EXAGGERATED BLOOD PRESSURE RESPONSE TO EXERCISE: FROM DEFINITIONS TO CLINICAL INTERPRETATION

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Abstract: Blood pressure is routinely monitored during graded exercise testing to ensure procedural safety and characterise the haemodynamic response to increasing workload. The blood pressure response to exercise may also provide clinically relevant information not evident from resting values alone. An exaggerated blood pressure response to exercise has been associated with masked hypertension, incident hypertension, and adverse cardiovascular outcomes, particularly in individuals with normal or high-normal office blood pressure. Clinical interpretation remains difficult because definitions vary across recommendations and studies, while peak blood pressure is influenced by exercise intensity, achieved workload, exercise capacity, testing modality, measurement conditions, and patient characteristics. The purpose of this narrative review is to summarise the clinical relevance of exaggerated blood pressure response to exercise and to discuss the main limitations of its current interpretation. A focused narrative synthesis of PubMed-indexed publications was performed, including hypertension guidelines, exercise-testing recommendations, systematic reviews, meta-analyses, and original clinical studies. Available evidence suggests that fixed peak systolic blood pressure thresholds are useful for recognising an exaggerated response. However, peak blood pressure alone does not indicate whether the observed high blood pressure is explained by the high workload achieved or represents an excessive rise relative to the workload performed. Workload-indexed measures and individualised reference values may refine interpretation, particularly during cycle ergometry, although calculation methods and classification thresholds remain insufficiently standardised. When an exaggerated response is observed during clinically indicated exercise testing, it should prompt reassessment of the patient's office and out-of-office blood pressure profile, including home or ambulatory blood pressure monitoring when appropriate, rather than diagnosis of hypertension or treatment adjustment based on the exercise test alone. Future studies should establish reference standards that account for testing modality, age, sex, workload, and clinical context, and determine whether these approaches improve risk stratification and clinical management.
Keywords: exaggerated blood pressure response to exercise; exercise testing; systolic blood pressure; workload-indexed blood pressure; hypertension.

1. INTRODUCTION

During graded exercise testing, blood pressure (BP) is routinely monitored as part of the haemodynamic response to increasing workload and contributes to both test safety and clinical interpretation (Fletcher et al., 2013). Exercise BP may also provide information not evident from resting office BP alone, particularly in relation to masked hypertension and future hypertension risk (Carlén et al., 2024; Cuspidi, Gherbesi, et al., 2023).

An exaggerated blood pressure response to exercise (EBPR) has been associated with masked hypertension, future hypertension, and adverse cardiovascular outcomes, but interpretation varies across definitions, testing contexts, and study populations (Carlén et al., 2024; Cuspidi, Gherbesi, et al., 2023; Perçuku et al., 2019; Petrasch et al., 2025). A central limitation is reliance on fixed peak systolic BP thresholds, because the same peak value may have different meanings depending on achieved workload, exercise capacity, age, sex, and testing context (Carlén et al., 2024; Currie et al., 2025; Janssens et al., 2025). Workload-indexed measures and individualised reference values may refine contextual interpretation, particularly during cycle ergometry, but their clinical application remains limited by differences in calculation methods, exercise modality, and reference populations (Carlén et al., 2024; Hedman et al., 2021; Rycroft et al., 2024). The aim of this narrative review is to summarise current definitions and clinical relevance of EBPR and to discuss the main factors that influence its interpretation in clinical practice.

2. MATERIALS AND METHODS

This narrative review was based on a focused PubMed search of English-language publications addressing exaggerated blood pressure response to exercise, exercise blood pressure measurement, workload-indexed blood pressure assessment, hypertension risk, and out-of-office blood pressure evaluation. Hypertension and exercise-testing guidelines, systematic reviews, meta-analyses, and relevant original clinical studies were considered. The review was not designed as a systematic review or meta-analysis, but as a focused clinical synthesis of practical and methodological factors that influence the interpretation of EBPR. The literature search was last updated in June 2026.

3. CURRENT TERMINOLOGY AND HETEROGENEITY IN EBPR DEFINITIONS

There is no universally accepted definition of EBPR, and several partly overlapping terms are used in the literature, including exaggerated exercise BP, hypertensive response to exercise, exercise-induced hypertension, and exercise hypertension (Currie et al., 2025; Petrasch et al., 2025). In this review, EBPR refers to an excessive BP rise during dynamic exercise testing, irrespective of the specific threshold used in individual studies or guidelines.

Peak exercise blood pressure thresholds

Most clinical and research definitions of EBPR are based on the highest systolic BP reached during exercise, although some also include peak diastolic BP or an excessive diastolic BP increase from baseline. Commonly cited criteria from the American Heart Association (AHA) and the American College of Sports Medicine (ACSM) use peak systolic BP thresholds of ≥210 mmHg in men and ≥190 mmHg in women (Currie et al., 2025; Fletcher et al., 2013). The 2020 European Society of Cardiology (ESC) sports guidelines note that peak cycle ergometry values >220 mmHg in men and >200 mmHg in women are above the 95th percentile in young Olympic athletes (Pelliccia et al., 2021). The 2023 European Society of Hypertension (ESH) guidelines emphasize that there is no consensus regarding the normal BP increase during exercise and state that peak cycle ergometry values above 220 mmHg in men or 200 mmHg in women warrant further clinical evaluation, including ambulatory BP monitoring. These values should therefore be interpreted as triggers for additional assessment rather than as diagnostic criteria for arterial hypertension (Mancia et al., 2023).
Selected peak systolic BP thresholds and individualised reference approaches are summarised in Table 1.

Table 1. Selected approaches to peak systolic blood pressure thresholds during exercise

Approach	Criterion	Interpretation
AHA 2013 / ACSM 2022	≥210 mmHg in men; ≥190 mmHg in women	Commonly used EBPR criterion; not diagnostic of sustained hypertension.
ESC 2020	>220 mmHg in men; >200 mmHg in women during cycle ergometry	Values beyond the 95th percentile in young Olympic athletes; not a universal diagnostic threshold.
ESH 2023	>220 mmHg in men; >200 mmHg in women during cycle ergometry	Values warrant further clinical evaluation, including ambulatory BP monitoring.
Individualised research reference values	Upper reference limits adjusted for age, sex, resting BP, and exercise capacity	Contextual research approach; not established as a routine guideline standard.

Abbreviations: ACSM, American College of Sports Medicine; AHA, American Heart Association; BP, blood pressure; EBPR, exaggerated blood pressure response to exercise; ESC, European Society of Cardiology; ESH, European Society of Hypertension.
Note: AHA/ACSM criteria are presented as summarised by Currie et al. (2025).
Sources: Currie et al., 2025; Fletcher et al., 2013; Pelliccia et al., 2021; Mancia et al., 2023; Hedman et al., 2021; Carlén et al., 2024.

Table 1 illustrates why the same peak exercise BP value may be interpreted differently depending on whether a fixed threshold, a recommendation for further evaluation, or an individualised reference limit is applied. This heterogeneity in definitions and testing methods is reflected in the systematic review by Petrasch et al. (2025), which included 25 studies and 15,391 participants and reported substantial heterogeneity in exercise modalities, protocols, BP measurement techniques, exercise intensities, and threshold values. Reported prevalence and prognostic associations of EBPR should therefore be interpreted in relation to the definition and testing context used.

Workload-indexed assessment of exercise blood pressure

Workload-indexed measures express the increase in systolic blood pressure (SBP) relative to exercise intensity, commonly as SBP/metabolic equivalent (SBP/MET) slope during treadmill testing or SBP/Watt slope during cycle ergometry (Hedman et al., 2020, 2021). They may complement peak BP thresholds by distinguishing a high peak systolic BP reached at a high workload from an excessive BP rise relative to the workload performed. This distinction is important because the same peak systolic BP may reflect different exercise capacity and haemodynamic responses (Carlén et al., 2024; Janssens et al., 2025).

However, workload-indexed measures remain insufficiently standardised. SBP/MET and SBP/Watt slopes depend on how exercise intensity is expressed and calculated and should therefore be interpreted within the specific modality and calculation method used (Hedman et al., 2021; Rycroft et al., 2024). An SBP/MET slope of approximately 10 mmHg/MET has been cited in the literature, but in a lower-risk male reference cohort this value was closer to the upper reference range than to the average response (Currie et al., 2025; Hedman et al., 2020). Similarly, reference equations and upper-percentile approaches have been proposed for SBP/Watt responses during cycle ergometry, and recent cohort data suggest that high SBP/Watt slopes may add clinically relevant information (Carlén et al., 2024; Hedman et al., 2021). However, these measures are better regarded as contextual interpretative tools than as standardised diagnostic criteria for EBPR.

4. METHODOLOGICAL AND PHYSIOLOGICAL CONSIDERATIONS FOR INTERPRETATION

Peak systolic BP reflects a dynamic cardiovascular response to increasing exercise intensity and should not be interpreted independently of the testing context, including resting BP, achieved workload, exercise capacity, exercise modality, testing protocol, and the method and timing of BP measurement (Currie et al., 2025; Hedman et al., 2021).

Age and sex

Age and sex are important determinants of exercise systolic BP, and their effects may not be fully captured by fixed sex-specific peak thresholds; during cycle ergometry, women generally reach lower absolute peak systolic BP values than men, although their response may be higher when expressed relative to workload (Hedman et al., 2021; Janssens et al., 2025). Reference equations derived from cycle ergometry have therefore incorporated age, sex, resting systolic BP, exercise capacity, and anthropometric variables to support individualised interpretation of exercise systolic BP (Hedman et al., 2021). The limitations of fixed sex-specific thresholds may be particularly relevant in older women. In a large real-world treadmill cohort, the sex difference in peak systolic BP narrowed with increasing age, whereas application of the conventional lower threshold for women classified EBPR more than five times more frequently in women than in men. These findings do not establish new thresholds, but they question whether a fixed 20 mmHg difference between male and female peak systolic BP thresholds is equally appropriate across age groups (Li et al., 2025).

Exercise capacity and workload

Peak systolic BP should be interpreted in relation to the workload achieved, because the same absolute value may have different meanings at low and high exercise intensities (Carlén et al., 2024; Janssens et al., 2025). In the study by Janssens et al. (2025), exaggerated peak systolic BP according to conventional sex-specific thresholds was common among healthy participants and occurred more frequently among endurance-trained athletes; participants with exaggerated peak systolic BP but a lower systolic BP/workload slope were younger and had substantially higher peak oxygen uptake than those with a non-exaggerated peak value but a higher workload-indexed response. Thus, a high peak systolic BP may sometimes reflect high exercise capacity rather than an excessive pressure rise relative to workload. Conversely, a greater systolic BP rise relative to workload may reflect a different haemodynamic response, with a larger pressure increase for the external work achieved (Carlén et al., 2024; Hedman et al., 2021). In normotensive adults referred for maximal cycle ergometry, both peak systolic BP above an individualised upper reference limit and higher SBP/Watt slopes were associated with incident hypertension, while a steep workload-indexed response did not always coincide with elevated peak systolic BP (Carlén et al., 2024). These findings suggest that elevated peak systolic BP and a steep workload-indexed response may identify partly different risk profiles.

Exercise modality, protocol, and measurement

Exercise modality and testing protocol influence how exercise intensity is expressed, while measurement conditions influence how the BP response is recorded and interpreted (Currie et al., 2025; Fletcher et al., 2013). Treadmill testing commonly expresses exercise intensity in estimated metabolic equivalents, whereas cycle ergometry allows external workload to be measured directly in watts; MET-based and Watt-based BP indices should therefore be interpreted within their specific modality and calculation method rather than as interchangeable measures (Fletcher et al., 2013; Hedman et al., 2021; Rycroft et al., 2024). The calculated slopes depend on method: SBP/MET varies with estimated versus measured exercise capacity, and SBP/Watt with the BP reference point and work-rate interval used (Carlén et al., 2024; Rycroft et al., 2024). The interpretation of exercise BP also depends on measurement conditions, including arm position and movement, handrail gripping, manual versus automated measurement, and whether BP is recorded during active exercise or recovery (Currie et al., 2025). These factors support contextual assessment of EBPR rather than reliance on a single peak systolic BP threshold.

5. CLINICAL INTERPRETATION AND PRACTICAL IMPLICATIONS

Exercise BP should not be regarded as a substitute for standard office and out-of-office BP assessment, but EBPR may serve as a clinical signal warranting further evaluation (Currie et al., 2025; Mancia et al., 2023).

The first practical consideration is procedural safety. Markedly elevated resting BP should prompt postponement or careful reconsideration of exercise testing, while systolic BP >250 mmHg or diastolic BP >115 mmHg during exercise is generally considered an indication for test termination (Currie et al., 2025; Fletcher et al., 2013). These safety thresholds are higher than commonly used EBPR thresholds and should be distinguished from an exaggerated response that does not itself require test termination.

EBPR may be particularly relevant in individuals with normal or high-normal office BP, because it has been associated with masked hypertension and future hypertension risk (Carlén et al., 2024; Cuspidi, Gherbesi, et al., 2023). In such individuals, EBPR should prompt reassessment with standard office and out-of-office BP measurements, preferably using ambulatory or home BP monitoring, rather than classification as hypertensive on the basis of the exercise test alone (Mancia et al., 2023; McEvoy et al., 2024).

In patients with established hypertension, including those receiving treatment, the clinical meaning of EBPR remains less clearly defined. EBPR despite apparently controlled resting BP may suggest residual BP dysregulation under physiological stress, but exercise BP currently has no established treatment target and should not by itself prompt antihypertensive adjustment (Currie et al., 2025; Cuspidi, Faggiano, et al., 2023; Jones et al., 2022). Therapeutic decisions should be based on confirmed office and out-of-office BP, overall cardiovascular risk, hypertension-mediated organ damage, comorbidities, symptoms, and current hypertension guidelines rather than on EBPR alone (Mancia et al., 2023; McEvoy et al., 2024).

Exercise test reports should include resting, exercise, and recovery BP values, peak systolic and diastolic BP, exercise modality and protocol, achieved workload or metabolic equivalents, and the method and timing of BP measurement (Currie et al., 2025; Fletcher et al., 2013). When available, workload-indexed BP measures or individualised reference values may be reported after cycle ergometry, provided that the calculation and reference method are stated (Carlén et al., 2024; Hedman et al., 2021). This may help frame EBPR as a signal for further assessment while limiting overinterpretation of a single peak BP value.

6. CONCLUSION

Fixed peak systolic BP thresholds remain useful pragmatic reference values for recognising EBPR during exercise testing, but they should not be interpreted as universal diagnostic boundaries. A peak value alone does not capture the context in which it was reached, including patient characteristics, achieved workload, exercise modality, testing protocol, and BP measurement conditions. Workload-indexed measures and individualised reference equations may provide complementary information, particularly during cycle ergometry, but remain interpretative tools rather than routine diagnostic criteria. When EBPR is observed, it should prompt reassessment of office BP and, when appropriate, out-of-office BP, rather than diagnosis of hypertension or treatment adjustment based on the exercise test alone. Future studies should establish reference standards that account for modality, age, sex, workload, and clinical context, and determine whether these approaches improve risk stratification and clinical management.

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