Most importantly, inactivity should be avoided and physical activity encouraged and reassurance provided to counter the fear of moving that could detrimentally affect bone strength and health/quality of life more broadly.

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