The breathless teenager

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SUMMARY

The experience of breathlessness is a subjective sensation of difficult, labored and uncomfortable breathing. Breathlessness is physiological when exercising beyond normal tolerance, but pathological when it occurs with little or no exertion.

Lung function has been found to increase during adolescence with increasing height, but also afterwards, until a maximum is reached at the age of 25 years. Asymptomatic airway hyperresponsiveness (AHR) during childhood and early adolescent leads to lower maximum levels of lung function compared to those without a history of AHR. These findings are present for both females and males. The differences are minor, but significant, and persist throughout the period studied of 20 years. It is, thus, not known whether this decrease of lung function continues over time. For the increasing in lung function, there may be other factors at play, such as diaphragm strength. Expiration is an active maneuver achieved by the diaphragm, whereas inspiration is passive. Simultaneous with increasing lung function, the strength of the diaphragm muscles has been found to be stronger in young people than in elderly, with differences of 25% described.

Respiratory symptoms among adolescents may occur during exercise, as part of a poor level of fitness, exercise-induced asthma (EIA), exercise-induced laryngomalasia (EILO), exercise-induced hyperventilation, and/or shortness of breath due to heart disease or obesity.

Shortness of breath occurs naturally during exercise, to a greater degree in adolescents than in children, but less than among young adults. The degree of fitness (fitness score), measured by oxygen uptake (VO$_2$/kg), is negatively associated with the level of dyspnea measured by a Borg scale – the better fitness score the lower Borg score. The fitness score is also closely associated with the level of activity performed – high training intensity is associated with better fitness score. In periods with less activity, however, the fitness score is found to decline to the level found before the training. During periods of higher physical activity participants drop in weight with decreasing fat percentage, but this also returns to their initial level when the activity is stopped. In adolescents, continued training is needed to hinder breathlessness during exercise, which is similar to findings in adulthood. It is therefore important to motivate physical activity in this period of life, not least to keep the weight low.

There is a substantial evidence for the importance of regular aerobic exercise, which has been shown to be good for general health even when performed at a low intensity or frequency. Asthmatic subjects should not avoid physical exercise, since evidence is accumulating for better disease control, and breathlessness, after aerobic training. However, a large group of elite athletes and normal healthy adolescents claim of respiratory symptoms during exercise. Not all adolescents with exercise-induced respiratory symptoms have asthma, although asthma is the most frequently found chronic disease in this age group, and those without asthma should, thus, not be treated with anti-asthmatic drugs. Too much aerobic exercise may be detrimental to the airway surface particularly seen in the elite athlete population. Elite athletes participating in endurance sport have shown a significant respiratory impairment, and development of asthma, during their daily intense exercise. Respiratory function and
AHR in elite athletes might return to normal after cessation of competitive activity, but this topic needs further study.

Exercise-induced asthma (EIA) is found among 80% of adolescents and young adults with asthma. It is of course necessary to do exercise in order to experience exercise-induced respiratory symptoms, something many adolescents do not do willingly and independently! This might explain the lower frequency of EIA among adolescents compared to children and young adults. There are two different hypotheses regarding the scientific basis of exercise induced asthma: the thermal hypothesis and the osmotic hypothesis – of which the osmotic hypothesis is most plausible. The osmotic hypothesis relates to development of dryness on the airway surface during hyperventilation in exercise. The increasing concentration of molecules (sodium, potassium ect) on the airway surface increases the osmotic load, leading to a leak of water from inflammatory cells. If the inflammatory cells are there – this is only the case in asthmatic subjects. This leak weakens the cell membranes leading to release of inflammatory mediators. These mediators are responsible for both smooth muscle bronchoconstriction and development of subcutaneous edema. Some patients with known symptoms of EIA develop tolerance with repetitive exercising. The largest fall in lung function is observed the first time exercise is performed. The second time, a little less reduction is seen, and this improvement continues with subsequent rounds. It requires around 4 rounds of exercise of 7 minutes in length to reach a state where the reduction in FEV1 during exercise is so limited that the patients feel no symptoms of EIA. This phenomenon can be used actively in training; with a longer part of warm up in subjects with asthma will lead to reduced EIA while performing activity. The period of rest between two rounds of exercise should be 30 minutes when wanting to take advantage of the tolerance phenomenon; after this the tolerance effect wears off, and once 4 hours of rest is reached, individuals respond the same as to a primary round of exercise. Some asthma patients, thus, show a similar lung function reduction every time they exercise and lack this tolerance phenomenon.

In young elite athletes, the airway epithelium might be damaged by aerobic exercise, as described above, making development of EIA easier with a much lower effort – and they will need intensive medication. Asthma is frequently found among young adults performing endurance sport; on the other hand it was not possible to document airway inflammation among adolescent swimmers without asthma, although adult swimmers have a substantially high frequency of asthma (30-40%) compared with healthy aged matched controls (6-8%). Asthma in elite athletes should be treated according to the GINA guidelines, and they will often need step 3 or 4 treatment, due to daily symptoms and use of beta2-agonists. It may be necessary to seek special dispensation for the use of beta2-agonists from doping agencies.

Not all who wheeze have asthma, as the diagnosis of asthma requires asthma-like symptoms and evidence of variable airway obstruction. Patients with asthma-like symptoms and no signs of bronchial airway obstruction may alternatively suffer from upper airway closure during exercise. This exercise-induce laryngeal-obstruction (EILO) involves supra glottic and/or glottic closure. It is more common among females, and less common in adolescents (5%) than among young adults (9%). Closure of the laryngeal area during exercise induces shortness of breath. Unfit patients will develop EILO with a minor effort, whereas elite athletes normally require more exertion to develop EILO. In a recent study, half of the participating adolescents with breathlessness during exercise had no disease which could explain their symptoms. They might simply be unfit. The diagnostic work-up for EILO includes evaluation of the inspiratory flow; however, the expected reduction in this during exercise is seldom seen on the flow-volume loop. It is therefore necessary to perform laryngoscopy during continues exercise, called CLE test, which can demonstrate the presence or absence of EILO and furthermore at which level in the laryngeal area this obstruction is observed. The explanation for the lower frequency of EILO in males could be that their larger laryngeal area, which increases in size during the teenage period. Treatment of EILO is dependent of severity of the disease, which can be grade from 1 to 3 depending of severity of closure. The patients suffering of grade 2 and above might be referred to surgery in case of supraglottic closure, and speech pathologist in case of glottis closure. Some patients have both EILO and EIA, and among elite athletes the frequency of double disease has been found to be as many as 30%. Not least among swimmers this phenomenon has been discovered.
during adolescents, as their training start to be heavy during their teen-age period. Treatment of this group may be best suited to a specialist setting, as it can be challenging to diagnose the level of asthma, due to breathlessness during their laryngeal closure, and therefore appropriate treatment level in these patients. It has been shown that elite athletes with EILO, and no EIA, were treated more rigorously with anti-asthma therapy than those with EIA only, whilst the group of adolescents with both EIA and EILO received the highest doses of inhaled steroid (ICS), which can be explained by the overlap in symptoms between the two diseases. High doses of ICS might have side effects, such as limited growth.

Exercise-induced hyperventilation syndrome occurs when the minute ventilation exceeds metabolic demands, resulting in respiratory alkalosis. This may result in respiratory symptoms such as shortness of breath, breathlessness, chest tightness, light-headedness and sometimes paresthesia. Hyperventilation often occurs in the context of anxiety, often among females, and the anxiety seems to exacerbate the other symptoms further. There is no standard criterion for establishing the diagnosis of hyperventilation, although documentation of either arterial or end tidal PCO2 during an episode can support the diagnosis. Another dimension with increasing focus lately is dysfunctional breathing, where the level of severity can be documented by the use of the Nijmegan questionnaire consisting of 16 complaints whose frequency of incidence can be indicated on a five point ordinal scale. There is an overlap between these 16 complaints and the questionnaires used in asthma. A score above 23 points suggest severe respiratory problems. It has been found that around 5% of adolescents display dysfunctional breathing, with a greater tendency among females (OR 3.2) and asthma patients (OR 11.3). A study of the level of asthma control using the asthma control questionnaire (ACQ) showed less control among asthma patients with high Nijmegan score, compared with asthma patients with low Nijmegan score – without evidence of a simultaneous increase of airway inflammation. Focus on dysfunctional breathing is needed, as adolescents with these symptoms might be receiving higher doses of ICS due to misinterpreted uncontrolled asthma. Overtreatment of adolescents with any type of steroid should be avoided due to the potential effect on growth.

Sudden death among adolescents has been investigated by a Danish research group, who showed that 50% of the sudden deaths among the young occurred in individuals who had suffered preceding symptoms suggestive of respiratory or cardiac disease, such as shortness of breath, with significantly higher frequency of breathlessness than a control group of healthy adolescents. Sudden death among adolescents, are however, very seldom seen.

Studies in adolescents have shown a strong association between weight gain and decreased fitness. On the other hand, no effect was found on the metabolic response, neither with respect to pH, CO2 nor O2. Even when overweight adolescents are instructed to train, the fitness score has been shown to increase – even though the weight remained constant. Furthermore, in adolescents receiving weight loss treatments, the shortness of breath scores during exercise were found to be substantial lower after the weight loss.

In conclusion, a substantial number of adolescents experience breathlessness without underlying pathology – and they might simply be unfit. The remainder may suffer from respiratory symptoms due to one or more underlying diagnosis, including EIA, EILO or dysfunctional breathing.

REFERENCES