Summary and Key Recommendations

- Prolonged physical inactivity leads to reduced aerobic capacity and loss of muscle mass (sarcopenia). This compromises the body's ability to withstand the physiological demand of major surgery increasing risk of adverse perioperative outcomes. Inactivity also promotes chronic health conditions that further elevate risk.

- Baseline activity levels, and objectively measured functional capacity, should be assessed prior to major surgery to help guide individual patient management.

- Preoperative exercise training has the potential to offset poor physical fitness resulting from chronic inactivity, or the effect of neoadjuvant cancer therapies, and improve perioperative outcomes.

- Surgery presents a ‘teachable moment’ to facilitate lifestyle change. Enhanced patient motivation in the preoperative period requires structured support to provide the opportunity and capability to make change.

- Combined programmes incorporating aerobic, resistance and inspiratory muscle training may yield the greatest benefits. An ‘exercise prescription’ approach may be most effective.

- Patient and perioperative team education is critical to success and compliance. Consistent messaging across the entire perioperative pathway by all team members is key.

- Provision of preoperative structured exercise training is a collaborative effort between patients, primary care, secondary care and public health services to ensure available resources are appropriately allocated to patients most likely to benefit.

- A ‘menu’ of exercise support options will engage the widest number of surgical patients, one size cannot fit all.

- Exercise can be considered as one component of a multimodal prehabilitation approach to improve patient ‘readiness’ for surgery.
1. INTRODUCTION

Sedentary behaviour is defined as activity involving an energy expenditure of <1.5 metabolic equivalents (METS), typically lying or sitting. 44% of UK adults do not currently achieve national recommendations for physical activity, with 30-40% spending 6 or more hours sedentary per day [1]. There is a clear association between inactivity and major comorbid disease: sedentary individuals have a two to threefold increased risk of cardiovascular disease and death, diabetes, obesity, malignancies of multiple organ systems and all-cause mortality [2]. This represents a major challenge at both the individual patient and public health level.

Sedentary behaviour is also associated with reduced aerobic fitness levels. This is particularly pertinent as part of the ageing process given that maximal aerobic capacity (VO2 max – a marker of aerobic fitness) naturally declines by approximately 10% per decade beyond 30 years of age [3]. In addition, a progressive loss of lean muscle mass, or sarcopenia, occurs as a common component of the increasingly recognised and linked ‘frailty syndrome’. Collectively, these changes significantly compromise the ability of patients to withstand the physiological insult of major surgery.

Encouragingly, these physiological changes can be offset through regular exercise and are minimised in habitually active individuals. Indeed, the Academy of Medical Royal Colleges have described regular exercise as a cheap, effective and readily accessible ‘miracle cure’ for population health. Interest continues to build in the preoperative optimization of physical fitness, with the aim of improving outcomes following surgery.

In the following guideline, we outline the extent of the threat posed to the surgical patient from sustained physical inactivity. We also provide evidence-based guidance as to how best advise and support patients in enhancing their physical fitness to improve perioperative outcomes.

2. NATIONAL PHYSICAL ACTIVITY RECOMMENDATIONS

The UK Chief Medical Officer’s (CMO) guidance [4] recommends adults to undertake the following amounts of weekly physical activity to safeguard aerobic capacity and protect against loss of lean muscle mass [4]:

- **150 minutes of ‘moderate’ intensity aerobic exercise**
  OR
- **75 minutes of ‘vigorous’ intensity aerobic exercise**
  AND
- **Muscle strengthening activity at least twice per week**

Older adults (>65 years of age) should also undertake activities that improve balance at least twice per week.

**Activity** describes any body movement that contracts muscles to burn more calories. The exact nature and format are not specified, however table 1 provides examples of ‘moderate’ and ‘vigorous’ activities as defined by the World Health Organisation (WHO).
Table 1: WHO classification of aerobic exercise intensity

<table>
<thead>
<tr>
<th>Moderate Level (4-6 METS)</th>
<th>Vigorous Level (6 METS +)</th>
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</thead>
<tbody>
<tr>
<td><strong>Activity</strong></td>
<td><strong>Activity</strong></td>
</tr>
<tr>
<td>Gardening</td>
<td>Heavy shovelling or digging</td>
</tr>
<tr>
<td>General housework and domestic chores</td>
<td>Hiking</td>
</tr>
<tr>
<td>Involvement in children's games and sports</td>
<td>Carrying heavy loads (&gt;20kg)</td>
</tr>
<tr>
<td>Carrying moderate loads (&lt;20kg)</td>
<td></td>
</tr>
<tr>
<td><strong>Exercise</strong></td>
<td><strong>Exercise</strong></td>
</tr>
<tr>
<td>Brisk walking</td>
<td>Running</td>
</tr>
<tr>
<td>Doubles tennis</td>
<td>Competitive sports</td>
</tr>
<tr>
<td>Slow swimming</td>
<td>Walking uphill</td>
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<tr>
<td>Dancing</td>
<td>Fast cycling</td>
</tr>
<tr>
<td>Slow cycling</td>
<td>Fast swimming</td>
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<td></td>
<td>Aerobics</td>
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</table>

For individual patients, achieving these targets leads to a reduced incidence and severity of major chronic health conditions (e.g. heart disease, diabetes and cancer) reflected in a 30% reduction in all-cause mortality compared to less active adults. Physical, mental and sleep health are enhanced in active individuals with an associated superior quality of life [4]. Regular physical activity has been shown to be superior to specific pharmacological interventions for chronic health conditions, with greater compliance and a lower associated side-effect profile [5].

The population health challenge is stark. Less than one-third of adults are compliant with these recommendations. A perceived lack of general patient awareness is compounded by some uncertainty amongst perioperative clinicians. Prior work by our team supported by the Preoperative Association reinforces this. A national online survey of 650 primary and secondary healthcare professionals demonstrated that only 51% and 23% respectively were aware of the WHO recommended activity levels. In addition, only one-half of all respondents recommended increased physical activity prior to major surgery. This worrying finding can only be improved through increased awareness and education amongst healthcare professionals managing patients in the lead up to major surgery.

3. PERIOPERATIVE IMPLICATIONS OF PHYSICAL INACTIVITY

Aerobic fitness can be defined as the coordinated capacity of the cardiovascular, respiratory and musculoskeletal systems to boost the delivery and handling of oxygen within the body. Major surgery represents a major stressor and subsequent physiological challenge to the body: the association between physical fitness and the patients’ ability to tolerate surgery is well established across a broad range of surgical procedures [6]. Patients with lower aerobic fitness levels have a significantly increased risk of adverse perioperative outcomes including; major morbidity, mortality, increased hospital length of stay (LOS) and reduced health-related quality of life. This is compounded through the increased risk from associated comorbid disease and frailty (where this exists) [7].
4. PREOPERATIVE ASSESSMENT OF FUNCTIONAL CAPACITY

Accurately defining an individual’s functional capacity is therefore a key component of comprehensive preoperative assessment. The METS study has confirmed the extremely poor sensitivity and specificity of subjective patient reporting for identifying ‘less fit’ patients [8]. Therefore, an objective assessment is recommended. A number of independently validated testing modalities are employed including:

• Timed stair climbing [9]
• The 6-minute walk test [10]
• The incremental shuttle walk test [11]
• Cardiopulmonary exercise testing (CPET) [12]

Of available options, CPET has the strongest evidence base at the time of writing. Approximately 60% of UK Trusts are now able to access CPET for assessment of patients in the preoperative setting. Whilst further discussion of objective exercise testing, and delineation of risk thresholds for individual testing modalities is beyond the scope of this document, several recently published sources are available [12]

5. EXERCISE PREHABILITATION STRATEGIES

5.1 The rationale for preoperative exercise training

Preoperative exercise may form one component of a ‘prehabilitation’ approach [13], seeking to optimise physical and mental health and wellbeing prior to surgery, whilst minimising the risk and severity of postoperative complications thereby supporting a smooth and complete recovery. Other prehabilitation efforts may be directed (not exclusively) at diet and nutrition, cessation of smoking, alcohol reduction or psychological preparation for surgery. This approach can be considered in a continuum with ‘preoptimization’ of chronic health conditions and postoperative recovery, with pre and rehabilitation running through the entire perioperative journey.

As detailed above, inactive surgical patients stand to gain substantial health benefits from reaching CMO targets for physical activity. For the most inactive and least fit patients, being supported toward this level before surgery may reflect a substantial increase in their objectively measured functional capacity. However, in the majority of cases, a more structured approach may give patients the best chance of achieving meaningful improvements in functional capacity that can influence their outcome. Exercise is closely linked to but distinct from activity, and can be defined as purposeful effort to achieve measurable improvement in a specific domain of physical fitness such as aerobic capacity. This subtle shift in mindset from ‘increasing physical activity’ to ‘structured exercise training’ is key for patients facing highest risk, major surgery, typically associated with shorter preoperative timeframes.

The theory underpinning this concept is shown in Figure 1. A structured programme should lead to an enhanced functional capacity prior to surgery, creating enough physiological reserve to deal with the subsequent surgical stress response. This facilitates a reduction in postoperative morbidity and functional dependence compared to patients remaining inactive prior to surgery.
Figure 1: Proposed protective effect of exercise prehabilitation on perioperative functional status

The green line represents a preoperatively inactive patient who experiences the expected marked reduction in functional status following surgery. During the postoperative rehabilitation phase, the rate and extent of their recovery will be influenced by the incidence of complications. A single perioperative complication delays recovery and may result in a permanent reduction in functional status or long-term loss of independence. The blue line represents a prehabilitated patient whose fitness has improved prior to surgery. On exposure to the same major physiological insult with surgery they experience a smaller initial drop in functional status alongside a swifter return to independence through a shorter recovery period. Additionally, their enhanced reserve enables a faster recovery and less risk of longer-term dependency should a complication still occur.

Improving aerobic fitness and sarcopenia (loss of muscle mass) requires a combined approach consisting of both muscle strength (resistance) and aerobic training. Inspiratory muscle training (IMT) may form a third component of a multimodal preoperative training programme as a specific form of resistance training to build strength and endurance in the muscles of breathing.

5.2 Evidence for preoperative exercise training

The evidence base for preoperative exercise continues to build for patients undergoing major surgery across a range of specialties. Systematic reviews have demonstrated significant reductions in overall, and pulmonary morbidity, alongside improved postoperative functional status following major colorectal, vascular and hepatobiliary surgery [14]. The included trials compared aerobic, resistance and IMT or combination programmes to standard care. A further review suggested greater reductions in complications with combined programmes. Reduced complication rates have
also been demonstrated in systematic reviews of exercise prehabilitation prior to oesophagectomy [16] and major cardiac surgery [17].

Despite this growing cross-specialty body of evidence, the authors of the above reviews have consistently acknowledged the heterogeneity between included studies and the relatively small size of included trials. We are aware of four major multicentre exercise prehabilitation trials underway that will address this, significantly enhancing the current evidence base.

### 5.3 Preoperative exercise training in major cancer surgery

Patients preparing for major cancer surgery face a unique challenge. A study published by West et al [18] demonstrated a 16-19% drop in objectively measured aerobic capacity following preoperative neo-adjuvant chemoradiotherapy (NARCT). Combined with the typically short window between cancer diagnosis and surgery, this substantially increases perioperative risk. Crucially, this fitness drop can be reversed in workable timeframes (4-6 weeks) [18]. Whilst the study was not powered to detect perioperative outcomes, confirming that an appropriately constructed training programme can offset the negative impact of NACRT on patient fitness levels preoperatively is important. A recent collaborative publication on multimodal prehabilitation guidance for people with cancer has been published by the Royal College of Anaesthetists, National Institute of Clinical Excellence and Macmillan Cancer Support [19].

### 5.4 Trainability, adaptive response and aerobic exercise intensity

Older people enjoy similar relative fitness improvements to younger individuals with aerobic exercise. Indeed an individual’s adaptive response to exercise varies significantly, with up to 40% of individuals appearing to get no initial fitness benefit (non-responders) [20]. This phenomenon appears to be dependent on certain genetic and environmental factors, but is independent of age and sex. The number of non-responders diminishes as volume of exercise increases, suggesting that longer duration programmes of higher intensity may be more beneficial [20]. Despite this, significant fitness improvements can be made in as little as 3-4 weeks with most early time-efficient benefits being made in shifting sedentary individuals to low and intermediate levels of fitness.

Short-term benefits in improving fitness are crucial in the context of short preoperative timframes. High Intensity Interval Training (HIIT) has been shown to be superior to moderate continuous training (MCT) in this regard. HIIT is also associated with a greater magnitude of benefit for any given duration of programme [21].

### 5.5 Safety of Aerobic training

This remains a valid concern given the ‘average’ patient undergoing major surgery is 67 years of age with at least 2 comorbidities. However, published studies continue to demonstrate the safety of preoperative interventions across surgical populations with very low adverse event rates. This must also be considered in the context of several thousand maximal effort cardiopulmonary exercise tests now undertaken across the UK with very low adverse event rates reported. Any aerobic training programme (MCT or HIIT) would not be expected to reach these exercise intensities thereby providing additional safety reassurances [12].

Additional robust data available comes from the cardiac rehabilitation setting. Large published data series from Scandinavia have demonstrated an overall risk of 1 serious adverse cardiac event per 23,000 and 130,000 exercise hours for HIIT and MCT respectively [22]. Risk is increased approximately 7-fold during rehabilitation of previous habitually sedentary individuals with cardiac disease. Absolute risk would therefore appear to be low even in the highest risk group of individuals undertaking any form of exercise.
Despite this excellent overall safety profile, there is a need for vigilance in high-risk patient populations. We advocate a risk profile assessment encompassing evaluation of clinical risk factors, physical examination and ideally an objective assessment of physical fitness for individual patients prior to undertaking regular exercise.

6. CLINICAL IMPLEMENTATION

Work by Macdonald et al [23] has confirmed that the preoperative period is a ‘teachable moment’ to facilitate health behaviour change. This study identified high levels of patient motivation to increase activity levels and engage with exercise training before surgery. Patient confidence levels to effect that change were lower, suggesting that structured support is necessary to successfully enhance patient fitness. This is backed by established behavioural science principles, that motivation must be coupled with capability and opportunity to effect change.

Successful implementation and adherence of patients to preoperative exercise programmes can prove challenging. However, a number of exercise prehabilitation programmes are now established in the UK [24-25] reporting high levels of patient engagement, adherence and excellent patient reported outcomes. Without exception, these services have sought to break down the numerous barriers that may prevent patient engagement including, amongst others:

- Available patient time
- Distance from available support
- Travel and parking costs
- Reluctance to undertake additional hospital visits
- Comorbid disease and anxiety around exercise
- Availability of space, equipment and staff time

Overcoming these issues requires an integrated approach involving patients, healthcare professionals and commissioners.

6.1 Patient Selection

Appropriate targeted patient selection is key. Moving from a sedentary to an active lifestyle is likely to benefit any patient approaching surgery. However the characteristics of patients most likely to benefit from more structured preoperative exercise intervention include:

- Planned major/complex surgery (NICE elective surgery grading) – particularly where intra-body cavity surgery is planned e.g. laparotomy, thoracotomy procedures.
- Evidence of sedentary behaviour or low activity level (<150 minutes/week moderate activity)
- Significant co-morbid disease likely to benefit from increased activity/exercise (see introduction)
- Patients at risk of reduced or compromised fitness levels or sarcopaenia e.g. those undergoing preoperative chemo-radiotherapy and age > 70 years.

A baseline risk assessment should be undertaken including clinical risk factors relevant to exercise ± an objective fitness assessment if there is any clinical doubt.

Recently, a tiered approach has been advocated to rationalise the exercise ‘offer’ made to patients undergoing surgery and the prudent use of likely limited resources to provide more intensive, structured training support (Figure 2).
6.2. Education

Success is dependent on consistent and repeated messaging by healthcare professionals throughout the perioperative pathway. Results from our national survey (previously described – section 2) starkly bring this in to focus. Addressing this is essential for engagement of patients and carers. Shared-learning and more integrated working across primary and secondary care, is a key goal set out in the NHS England 5-year plan. This is the concept of ‘Making Every Encounter Count’ (MECC).

6.3. Potential exercise interventions and principles for programme design

Table 2 presents a ‘menu’ of possible preoperative options that can be considered and tailored based on patient, clinical and local resource factors. It should be recognised that no approach will be suitable for all patients or all settings.

When designing an exercise programme, a ‘prescribing’ approach is useful. The ‘FITT’ acronym requires the frequency, intensity, time and type of exercise to be specified. The goal of each component should be clear. Improvement of aerobic capacity or the building of lean muscular strength and endurance will require different forms of training. Programmes should incorporate a baseline objective assessment of fitness with a preoperative re-assessment to measure improvement. A structured review of currently available evidence including suggested protocols and targets for aerobic, resistance and IMT has been previously published to guide perioperative teams [26]. The internationally recognised consensus for exercise reporting template (CERT) [27] is a framework for the academic reporting of exercise interventions and a very practical guide to the elements that must be considered when designing a clinical programme.

Figure 2: A tiered approach to preoperative exercise support (adapted from 13 & 19)
Options for local implementation will very much depend on infrastructure and resources available, it is notable that existing UK exercise prehabilitation services have developed varied models. In particular, we advocate engagement with public health colleagues that may provide access to facilities and staff outside of the hospital setting that can be readily offered to surgical patients. Options may range from exercise information leaflets to exercise-on-referral classes in health and leisure facilities. The latter option is likely to be more enjoyable and lead to higher rates of compliance. Of note, several UK prehabilitation programmes have utilised public health trainers, supported by healthcare professionals, to deliver structured exercise training. This builds on the substantial experience of these individuals of working with a range of patients with highly varied chronic conditions and healthcare needs.

6.5 Ensuring Safety

Ensuring patient safety at all times whilst encouraging increased exercise and activity levels is paramount. As well as advocating the importance of screening for any physical or medical conditions that may preclude certain exercise regimes, we suggest the following as good practice:

- All patients should be provided with information pertaining to safe exercise and warning signs that warrant cessation of exercise and the need to seek medical advice. This can be delivered within a patient information leaflet or via online tools.
- Patients participating in structured exercise initiatives should ideally be supervised by a trainer with a Basic Life Support qualification
- All participating centres should be equipped with appropriate resuscitation equipment e.g. automated defibrillators

6.6 Preoperative exercise in multimodal prehabilitation

As outlined above, exercise may form one component of a multimodal prehabilitation approach to enhance general health and wellbeing prior to surgery. Multiple unhealthy behaviours are known to cluster in surgical patients [23], particularly those requiring major intervention. There is significant potential for synergy between simultaneous interventions, for example, the benefits of a preoperative exercise programme will be significantly enhanced by nutritional support and cessation of smoking. In addition, engagement with the modification of one unhealthy behaviour may motivate patients to tackle others [28].

7. GENERAL RECOMMENDATIONS

- All efforts should be made to identify habitually inactive patients prior to surgery. As a minimum, patients undergoing surgery should be encouraged to increase physical activity to 150 minutes per week of moderate intensity or 75 minutes per week of vigorous intensity (per CMO guidance).
- Patients with chronic health conditions or those approaching major intervention will likely require structured exercise training support to objectively enhance their fitness prior to surgery
- Training may focus on aerobic capacity, resistance training or inspiratory muscle training depending on type of surgery. Combined programmes may yield the greatest benefits
- Programmes require a minimum preoperative duration of 4-6 weeks to optimize effect, particularly in older adults. Although HIIT has been shown to be superior to MCT for enhancing aerobic capacity, we recommend that this is only undertaken following thorough clinical assessment of risk factors and in a monitored supervised environment with appropriate back up facilities.
- Ideally patients should be offered options to ensure compliance and fit with varied needs and preferences.
<table>
<thead>
<tr>
<th>Intervention</th>
<th>Delivery</th>
<th>Positives and indications</th>
<th>Drawbacks and barriers</th>
</tr>
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<tbody>
<tr>
<td>Patient information leaflets</td>
<td>This can act as an intervention in itself and signpost other locally available opportunities. Distribution at contact points along the preoperative pathway</td>
<td>• Simple, cheap, versatile and able to reach a large number of patients&lt;br&gt;• Can reinforce simple verbal advice from the perioperative team&lt;br&gt;• National resources available at <a href="https://rcoa.ac.uk/patient-information/preparing-surgery-fitter-better-sooner">https://rcoa.ac.uk/patient-information/preparing-surgery-fitter-better-sooner</a></td>
<td>• Challenging to monitor compliance or establish impact&lt;br&gt;• Likely to engage only the most motivated of patients without clear signposting and pathways to structured support</td>
</tr>
<tr>
<td>Exercise on prescription / Exercise on referral (ERS)</td>
<td>Prescribed according to the ‘FITT’ acronym (frequency, intensity, time and type). Widely commissioned already in UK primary care for health conditions e.g. obesity, diabetes</td>
<td>• Flexible, allowing tailoring to individual need and ability&lt;br&gt;• Can incorporate everyday activities&lt;br&gt;• Can be delivered through local gym/health centres&lt;br&gt;• Evidence based for achieving short term increases in physical activity (NICE recommended)</td>
<td>• Heavily reliant on patient engagement, motivation and local infrastructure&lt;br&gt;• May involve financial costs for patients&lt;br&gt;• May have limited medium to long-term impact and not all patients achieve intended targets&lt;br&gt;• Not trialled in the preoperative setting</td>
</tr>
<tr>
<td>Group based exercise prehabilitation</td>
<td>A range of venues and formats are currently utilised in the UK</td>
<td>• ’Tailored’ support to the preoperative context&lt;br&gt;• Highly motivating and effective for some patients who would not otherwise engage individually. Can be delivered through local gym/health centres or make use of existing cardiac/pulmonary rehabilitation programmes and facilities&lt;br&gt;• Naturally incorporates supervision and monitoring</td>
<td>• Many patients are uncomfortable in the group setting&lt;br&gt;• Limited flexibility for busy patients&lt;br&gt;• Requires allocation of facility space and staff time</td>
</tr>
<tr>
<td>Online exercise prehabilitation classes</td>
<td>Sessions can be designed for remote participation led and supervised by staff</td>
<td>• Removes travel and cost pressures&lt;br&gt;• Wearable device integration can allow monitoring and interaction with facilitating staff</td>
<td>• Reliant on comfortable use of information technology and access to reliable Wi-Fi.</td>
</tr>
<tr>
<td>Digitally facilitated self-managed exercise prehabilitation</td>
<td>Digital platforms can be customised to allow engagement with a ‘home-based’ exercise programme</td>
<td>• Home-based support is the preference of approximately 50% of surgical patients.&lt;br&gt;• Offers maximum flexibility to patients and the travel/cost advantages of online classes</td>
<td>• Requires a degree of IT confidence&lt;br&gt;• Monitoring engagement and adherence can be challenging&lt;br&gt;• Requires clear safety processes prior to enrolment</td>
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References


