The BASES Expert Statement on Aerobic Training for Older and Clinical Groups using Arm Crank Ergometry

Produced on behalf of the British Association of Sport and Exercise Sciences by Dr Lindsay Bottoms, Dr Paul Smith, Dr Garry Tew and Dr Mike Price FBASES.

Introduction

While lower-limb exercise is more commonly studied and prescribed than upper-body exercise, this alternative exercise mode has many important applications. This expert statement outlines the potential benefits associated with arm crank ergometry. Although not as familiar as treadmill running or cycle ergometry, most modern fitness centres offer arm crank ergometry, and commercially-available equipment is available for the domestic setting. Information contained herein presents evidence linked to the feasibility of aerobic training using arm crank ergometry for a variety of sub-populations. Further, it also provides testing and training recommendations. Although this statement focuses specifically on older and clinical groups, detailed arm crank ergometry testing guidelines for young and healthy participants are available (Smith & Price, 2007). This statement extends the reference to arm crank ergometry in the BASES expert statement, which focused on spinal cord injury populations (Goosey-Tolfrey *et al.*, 2013).

Background and evidence

Important points regarding acute responses and chronic adaptations to arm crank ergometry include:

- In healthy individuals, peak oxygen consumption ($\dot{V}O_2$peak) for arm crank ergometry is ~30% lower compared to lower body exercise
- At the same absolute intensity, arm crank ergometry evokes a lower stroke volume, a higher heart rate and a greater sympathetic response compared with lower-body exercise
- It is feasible to employ constant load, submaximal efforts, all-out sprint activity or high intensity, interval training with arm crank ergometry
- Compared to lower body exercise, arm crank ergometry is inefficient, however meaningful training adaptations can be achieved using comparatively low absolute exercise intensities
- A cross-transfer effect of arm crank ergometry training (i.e., where fitness gains linked to arm crank ergometry result in functional improvements during lower body exercise) is evident for sedentary and clinical participants.

Applications for older and clinical populations

Clinical applications of arm crank ergometry clearly exist. Cardiopulmonary testing is useful to evaluate the physical capacity of people with lower extremity impairments caused by vascular, orthopaedic or neurological conditions. Thus, arm crank ergometry can form an integral aspect of training in sedentary, obese and older participants, as well as the clinical rehabilitation of individuals with peripheral arterial disease, chronic obstructive pulmonary disease, spinal cord injury, stroke and chronic heart failure.

Aerobic training for older participants

Few studies have investigated the effects of arm crank ergometry training in older adults. The most relevant example is that of Pogliaghi *et al.* (2006). They examined physiological and functional adaptations in two groups of older men during 12 weeks of training using either arm crank ergometry or leg cycling, compared to that of a control group. At baseline and following the intervention, participants performed cardiopulmonary exercise tests to exhaustion using an arm crank and cycle ergometer. Physiological responses and fitness capacity did not change in the control group; results for the training groups is summarised in Table 1.

Both training modes evoked meaningful improvements in sub-maximal and maximal measures of cardiorespiratory fitness. Mode-specific and cross-transfer adaptations were observed in both training groups; cross-transfer effects amounted to ~50% of mode-specific effects. The 'transferability' of training benefits has been classically interpreted as indirect evidence of a central, cardiovascular-related form of adaptation.

Aerobic training in chronic obstructive pulmonary disease

This common lung disease is characterised by airflow obstruction that is not fully reversible. Associated with breathing difficulties (dyspnoea), exercise intolerance and impaired quality of life, pulmonary rehabilitation plays an important role in the management of chronic obstructive pulmonary disease. Pulmonary rehabilitation using arm crank ergometry is recommended as part of the exercise

Table 1. Changes in key variables following 12 weeks of training in older adults (reproduced from Pogliaghi *et al.*, 2006)

Group	Variable	Change on cycle ergometer test	Change on arm crank ergometry test
Arm crank ergometry training	Peak power (W)	↑ 12 (8%)	↑ 19 (22%)
	$\dot{V}O_2$ peak (L·min^{-1})	↑ 0.21 (9%)	↑ 0.37 (23%)
	Peak O_2pulse (mL·beat^{-1})	↑ 1.5 (10%)	↑ 2.4 (22%)
	Power at VT (W)	↑ 5 (5%)	↑ 10 (17%)
	$\dot{V}O_2$peak at VT (L·min^{-1})	↑ 0.09 (5%)	↑ 0.19 (18%)
Cycle training	Peak power (W)	↑ 26 (18%)	↑ 4 (5%)
	$\dot{V}O_2$ peak (L·min^{-1})	↑ 0.39 (18%)	↑ 0.16 (9%)
	Peak O_2pulse (mL·beat^{-1})	↑ 2.4 (17%)	↑ 1.2 (10%)
	Power at VT (W)	↑ 19 (19%)	↑ 3.5 (5%)
	$\dot{V}O_2$peak at VT (L·min^{-1})	↑ 0.21 (13%)	↑ 0.07 (6%)

Data are presented as absolute changes in mean values with relative changes in parentheses. Specific effects are shaded in pale red.
VT = ventilatory threshold

training regime as it has a positive impact on exercise capacity, arm strength and reduces symptoms of dyspnoea (Ries *et al*., 2007).

Aerobic training in peripheral arterial disease

Lower-limb peripheral arterial disease is a medical condition characterised by a narrowing of the arteries in the legs. A common symptom of peripheral arterial disease is intermittent claudication, a cramp-like leg pain that occurs while walking due to insufficient muscular blood flow. Regular walking exercise improves functional outcomes in people with intermittent claudication. However, since walking can be painful, the desire and ability of these patients to perform such activity is often limited. It has been demonstrated that arm crank ergometry is well-tolerated in peripheral arterial disease and, as an alternative training modality, can induce similar improvements in pain-free and maximum walking distances (Tompra *et al*., 2015). In contrast to moderate intensity, continuous exercise, this study employed an interval training approach of 2 min of moderate-to-hard exercise at 50-60 rev·min^{-1}, followed by 2 min of passive recovery, for duration of 40 to 60 min; training was completed 2 to 3 times per week for 12 to 24 weeks. Interval training was favoured to continuous training primarily because it allowed for a higher-intensity of exercise to be performed, thus maximising the potential for a cross-transfer effect of arm crank training to walking ability.

Testing and training recommendations

Assessing $\dot{V}O_2$peak and peak aerobic power (Wpeak) should precede and inform all aspects of training outlined below. We recommend Wpeak should be used to accurately prescribe subsequent, relative exercise intensity as $\dot{V}O_2$peak does not always increase in a linear fashion with power output. Ideally, all testing and training should adopt a crank rate between 70 to 80 rev·min^{-1} where achievable however, for participants exhibiting reduced fitness slower crank rates (50 to 60 rev.min^{-1}) may be more appropriate.

Protocols for Wpeak

Protocol 1 (older populations)

5 min warm-up at 30 W
Step increases of 5 W·min^{-1} until maximal volitional exhaustion
(Pogliaghi *et al*., 2006).

Protocol 2 (clinical populations)

2 min unloaded arm cranking at 50-60 rev·min^{-1}
Ramp of 5-15 W·min^{-1} until maximal volitional exertion
(Janaudis-Ferreira *et al*., 2012).

In both examples, we recommend that test time is accurately recorded to allow the precise calculation of final minute, peak aerobic power (Wpeak).

Interval training

Ideally, approximately 10 to 20 min of 'heavy' exercise should be achieved using a 1:1 work-to-rest ratio. For intensities ranging between 80 to 90% Wpeak employ 5 to 10 intervals lasting 1 to 2 min. Where a slightly lower intensity range of 70 to 80% Wpeak is used, employ 5 to 10 intervals of 2 to 4 min duration.

Continuous training

Begin at a relative power 40 to 60% Wpeak and complete a session of 20 to 40 min duration.

Conclusions

- Established testing guidelines exist for arm crank ergometry (Smith & Price, 2007)
- Arm crank ergometry has many useful training applications, many of which extend to older participants and settings of clinical rehabilitation
- It is feasible for most sub-populations of participants to engage with arm crank ergometry, which is sometimes better tolerated than other modes of lower body exercise
- The nature of training can take the form of constant load, moderate exercise, high-intensity, interval training or all-out repeated sprint activity, though evidence supporting the implementation of sprint exercise is limited. ■

Dr Lindsay Bottoms

Lindsay is a Senior Lecturer at the University of Hertfordshire and has examined physiological aspects of upper body exercise training for over 10 years.

Dr Paul Smith

Paul is a Senior Lecturer at Cardiff Metropolitan University and has focused upon the development and implementation of exercise testing procedures employing arm crank ergometry for more than 15 years.

Dr Garry Tew

Garry is a BASES accredited sport and exercise scientist and a Research Fellow in York Trials Unit at the University of York. His PhD explored limb-specific and cross-transfer effects of arm crank exercise training in people with symptomatic peripheral arterial disease

Dr Mike Price FBASES

Mike is a Reader in Exercise Physiology at Coventry University. His upper body exercise research has focused on spinal cord injury, exercise testing guidelines and thermoregulation.

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