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Exercise-associated spontaneous pneumomediastinum in young people: diagnostic assessment, recurrence risk, and considerations for return to sport-a narrative review

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Abstract

Introduction: Exercise-associated spontaneous pneumomediastinum (SPM) requires differentiation from secondary pneumomediastinum; clinical improvement alone does not establish readiness to resume training.

Aim: To assess diagnosis, recurrence, and considerations for return to sport in young people with exercise-associated SPM.

Materials and methods: A narrative review with targeted PubMed searches. Twenty-four publications from 2021–2026 were purposively selected and their full texts verified. Qualitative synthesis distinguished recommendations from documented return.

Results: Uncomplicated cases generally had favorable outcomes with conservative management. Normal examination findings and a normal initial chest radiograph did not exclude SPM. Clinical series differed in recurrence frequency and noted coexisting asthma in some patients with recurrent episodes. Three of the ten included activity-associated case reports clearly documented resumption of activity.

Conclusions: Return decisions require individual assessment of the episode and comorbidities. Resolution of symptoms or imaging abnormalities does not establish tolerance of full training. Available evidence does not define a universal interval for safe return; prospective data on activity and subsequent outcomes are needed.

Keywords: spontaneous pneumomediastinum; physical exertion; Macklin effect; diagnosis; recurrence; return to sport.

1 Introduction

Pneumomediastinum is the presence of free air in the mediastinum. Spontaneous pneumomediastinum (SPM) is distinguished from pneumomediastinum associated with trauma, procedures, esophageal perforation, or injury to the trachea or major bronchi [1]. Young men predominated in SPM cohorts. Coughing, vomiting, and intense physical exertion were among the events reported before symptom onset. Some patients had asthma [2].

Alveolar air leakage with subsequent tracking along the bronchovascular sheaths, known as the Macklin effect, provides an accepted explanation for SPM [1,2]. Episodes have been reported after cycling, weightlifting, and competitive swimming [3-5]. Once the acute episode has resolved, the question of resuming training remains.

Recurrence data come mainly from cohorts that were not restricted to athletes [6,7]. Outcomes after return to sport are described primarily in individual case reports [3,5]. This review aims to assess diagnostic evaluation, management, and recurrence of exercise-associated SPM in young people. Particular attention is given to

distinguishing recommendations for rest, clearance to train, and actual resumption of activity with subsequent follow-up.

2 Materials and methods

2.1 Literature search and selection

A narrative review was conducted using purposive source selection and targeted PubMed searches. The 2021–2026 publication window was chosen to examine contemporary clinical data and reporting of return to activity. The MeSH term "Mediastinal Emphysema" and terms for pneumomediastinum were combined with terms relating to activity, recurrence, diagnosis, and management. The diagnostic and treatment query excluded the terms COVID-19 and SARS-CoV-2. No language filter was applied.

The queries yielded 80, 92, and 177 results, corresponding to 249 unique records after deduplication. Their titles were reviewed; subsequent selection was purposive and considered the association with exercise and relevance to the clinical questions addressed. A systematic eligibility assessment of all records was not performed. Metadata and full texts of selected publications were verified using PubMed, PubMed Central, and publishers' websites.

Twenty-four publications from 2021–2026 with verified full texts were included: ten activity-associated case reports, eleven supporting clinical publications, and three reviews. The term "young people" refers to the children, adolescents, and young adults in the sports-related reports, who were 8-23 years old.

In the sports-related group, SPM was defined as confirmed nontraumatic, noniatrogenic pneumomediastinum without diagnosed esophageal perforation or injury to the trachea or major bronchi. Pneumomediastinum following mechanical ventilation or compressed-gas diving was excluded. Asthma, coughing, and vomiting did not preclude inclusion and were recorded as accompanying circumstances. The association with exercise was based on the temporal sequence reported in the clinical history.

Supporting clinical publications were selected if they provided data on symptoms, imaging, differential diagnosis, treatment, or recurrence. Data from mixed populations were used when relevant findings could be extracted separately or could inform the differential diagnosis. Reviews provided mechanistic and general clinical context. Publications whose population definitions precluded interpretation were omitted. Abstracts were not used as the basis for data extraction.

2.2 Data extraction and synthesis

Study design, numbers of patients or episodes, demographic data, activity, accompanying factors, diagnostic confirmation, assessment of secondary causes, treatment, recurrence, and follow-up were recorded. Documented resumption of activity required an explicit description of exercise actually undertaken, including partial or gradual return. This was distinguished from a recommended period of rest, clearance to train, and resolution of symptoms or imaging abnormalities alone. The timing of return and subsequent follow-up were recorded when reported. Data were synthesized qualitatively in tables.

No pooled recurrence proportion was calculated, and sample sizes from primary publications and reviews were not combined. Possible overlap between datasets and incomplete follow-up were considered. No formal risk-of-bias assessment was performed; limitations were discussed for individual sources. Absence of information about an event was not treated as confirmation that it had not occurred.

3 Review findings

3.1 Physical exertion and proposed mechanisms

In the Macklin effect, an increased pressure gradient between an alveolus and the interstitium may cause alveolar rupture. Air travels into the mediastinum along the bronchovascular sheaths, and further spread through tissue planes may explain cervical subcutaneous emphysema or pneumopericardium [1,3]. Exercise preceded the episode in 11 of 100 patients reported by Morgan et al. [2] and in 56 of 237 patients reported by Yu et al. (23.6%) [6].

During resistance training, pressure increases associated with straining and Valsalva-like maneuvers are considered a possible mechanism. In the 21-year-old man described by Elhag et al., throat and neck pain began while lifting a weight with maximal effort, without preceding cough or vomiting, a history of asthma, or use of inhaled substances [4].

Exercise in inverted positions and breath-holding preceded extensive pneumomediastinum in the patient reported by Plowman et al. [8]. Attribution to repeated Valsalva maneuvers is uncertain: in the case description, the patient denied straining or performing these maneuvers in inverted positions, although the authors suggested them in the discussion. Breath-holding alone does not establish that a Valsalva maneuver was performed.

Reports following endurance exercise include two episodes of SPM with pneumopericardium approximately two years apart in a 21-year-old female cyclist [3] and pneumomediastinum after a 3.5-hour cycling session in a 23-year-old triathlete [9]. Herrmann et al. considered the effects of increased work of breathing and trunk flexion on pressure dynamics but did not verify these hypotheses through measurements [3].

In swimmers, breath-holding techniques have been proposed as contributing factors. In the 14-year-old swimmer reported by Tanimura et al., the first and third episodes were confirmed by computed tomography (CT), whereas the second was considered probable. Incomplete healing of the earlier injury was also considered but was not confirmed by follow-up investigations [5]. SPM was also reported in an eight-year-old girl after swimming and submerging in a pool, without reported trauma [10]. This case did not involve compressed-gas diving.

Coughing and airway disease may coexist with training. In a 23-year-old runner, wheezing and a coughing episode preceded symptoms of pneumomediastinum after a winter run. Subsequent spirometry was normal, but a methacholine challenge demonstrated bronchial hyperresponsiveness, and the authors diagnosed asthma [11]. Zafar and Afzal described SPM after a 3.5-hour bicycle ride in a 23-year-old man with stable asthma, without a coughing episode or exacerbation [12]. Vaping was reported in a 19-year-old man who developed pneumomediastinum after starting intensive resistance training [13].

Sport-specific explanations rely on the clinical history and the established mechanism of air leakage. The lack of measurements during episodes limits assessment of the contribution of breathing technique, body position, or training load [3-5,8-13].

3.2 Clinical presentation and diagnostic assessment

Symptoms and physical examination

In the cohort reported by Morgan et al., chest pain occurred in 76% of patients, dyspnea in 57%, and neck pain in 47% [2]. In the pediatric series by Takano et al., chest pain was recorded in 23 of 39 episodes (59.0%) and sore throat in eight (20.5%) [14]. These data come from broader clinical populations. Throat and neck symptoms and painful swallowing may predominate after exercise, as in the resistance-training case described by Elhag et al. [4]. Examination may reveal subcutaneous crepitus or Hamman's sign, a precordial crunch synchronous with cardiac activity [1,2]. In the study by Wald et al., no notable abnormalities were documented on physical examination in 42 of 166 episodes (25.3%) [15]. The swimmer reported by Tanimura et al. had normal oxygen saturation and auscultatory findings and no subcutaneous emphysema, despite CT-confirmed pneumomediastinum [5].

Imaging

Chest radiography (CXR) is usually the initial investigation for suspected SPM [1]. In six cases reported by Morgan et al., pneumomediastinum was diagnosed only on CT, although subtle abnormalities were identified on retrospective review of some radiographs [2]. Initial CXR was also normal in the swimmer and triathlete; in the latter, the diagnosis was established by CT angiography performed to investigate pulmonary embolism [5,9].

CT is useful when suspicion persists despite nondiagnostic CXR or when the cause or complications require evaluation. It shows the extent of pneumomediastinum and associated findings, including pneumothorax or pneumopericardium [1].

Air along the bronchovascular sheaths may indicate the Macklin effect, which Kumeda and Saito used in the differential diagnosis of pneumomediastinum after vomiting [16]. This finding supports an alveolar source of air leakage but does not, by itself, confirm SPM or exclude esophageal perforation [17].

Differential diagnosis and selection of additional investigations

The history should cover trauma, procedures, the sequence of exercise and symptoms, coughing, vomiting, airway disease, and inhalational exposures [1,2,4]. Forceful vomiting, fever, abdominal pain, deterioration in general condition, cardiorespiratory instability, or fluid in the pleural space or mediastinum increase suspicion of esophageal injury [1,2,16,17]. However, tachycardia and leukocytosis also occurred in primary SPM, affecting 31% and 30% of patients, respectively, in the cohort reported by Morgan et al. [2].

When esophageal injury is suspected, targeted imaging is used, such as contrast esophagography or CT with oral contrast. Suspected airway injury may require bronchoscopy [1,2]. The fact that symptoms followed training does not replace evaluation of the cause of pneumomediastinum.

In the selected cohort reported by He et al., 32 of 63 patients underwent fluoroscopic esophagography. No perforation was detected and management was unchanged; however, exclusion criteria included asthma, pulmonary infiltrates, pleural effusion, and the combination of vomiting and fever. Recovery was confirmed at follow-up in 20 patients; in the remaining 43, it was inferred from the absence of subsequent presentations [17].

Yu et al. studied a different population: among 30 adults with nontraumatic pneumomediastinum, four patients in the group without reported marijuana use had esophageal perforation requiring intervention [18]. These findings support tailoring investigations to the history, clinical condition, and imaging findings. They neither quantify the risk of perforation in athletes nor provide a validated diagnostic algorithm for this group [1,17,18].

3.3 Management and follow-up

Conservative management predominated in stable patients with uncomplicated SPM: activity restriction, analgesia, observation, and treatment of comorbidities after exclusion of esophageal and major airway injury [1,19]. Favorable outcomes were also described after cycling and resistance training [3,4,9,13].

Supplemental oxygen was sometimes administered despite normal oxygenation. The proposed rationale is to increase the nitrogen partial pressure gradient, promoting air resorption [1,20]. The benefit and appropriate regimen for routine oxygen therapy without hypoxemia have not been established; hypoxemia provides a separate indication for oxygen [1]. Routine prophylactic antibiotics and dietary restriction lack convincing justification in isolated SPM without infection or esophageal injury [1,19]. In the patient reported by Zahid and Afzal, oral intake was resumed after perforation had been excluded [13].

Hospitalization occurred in 57% of patients reported by Morgan et al., with a mean stay of 2.3 days [2], and in 84% of episodes reported by Wald et al. [15]. In the cohort reported by Yu et al., the mean stay was 7.5 days [6]. The observational comparison of general ward admission with discharge from the emergency department by Wald et al. found no significant differences in clinical outcomes [15]. These data do not determine the required period away from sport.

In the mixed series by Mikoś et al., five of 11 children had primary pneumomediastinum, and six had pneumomediastinum associated with asthma or pneumonia. Three children with pneumonia developed respiratory failure; two required mechanical ventilation and one required oxygen via a high-flow nasal cannula. Pneumomediastinum preceded respiratory support [21]. These findings must be interpreted in light of the severity of the underlying disease.

3.4 Recurrence

The proportions of patients with recurrence were 4.6% in the cohort by Yu et al., 16.7% in that by Kumeda et al., and 2.5% in that by Wald et al. [6,7,15]. Liu et al. recorded recurrence in two of 70 patients [22], and Takano et al. described one further episode after two years [14]. Details are presented in Table 1. Differences in populations and follow-up limit comparisons and extrapolation to athletes.

Asthma was present in nine of 11 patients with recurrence and in 90 of 226 without recurrence in the cohort by Yu et al. Kumeda et al. recorded asthma in two of five patients with recurrence and in none of the remaining 25 [6,7]. These findings suggest an association with airway disease, although the number of recurrences was small. Whether asthma treatment prevents further SPM episodes was not assessed. Recurrences were also described in the cyclist and young swimmer without diagnosed asthma [3,5].

Table 1 Recurrence of SPM in selected cohorts and clinical series

Publication	Unit of analysis	Patients with recurrence	Follow-up and limitations
Yu et al. 2023 [6]	237 patients; mean age 23.4 years.	11/237 (4.6%).	Mean follow-up 48.6 ± 30.9 months. Single-center cohort; only 11 patients with recurrence.
Kumeda et al. 2023 [7]	30 patients; median age 16 years.	5/30 (16.7%).	First recurrence after 32–315 days. One patient had another recurrence after 372 days. No regular follow-up visits; data supplemented by telephone.
Wald et al. 2024 [15]	166 episodes in 163 patients aged 5–25 years.	4/163 (2.5%).	Recurrences 179–1784 days after discharge. Data from records within the same healthcare system. A later episode in one individual, at age 28, was not included among the 166 analyzed episodes.
Liu et al. 2026 [22]	70 patients; median age 17 years (range 5–65 years).	2/70 (2.9%).	Follow-up one week after discharge. Neither time to recurrence nor the duration of follow-up for the whole cohort was reported.
Takano et al. 2026 [14]	39 episodes; median age 15 years.	One patient with recurrence.	A further episode after two years. Cohort follow-up duration was not specified; no recurrence proportion was calculated using the 39 episodes.

The proportions for Wald et al. (4/163) and Liu et al. (2/70) were calculated using patient counts. For 2/70, the rounded value is 2.9%; the authors reported 2.8%. Time to recurrence is not equivalent to cohort follow-up duration. No pooled proportion was calculated.

3.5 Considerations for return to sport

In the case reports, decisions to resume activity considered symptom resolution, clinical stability, comorbidities, and, in some cases, follow-up imaging [3,5,11,23].

Actual resumption of activity was documented in three of the ten included exercise-associated case reports: the cyclist, swimmer, and runner with asthma [3,5,11]. In the cyclist, regular training was documented two weeks after the second episode, with no further problems over 12 months [3]. The runner returned to long-distance running with pharmacologically controlled asthma. The authors reported over one year without recurrence but did not specify the return date or the duration of follow-up after running was resumed [11].

After the swimmer's third episode, resistance training was resumed two months after discharge, followed by gradual reintroduction of swimming. Rehabilitation included diaphragmatic breathing and limiting prolonged breath-holding. The exact duration of subsequent follow-up was not reported, and the program was not compared with alternative management [5].

In the female swimmer reported by Palermi et al., whose symptoms coexisted with vomiting, CT confirmed resolution of pneumomediastinum on day 10. After three symptom-free months and assessment at a sports medicine clinic, she was cleared to train, with a plan to increase intensity over four weeks. Implementation of this plan and follow-up after resumption of training were not clearly documented [23]. Table 2 summarizes all ten reports.

Table 2 Return to activity and recommendations in case reports

Publication and patient	Reported activity and follow-up	Recommendations or missing data
Herrmann et al. 2022 [3] 21-year-old woman; cycling.	After the first episode, return was described following CXR on day 8 after discharge. After the second: regular cycling training after two weeks; 12 months without further problems.	Two episodes approximately two years apart. Return timings and strategies were not compared.
Tanimura et al. 2025 [5] 14-year-old boy; swimming.	After the first episode, activity resumed after two weeks; full activity was reached one month after starting exercise. After the third: resistance training two months after discharge, followed by gradual reintroduction of swimming.	A rest and return plan was described after the second, probable episode. Rehabilitation after the third lasted three months; the exact subsequent follow-up duration was not reported.
Klamfoth and Koroscil 2024 [11] 23-year-old man; running.	Returned to duty and long-distance running. Asthma was pharmacologically controlled; the authors reported over one year without recurrence.	Neither the return date nor follow-up duration measured from return was reported. CT resolution at four weeks does not establish the return date.
Palermi et al. 2025 [23] 18-year-old woman; synchronized swimming.	Cleared for gradual training after three symptom-free months. A plan to increase intensity over four weeks was described.	Implementation of the plan and follow-up after return were not clearly documented. Normal findings on electrocardiography, exercise stress testing, spirometry, and echocardiography at assessment do not establish a mandatory test panel for SPM.
Elhag et al. 2026 [4] 21-year-old man; resistance training.	Resumption of training was not described. One week after discharge, the patient reported no symptoms and CXR showed resolution of pneumomediastinum.	Advised to avoid heavy loads, intense exercise, and Valsalva maneuvers for at least two weeks.

Publication and patient	Reported activity and follow-up	Recommendations or missing data
Golder 2024 [9] 23-year-old man; triathlon.	Neither actual return nor long-term follow-up was described.	Discharged after 24 hours of observation; no return-to-sport timetable was provided.
Zafar and Afzal 2023 [12] 23-year-old man; cycling, asthma.	Resumption of training was not described. At telephone follow-up after one week, he reported improvement without recurrent symptoms.	Primary care follow-up was planned after one week. The timing of return to sport was not reported.
Zahid and Afzal 2025 [13] 19-year-old man; resistance training.	Neither resumption of training nor completion of the planned follow-up CXR was described.	Advised to stop vaping and avoid heavy weights. CXR was planned in 3–4 weeks before air travel.
Plowman et al. 2022 [8] 21-year-old man; exercise in inverted positions.	Neither return to exercise nor the outcome of long-term follow-up was described.	Follow-up imaging was planned after discharge; the timing of activity resumption was not reported.
Hassan and Ferguson 2021 [10] 8-year-old girl; pool activities.	Return to swimming was not described. The next day, symptoms had resolved and CXR showed partial improvement.	Advised to see a primary care physician the next day and given information about warning symptoms.

Recurrent chest pain, dyspnea, or neck and throat symptoms require reassessment [1,3,5].

4 Discussion

Applicability to physically active people

General reviews focus primarily on the diagnosis and management of SPM [1,19,20]. This review complements that perspective by collating exercise-associated reports and distinguishing recommendations, clearance to train, and documented return (Table 2). This allows assessment of whether reports of favorable outcomes also cover exposure to training loads.

Sports-related reports describe the circumstances and course of individual episodes but cannot establish the incidence of SPM among people who exercise. The proportions reporting preceding exercise in clinical cohorts refer to patients already diagnosed with pneumomediastinum [2,6]. Without comparison groups and training-load data, risk cannot be compared between sports or between recreational and competitive participation [4,5,9,23].

Comparisons are also complicated by definitions of SPM. He et al. excluded asthma and certain imaging abnormalities [17]. Magouliotis et al. separated 37 SPM cases from 50 secondary cases but also included patients

with asthma, chronic obstructive pulmonary disease, and idiopathic pulmonary fibrosis in the SPM group and noted classification difficulties [24]. These groups cannot be regarded as equivalent populations of healthy young people.

In sports medicine practice, pneumomediastinum diagnosed after training requires assessment of its cause, with particular attention to findings suggesting esophageal or major airway injury. The extent of investigation should be guided by the history, clinical condition, and imaging findings [1,17,18]. Reports of favorable outcomes with conservative management relate to stable patients with uncomplicated SPM [1,15,19].

The association between asthma and recurrence in the cohorts, together with its diagnosis only after the episode in the runner, highlights the relevance of airway disease to subsequent assessment [6,7,11]. A practical implication is to consider cough, wheezing, exertional dyspnea, and control of known airway disease when assessing readiness for activity [1,11].

The importance of follow-up after return to sport

The case reports show that descriptions of training loads and follow-up after activity resumption are often missing (Table 2). Absence of recurrence during rest cannot substitute for data on training tolerance. It would therefore be useful to record the dates of starting light exercise and full training, the loads undertaken, symptoms, and observation duration at subsequent follow-up. This would help assess outcomes after return, which cannot be established from recurrence data in broader cohorts alone [6,7,15].

The reported rest periods and follow-up investigations formed part of individualized management [3,5,11,23]. Their effectiveness was not compared, so they do not justify a fixed timetable or a uniform panel of tests before return. Recurrences in the cyclist and swimmer do not demonstrate that earlier return caused them [3,5].

Limitations and research needs

Case reports may overrepresent unusual, extensive, and recurrent episodes, while mild events may go undiagnosed or unpublished. Information on exercise generally comes from the clinical history, and follow-up after treatment is inconsistent [3–5,8,11,13,23].

Purposive selection, the 2021–2026 publication window, and the full-text requirement limit the representativeness of this synthesis. Earlier reports were not directly analyzed, narrowing the assessment of clinical experience. The absence of systematic eligibility assessment of all search results and formal risk-of-bias assessment means that conclusions must be interpreted in relation to the analyzed set. Publication dates also do not define the data collection period: recent reviews and cohorts may include older observations [6,19,20,22].

A prospective registry linking the course of a confirmed episode, comorbidities, the return process, and subsequent recurrences would allow assessment of which patient characteristics and training loads are associated with further events.

5 Conclusions

SPM should be considered when unexplained chest, neck, or throat pain and dyspnea follow exercise, even if initial CXR is normal [2,5,9]. Favorable outcomes with conservative management have often been reported in stable patients with uncomplicated SPM [1,15,19]. The association between recurrence and asthma supports considering airway disease in subsequent assessment [6,7].

Sports-related data describe individualized decisions to resume activity after clinical improvement, sometimes with follow-up imaging [3,5,11,23]. They do not establish a universal interval for safe return. Subsequent follow-up should document the exercise actually undertaken, its tolerance, and further episodes.

Disclosure

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