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Key points

- Improving diet quality, by increasing fruit, vegetable and wholegrain intake and reducing saturated fat intake, should be recommended in asthma, as there is evidence suggesting that this leads to improvements in airway inflammation, asthma control and exacerbation risk.
- Regular physical activity should be promoted for people with asthma, as it can improve quality of life and lung function, as well as general health.
- In obese asthmatic patients, weight loss should be recommended, as it leads to numerous health benefits, including improvements in asthma. Even small amounts of weight loss in adults (5–10% body weight) have been shown to improve asthma quality of life and asthma control in the majority of people with asthma.
- There is some evidence of benefit of meditation, yoga and breathing exercises for adults with asthma, while massage therapy shows promise in children with asthma. However, the evidence is inconsistent and more research is needed to make definitive recommendations.

Educational aims

- To summarise current knowledge on lifestyle interventions in asthma.
- To improve awareness of how lifestyle modification can be used in asthma management.
- To identify areas for future research on lifestyle interventions in asthma.

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Review

Evidence for lifestyle interventions in asthma

Asthma is a chronic inflammatory airways disease, estimated to affect 300 million people worldwide. Asthma management plans focus on optimisation of asthma pharmacotherapy. Lifestyle interventions also hold great promise for asthma sufferers as they are accessible, low cost and have minimal side-effects, thus making adherence more likely. This review explores lifestyle interventions that have been tested in asthma, including improving nutrition, increasing physical activity and introduction of relaxation therapies such as yoga and massage therapy. Available evidence suggests a protective effect of increasing fruit, vegetable and wholegrain intake and increasing physical activity levels in asthma. Weight loss is recommended for obese asthmatic patients, as just 5–10% weight loss has been found to improve quality of life and asthma control in most obese asthmatic patients. Other lifestyle interventions such as meditation, yoga and massage therapy show promise, with positive effects on asthma seen in some studies. However, the study protocols are highly variable and the results are inconsistent. Additional research is needed to further develop and refine recommendations regarding lifestyle modifications that can be implemented to improve asthma.

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Introduction

Asthma is a chronic inflammatory airways disease, affecting approximately 300 million people worldwide [1]. Asthma is most commonly associated with wheeze, cough, breathlessness and chest tightness, with these symptoms varying over time and in intensity [1]. Symptoms are often triggered by allergen, virus or exercise exposure, inducing airway hyperresponsiveness that causes the airway muscles to contract and mucous production to increase. The symptoms of asthma can be life threatening and this places a large burden on sufferers, through both reduced quality of life and the financial burden of their treatment.

There is no cure for asthma; consequently, the aim of management is to achieve good control of symptoms, maintain normal activity levels and minimise future risk of exacerbations [1]. The majority of management strategies involve asthma pharmacotherapy. Asthma medication is broken down into two main types: reliever medication for rapid resolution of symptoms (commonly short-acting β_2-agonists (SABAs)) and preventer medication for maintaining reduced airway inflammation (commonly inhaled corticosteroids) [1]. For those with severe asthma, who do not respond as well to traditional asthma medications, other medications such as systemic corticosteroids are used to reduce symptoms [1]. Some patients may benefit

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Lifestyle interventions may be key to living well with asthma, as increasing fruit, vegetable and wholegrain intake and exercise levels are shown to improve asthma. Future recommendations may include yoga, meditation and massage. http://bit.ly/2wbJp2J

from biological therapy, a new avenue in asthma pharmacotherapy that targets specific inflammatory pathways. Biological drugs such as omalizumab (which blocks IgE interaction) and mepolizumab and reslizumab (both of which target interleukin (IL)-5) are currently approved therapies for asthma [2].

Obesity and sedentary lifestyles are key research areas for the management of asthma. Obesity is associated with increased asthma severity, poorer asthma control and decreased quality of life [3, 4]. There is also evidence to suggest that obesity increases asthma prevalence [4]. A sedentary lifestyle, often also a contributing factor to obesity, can be associated with poorer asthma outcomes. People with asthma are less likely to exercise than non-asthmatics due to the risk of exercise-induced bronchoconstriction (EIB); however, this sedentary lifestyle may be contributing to their disease [5, 6].

Due to the medication burden in treating asthma, there has been increasing interest in the role of lifestyle interventions as adjunct or alternative treatments for people with asthma. The most common lifestyle interventions researched in asthma focus on manipulating diet and/or exercise, with specific attention to obesity. Other interventions that have been tested in studies of varying quality include meditation, yoga, massage therapy and acupuncture. Therefore, it is the aim of this review to examine various lifestyle strategies for the management of asthma.

Dietary interventions

Dietary patterns

Dietary intake consistently presents as an important modifiable factor in the development and progression of chronic conditions, and asthma is no exception. Different dietary patterns are hypothesised to exert effects on asthma development and management, but evidence in the literature is limited. There is some evidence that consumption of a Western diet is associated with asthma morbidity [7], leading to the comparison between Western-style eating patterns and heart-healthy regimens such as the Mediterranean diet in asthma management. High in saturated fats and omega-6 fatty acids, the Western diet is associated with inflammatory mechanisms, whereas the Mediterranean diet, which is traditionally high in fruits, vegetables, dietary fibre and omega-3 fatty acids, has been linked to anti-inflammatory pathways. As asthma is a chronic disease driven by inflammation, it is hypothesised to benefit from anti-inflammatory dietary patterns. Several studies have tested this hypothesis, ranging from cross-sectional assessment of dietary patterns [8, 9] to interventional studies implementing specific nutrients [10–13].

Anti-inflammatory eating patterns, such as the Mediterranean diet and Dietary Approaches to Stop Hypertension (DASH), have been explored in the management of asthma. The available research is primarily from cross-sectional studies, which have found promising results with adherence to a Mediterranean-style diet, such as improved asthma control [8]. Furthermore, in a recent systematic review of observational studies, 12 out of 15 studies in children found that adherence to a Mediterranean diet was protective against asthma symptoms [9].

There are limited interventional studies that have implemented a change in dietary pattern to modify asthma. One randomised controlled trial (RCT) including adults with symptomatic asthma found neither asthma control nor quality of life improved following a 12-week Mediterranean diet intervention [14]. In contrast, an RCT implementing the DASH diet for 6 months in adults with asthma found the percentage of participants reporting a clinically important improvement in quality of life and asthma control was greater in the intervention group compared to control [15]. There is a need for further clinical trials assessing overall eating patterns and diet quality on asthma management.

Nutrients

Sodium

Excessive sodium intake in Western countries is driven by increased consumption of processed foods. The hypothesised mechanism linking sodium intake to asthma involves changes to sodium transport across the cellular membrane of smooth muscle cells affecting the contractile properties of airway smooth muscle [16]. Epidemiological studies from the 1980s found associations between salt purchases and sodium intake with asthma morbidity and mortality [10]. However, there is a lack of evidence from clinical trials in the subsequent 20 years supporting dietary sodium modification for asthma control [10]. In a systematic review of sodium interventions in asthma, only one of the included nine studies reported quality of life, but there was no difference detected between high and low sodium diets [10]. In other outcomes such as airway hyperresponsiveness, none of the three studies that reported this outcome saw significant differences between high and low sodium diets, and there was also no difference between lung function and medication use across the studies included. The exception to this is exercise-induced asthma, where reducing sodium intake may be beneficial in improving lung function, with one of the included four studies reporting improved 5-min post-exercise lung function, but this was not reported across the other studies [10]. Until recommendations are clear in an asthmatic population, current general recommendations include avoiding added salt and foods high in sodium such as processed foods.

Antioxidants and vitamin C

Oxidative stress is a consequence of redox biology, occurring when excessive generation of reactive

oxygen species overwhelms antioxidant enzymes and small-molecule antioxidant compounds. Dysregulation of the oxidant–antioxidant balance can contribute to disease development and progression. Oxidative stress is one of the hypothesised mechanisms implicated in asthma pathogenesis [17]. Individuals with asthma have been shown to have increased generation of reactive oxygen species compared to healthy controls [17], suggesting that modifying intakes of antioxidant compounds may be useful. Dietary interventions that have manipulated antioxidant intake have found that the introduction of a low antioxidant diet in asthma results in a worsening of airway inflammation, lung function and asthma control [18]. Furthermore, restoration of antioxidant intake *via* increased fruit and vegetable intake has been shown to reduce the risk of an asthma exacerbation [19].

Vitamin C is the most recognised antioxidant and has thus been hypothesised as a potential complementary treatment for asthma. However, despite strong epidemiological evidence that vitamin C supplementation is positively associated with lung function [20], there is limited interventional evidence available supporting improved lung function in adults or children following supplementation [11]. In a systematic review of 11 RCTs, there was only one study that reported quality of life, with no significant difference between vitamin C and placebo. Their secondary outcome, exacerbation frequency, was only reported in the single childhood study, with no significant difference between the groups. Only one study found improvements in lung function and asthma symptoms. There was variability between studies, with doses from 500 mg to 5 g, as well as single-dose to long-term study designs (6 months). The lack of evidence and inconsistency between studies suggests more research is needed to fully evaluate the efficacy of vitamin C as a tool in asthma management. Furthermore, given recent trials demonstrating that interventions involving an increase in fruit and vegetable intake led to reduced medication use in children [21], and beneficial effects on asthma control and quality of life [15] and reduced asthma exacerbation risk [19] in adults, the efficacy of vitamin C in asthma management may rely on mode of delivery and antioxidant interdependency, resulting in improved results using whole-food interventions.

Dietary fibre

Reduced consumption of fruits, vegetables and wholegrains is a landmark feature of the Western lifestyle. These foods are rich sources of dietary fibre, a class of complex carbohydrates that cannot be broken down by mammalian enzymes in the small intestine and existing in soluble and insoluble forms. Commensal bacteria within the large intestine can ferment soluble fibre to produce metabolites, including short-chain fatty acids (SCFAs), which enter the systemic circulation and can produce end-organ effects. Some types of soluble fibre, such as inulin, also act as prebiotics, by enhancing the growth of beneficial bacteria in the gut, thereby further increasing production of SCFAs. The anti-inflammatory effect of SCFAs is an emerging research area in chronic inflammatory diseases. A recent systematic review demonstrated that prebiotic interventions are effective in reducing systemic inflammation [22]. The potential benefit of soluble fibre in asthma is less well established. While there is some epidemiological evidence demonstrating poorer lung function and increased airway inflammation in asthmatics with lower dietary fibre intake [23], it is difficult to distinguish the independent effects of soluble fibre on asthma management using these studies, as many foods that contain dietary fibre are rich sources of many other nutrients, which may contribute towards improved disease status. Nevertheless, two recently reported RCTs implementing a soluble fibre supplement in adults with asthma have reported that soluble fibre supplementation leads to improved lung function, asthma control and reduced airway inflammation [13], and reduced airway reactivity and systemic inflammation [12]. As per general healthy eating guidelines, regular consumption of fruits, vegetables and wholegrains should be recommended for this population. Fruits and vegetables may be of particular importance, as they provide both antioxidants and dietary fibre. An overview of systematic reviews by Garcia-Larsen *et al*. [24] recommends an increase in fruit and vegetables in clinical practice, despite few RCTs in the area. In particular, time of exposure seems important, and consumption of fruit and vegetables is supported in children with asthma, highlighting that the increased prevalence of asthma in childhood justified the intervention [24].

Probiotics and synbiotics

Probiotics are live microorganisms that are consumed for their health benefits, with common sources including yoghurt, kombucha and kefir. The proposed benefit of probiotics relates to the potential increase in beneficial gut bacteria that could be achieved with direct delivery of microorganisms to the gut. As well as their role in digesting prebiotics to produce SCFAs, the literature suggests a variety of mechanisms by which modulation of the microbiome can assist in developing immune tolerance, and hence could be relevant in asthma [25]. Nonetheless, evidence to date does not suggest any consistent benefit for the use of probiotics for the treatment of asthma. In a systematic review, the four included RCTs showed no benefit of probiotic supplementation on quality of life, number of asthmatic episodes or medication use [25]. One trial showed a longer time between episodes; however, there was no improvement in lung function or systemic inflammatory markers for

any of the trials. It is important to note that there is significant variability in the available literature, with all four trials using different strains of microorganisms. This has inevitably led to variability in responses. As research into specific strains grows, more consistent evidence may become available.

Synbiotics are supplements that include both prebiotics (soluble fibre sources) and probiotics. The combined effect of soluble fibre and probiotics could potentially enhance improvements in immune function and asthma outcomes. There have been few studies that have investigated this type of combined intervention. An RCT found that adults with asthma who were treated with synbiotics for 4 weeks had reduced cytokine production but there was no effect on bronchial inflammation [26]. Another study found that synbiotic use improved not only airway inflammation but also lung function [27]. Currently there are no recommendations for probiotic or synbiotic supplement use in asthma; however, more research in this area is needed.

Omega-3 fatty acids

Omega-3 polyunsaturated fatty acids (n-3 PUFAs) include eicosapentaenoic acid, docosapentaenoic acid and docosahexaenoic acid, and are commonly found in significant amounts in marine sources such as salmon, herring and sardines [28]. n-3 PUFAs are well known for their anti-inflammatory properties, which include inhibiting inflammatory cytokine production by modifying cell membrane fatty acid composition and competing with pro-inflammatory omega-6 fatty acids to downregulate production of inflammatory mediators [28]. Several of these same inflammatory pathways are involved in asthma and airway hyperresponsiveness; hence, n-3 PUFA supplementation has been proposed for the treatment of asthma.

To date, evidence for the use of n-3 PUFAs in asthma is contradictory. For children, there is evidence from 15 out of 23 RCTs in a systematic review to suggest that early introduction (at 6–9 months) and regular consumption (at least once per week) of fish including fatty fish improved asthma symptoms in children (aged 0–14 years) compared to no fish consumption [29]. In contrast, a recent systematic review of intervention studies in children aged <5 years found that supplementing with PUFAs did not affect asthma incidence or prevalence [30].

In a systematic review by Thien *et al.* [31], no consistent effect of marine fatty acid supplementation was found on lung function, asthma medication use or hyperresponsiveness. Nine studies were included, with marine fatty acid dose varying from 1.0 to 5.4 g and duration varying from 10 weeks to 12 months. Five out of the nine studies reported medication usage, with a small effect favouring marine fatty acids compared to placebo, predominantly due to one study reporting a significant reduction in the intervention group while the remaining four studies found no effect of supplementation. This was similar for lung function measures and hyperresponsiveness. None of the studies reported quality of life, and this would be of interest for future studies.

Due to the variation between trials of fatty acid dose, supplement duration and outcome measures, it is difficult to interpret the data. While the evidence for n-3 PUFA supplementation in asthma is inconsistent and not recommended, as with the general population, it is recommended that fish be consumed regularly in the diet.

Saturated fat

Saturated fatty acids are commonly found in animal products and processed foods such as full-fat dairy, untrimmed meat, cakes and pastries. High circulating levels of saturated fatty acids have been found to increase oxidative stress and inflammation [32]. For people with asthma, some data suggest that increasing saturated fat consumption worsens airway inflammation and reduces efficacy of bronchodilator medications [33, 34]. One study compared a high-fat, high-energy meal to a low-fat, low-energy meal and found the high-fat meal increased airway inflammation and reduced lung function [33]. A more recent study found that a meal high in saturated fat increased airway inflammatory markers and gene expression of Toll-like receptor 4, which initiates pro-inflammatory pathways [34].

This can be particularly important in certain asthma phenotypes such as obese asthma, where high saturated fat intake is common. Saturated fat consumption in asthma, as an individual diet component, and as a major component of Western diets, is likely to be a target for future research.

Vitamin D

Vitamin D is a fat-soluble vitamin important for bone and muscle health. It is predominantly produced endogenously through sunlight exposure; however, there are some food sources, including cow's milk, fatty fish, egg yolks and fortified products such as margarine. Vitamin D supplements are also available.

Vitamin D is suggested to be beneficial in asthma due to its effects on the immune system and genetic regulation of asthma susceptibility genes [35]. Low serum levels of vitamin D (≤30 ng·mL^{-1}) are common among adults and children with asthma, and have been associated with increased exacerbations, airway inflammation and poor lung function [36]. It has therefore been suggested that supplementing with vitamin D could improve asthma.

In a recent systematic review, nine trials were included that investigated the use of vitamin D supplementation in adults and children with asthma [37]. The studies ranged from 4 to 12 months long, including daily dosing from 500 to 1200 IU·day^{-1},

weekly dosing, monthly dosing or bolus dosing at the start of the trial. Three studies, including one with children, found that vitamin D supplementation reduced the rate of exacerbations that required systemic corticosteroids, and a meta-analysis of the pooled data found that this observation was statistically significant. Similarly, meta-analysis found that vitamin D supplementation decreased the risk of having an asthma exacerbation needing a hospital visit. There was no effect on lung function or asthma control. Only two studies reported quality of life: one reported a significant improvement following supplementation, while the other reported no significant effect. Although there was significant heterogeneity between study designs, the authors concluded that vitamin D reduces risk of exacerbation in asthma. While more research is needed in this area, particularly regarding dose based on age, sex and environmental exposure, vitamin D may emerge as a suitable adjunct therapy for asthma sufferers. Importantly, to avoid vitamin D deficiency, sunlight exposure is recommended for 10–15 min on arms and face, 2–3 times per week.

Exercise interventions

Physical activity is an important part of a healthy lifestyle. Both adults and children with asthma are less likely to exercise than non-asthmatics and this is known to contribute to the severity of their disease [5, 6]. The avoidance of physical activity may be attributed to the high prevalence of EIB in this population, which is defined as an acute narrowing of the airways occurring as a result of exercise. EIB can cause an increase in asthma symptoms including shortness of breath, wheeze and cough, and is estimated to occur in as many as 90% of patients with asthma [38]. However, EIB can be prevented or minimised by pre-treatment with SABAs, and regular exercise training also appears to have a protective role [39, 40]. Therefore, people with asthma can safely participate in regular physical activity, with recommendations to participate in 20–60 min of physical activity on 3–5 days of the week [40].

Physical activity has been shown to provide benefits to asthma specifically, in addition to general health. It is associated with reduced wheeze, fewer asthma exacerbations and fewer asthma-related emergency department visits [41]. A 2013 systematic review determined that exercise training provides a 17% improvement in asthma-related quality of life, a 3% improvement in lung function and an additional nine symptom-free days per month [42]. Evidence is inconsistent for the efficacy of physical activity on airway hyperresponsiveness, although another systematic review found that physical activity can reduce airway and systemic inflammation, including a reduction in C-reactive protein and sputum cell counts [43]. As asthma is an inflammatory disease, this may be a key mechanism behind which other improvements from exercise can be seen.

The majority of research has focused on land-based methods of exercise. However, swimming is often recommended for children with asthma, due to the warm air and low pollen exposure. Although there was no statistically significant difference between swimming and usual care/other physical activities on quality of life, asthma control, exacerbations and medication use, it has been shown that swimming increases cardiopulmonary fitness and lung function [44]. In children, it has not been determined whether swimming was superior compared to other forms of exercise.

In adults, water-based exercises have been less researched. A Cochrane systematic review of only three studies that included swimming and water aerobics found no significant difference between water-based and land-based exercise for treatment of asthma [45].

Traditional thinking in asthma has suggested that higher-intensity exercise, exercise in cold environments or endurance training can increase the risk of EIB and bronchial hyperreactivity [46]. A hypothesised reason behind this is the increase in mouth breathing, which increases airway exposure to allergens and pollutants by bypassing the nasal passage [46]. However, there is inconsistent evidence. One trial that explored high-intensity activity reported improvements in asthma control and reduced dyspnoea compared to steady-state training [47]. Other trials have reported reduced hyperventilation [48] and reduced asthma symptoms and acute asthma care required after the higher-intensity exercise [49]. However, since the 1990s, there has been little evidence exploring different physical training styles and their effects on asthma. Systematic reviews in both children and adults highlight the need for more research in this area [42, 50, 51], as studies are too heterogenous to compare between varying intensities and different exercise modalities such as aerobic and strength training. This research is urgently needed so that more specific physical activity recommendations can be developed for this population.

Diet and exercise

The majority of combined diet and exercise studies focus on weight loss for asthma and these are reviewed in the next section. However, there may be application for combined interventions in a non-weight-loss setting. Toennesen *et al.* [52] investigated an 8-week high-intensity interval training programme and/or a high-protein and low glycaemic index dietary intervention on quality of life and asthma control in non-obese patients with asthma. The dietary intervention was also designed to be anti-inflammatory, including higher amounts of vegetables, fruits and fish. Compared to the control group, the combined intervention

saw a significant improvement in asthma control and quality of life, while the groups using exercise alone or diet alone saw no change compared to control. There was no significant change in airway inflammation or airway hyperresponsiveness in any of the groups. However, the combined intervention group also lost a significant amount of weight (~5% body weight), so it is unclear whether the results were due to weight loss or the intervention components.

Obesity and weight loss

Asthma and obesity

Obesity is characterised by excessive accumulation of adipose tissue and is associated with altered disease pathophysiology in both children and adults. Both asthma and obesity are inflammatory conditions that are common in Westernised countries. Evidence shows that obesity contributes to an increase in asthma prevalence and can transform stable, well-controlled asthma towards a harder-to-treat phenotype [4, 53]. Obesity is associated with increased asthma severity, poorer asthma control, more frequent exacerbations, reduced response to asthma medications and decreased quality of life [3, 4]. While mechanisms linking obesity and asthma are yet to be fully elucidated, proposed contributing factors include inflammatory/metabolic/microbiome dysregulation, poor diet quality, physical inactivity, mechanical effects and genetics [3]. Due to the complex origins of obesity, it is likely that several obese–asthma phenotypes exist, with different contributing factors and clinical manifestations.

Weight loss and asthma

Weight loss should be recommended to all obese individuals with asthma due to the plethora of benefits, both to general health as well as the lungs. Whether achieved by diet, exercise or bariatric surgery, weight loss has been shown to improve asthma control, lung function and asthma-related quality of life [3]. Weight loss guidelines differ depending on the degree of obesity, and additional approaches that are more intrusive are recommended as body mass index (BMI) increases [54].

Lifestyle interventions

Lifestyle changes are often the first approach for addressing overweight and obesity (BMI ≥25 $kg \cdot m^{-2}$) in people with asthma. These changes should involve a multidimensional approach to reduce energy intake, increase physical activity and provide counselling for behaviour change. Dietary therapy should aim to lower calorific intake *via* tailored dietary support/education to achieve a 2500 $kJ \cdot day^{-1}$ energy deficit [55]. In addition, increased physical activity helps to achieve an energy deficit, with recommendations proposing weekly targets of 300 min of moderate-intensity exercise or 150 min of vigorous-intensity exercise, or a combination [55]. Importantly, behaviour therapy is designed to improve compliance to dietary modifications and physical activity plans through the development of self-monitoring skills [54].

Evidence surrounding the clinical impact of weight loss on asthma and obesity outcomes includes many poor quality, uncontrolled studies, where the primary outcomes were not related to asthma. However, in a recent systematic review, Okoniewski *et al*. [56] reviewed six RCTs that have used lifestyle weight-loss interventions aimed at improving asthma. All studies reported weight loss of 1.8–14.5%. Most studies reported improvement in at least one lung function outcome; however, two studies did not report any significant differences post intervention. All but one study found an improvement in quality of life scores; however, there were a variety of questionnaires used between the studies. Two studies found a relationship between amount of weight lost and improvement in asthma control. One study reported decreased use of reliever medication and reduced risk of exacerbations and this was the study with the highest weight loss (14.5%). Overall, the review suggests that even small amounts of weight loss can yield significant clinical benefits for patients with asthma, and should therefore be encouraged.

There is inconsistent evidence regarding whether weight loss by diet, exercise or diet and exercise is more effective. While all of the studies in the review reported weight loss, despite variability in the combination of dietary, exercise, cognitive and pharmacotherapy interventions used, three trials included found that dietary intervention or combined dietary and exercise interventions were more effective in achieving weight loss, over exercise alone. Combination interventions theoretically should be the most effective; however, this is an area of research that requires more investigation in this population.

There is also a lack of paediatric weight-loss intervention studies for obesity and asthma. In the systematic review by Okoniewski *et al*. [56], four RCTs assessed weight-loss interventions in children with asthma and at high risk of developing asthma. Despite variations in weight-loss interventions, including calorific restriction, cognitive behaviour therapy and exercise therapy, all studies reported significant weight loss in the intervention group. None of the studies reporting lung function showed a significant difference between intervention and control groups, with improvements seen in both arms across the trials. In three studies, at least one systemic inflammatory marker decreased. Two studies reported improved quality of life in the intervention arms, with a third study approaching significance for this outcome.

As limited weight-loss RCTs have been conducted in obese children, additional research is warranted to confirm the clinical impact of weight loss in this population. The evidence is varied regarding the ideal strategy to achieve weight loss in this population; however, interventions individualised to patients, that they can maintain long term, should be the focus. Based on current evidence, encouraging positive lifestyle changes should be considered as an adjunct non-pharmacological strategy for managing obese asthma. However, for some individuals, interventions that are more intensive may be required.

Pharmacotherapy

Pharmacotherapy strategies are suggested as an add-on treatment for patients with a BMI ≥30 kg·m^{-2} (or BMI ≥27 kg·m^{-2} plus obesity-related comorbidities), where lifestyle modifications have failed to achieve sufficient weight loss after 6 months [54]. Sibutramine, an appetite suppressant, and orlistat, a fat absorption inhibitor, are medications officially approved by the US Food and Drug Administration that can be used long term in weight loss, but they also present with side effects. Dias-Júnior *et al*. [57] conducted a 6-month intervention using dietary restriction plus sibutramine and orlistat in obese individuals with severe asthma. Subjects had a 7.5% weight loss and showed improvements in asthma control, lung function and symptoms, and a reduction in reliever medication use.

Weight loss surgery

Bariatric (weight loss) surgery may be an option for people aged 18–65 years with extreme obesity (BMI >40 kg·m^{-2}, or those with BMI >35 kg·m^{-2} and at least two significant obesity-related comorbidities). Because of risks associated with surgery, this approach should only be considered when less invasive weight loss attempts have been unsuccessful [54]. Bariatric surgery creates a physical barrier to lower energy intake and is the most effective strategy for achieving substantial weight reductions. Several studies have demonstrated positive asthma-related benefits resulting from bariatric surgery, including improvements in asthma control, asthma-related quality of life and lung function, and decreases in asthma medication requirements [58, 59]. Following bariatric surgery, many individuals with asthma show a reduction in airway hyperresponsiveness, possibly because obesity modifies contractile responses in airway smooth muscle [60]. These benefits have also been shown to continue, with observational studies reporting improvements in asthma control, rescue medication use, respiratory symptoms and quality of life scores up to 1 year post bariatric surgery [53].

Other lifestyle factors

Caffeine

Caffeine, commonly found in tea and coffee, is a natural stimulant but also a weak bronchodilator, which may be able to improve asthma treatment [61]. A Cochrane systematic review found that caffeine intake (5–10 mg·kg^{-1} body weight) moderately ameliorates lung function for up to 4 h post consumption [61]. Assuming an average of 150 mg of caffeine per cup of coffee, this equates to 1–5 cups of coffee required for bronchodilator effect.

Meditation, yoga and breathing exercises

Meditation is a complimentary therapy used to clear the mind and reduces stress and anxiety. It is traditionally associated with Eastern medicine and religion, but has grown to have a large following in Western countries. Meditation can be part of yoga, a spiritual system with engrained practices such as holding specific body positions and breathing. The effect of yoga and meditation on asthma is hypothesised to come from the retraining that occurs with the breathing and movement patterns, thus enabling an improvement in tidal volume, breathing rates and muscle relaxation [62].

In a recent systematic review of four RCTs, meditation has been found to improve some asthma outcomes [63]. The studies were 8 weeks to 3 months long, with the majority of studies requiring ~20 min daily meditation practice. Quality of life was measured in two studies, which indicated a significant improvement compared to the control group. All four studies reported lung function; however, there was no significant effect between groups. Only one study reported stress levels and medication use, finding a significant improvement in perceived stress and a reduction in reliever medication in the meditation group. This indicates much promise for meditation in asthma, particularly for quality of life. However, more research is needed, particularly in children, as current research has focused on yoga for children rather than meditation.

In a Cochrane systematic review of 15 RCTs that used yoga as an intervention, the results were heterogeneous [62]. Five studies found that yoga significantly improved quality of life, and three studies found a significant reduction in symptoms. Two studies found a reduction in medication use in the yoga intervention group; however, the quality of evidence for this outcome was lower than for quality of life and symptom reduction. There is some evidence that similar effects can be seen within a paediatric asthmatic population [64]. One paediatric study in particular, which followed 26 children for 2 years past the 40-day

intervention, found that those who practised yoga for 15–30 min every day remained asymptomatic [64]. Others that were followed-up in the 2-year period but practised yoga less consistently did show a reduction in symptoms and medication use, but not as strong as daily users. The inconsistent results may be explained by the variability of the yoga interventions, with differing types of yoga, regularity of practice and combinations of breathing, posture and medication use involved [62]. More evidence is needed, particularly focusing on standardised yoga interventions with longer follow-up, but yoga remains a promising lifestyle intervention that could be useful in an asthma population.

Breathing exercises are another non-pharmacological method of reducing asthma symptoms. Breathing exercises can vary by type; however, they all manipulate breathing technique in order to reduce hyperventilation. Some examples include lateral costal breathing, diaphragmatic breathing, nasal breathing and yoga [65]. In a systematic review of 13 RCTs investigating breathing exercises in adults, there were a number of improvements reported [65]. All eight studies that measured quality of life reported an improvement, and six out of seven studies that reported asthma symptoms favoured breathing exercise compared to inactive or education-only controls. Lung function was variable among the 11 studies that reported this, and, due to the discrepancies between different breathing exercise types and quality of evidence, the review could not recommend breathing exercises for adults with asthma. However, they noted that individually the studies indicated a positive impact on asthma symptoms and quality of life and, thus, for adults with asthma, breathing exercises may be useful, but comparing different types of exercises would be important for future research. In children, only three studies were found in a 2016 systematic review that assessed breathing exercises as an intervention for childhood asthma [66]. However, none of these studies used breathing exercises alone but rather as a part of a multifaceted intervention. As such, the reviewers could not recommend breathing exercises for children, but highlighted the need for further research in this area.

Meditation, yoga and breathing exercises are promising lifestyle interventions for the treatment of asthma, in both children and adults. With significant evidence to suggest an improvement in quality of life and symptoms, future research needs to focus on comparing different modes of delivery, to determine the most effective interventions for people with asthma.

Massage and manual therapy

Massage therapy is a traditional healing method that involves kneading or manipulating soft tissue and muscle to improve well-being. Evidence suggests that massage excites the vagus nerve, which may reduce cortisol levels, but the exact mechanisms are unknown [67]. Massage is a therapy that can be performed at home by family members, has no cost and is easily implemented, and therefore holds much promise for people with asthma.

In children, massage therapy has been found to enhance current asthma treatments. In a systematic review of 14 RCTs, 12 studies comparing conventional treatments with or without massage showed a significantly higher effectiveness in the massage group [67]. Seven studies measuring lung function outcomes found significant improvements with the addition of massage therapy to traditional treatments. Quality of life was not measured in this review, although the literature suggests that, in children, massage or manual therapy can reduce anxiety and therefore improve quality of life [68]. However, some of the studies in this review also used therapies such as Chinese medicine or acupuncture, so future research needs to focus on massage therapy alone and particularly on quality of life outcomes.

Hondras *et al.* [68] reviewed studies using massage or manual therapy in adults with asthma, finding only three studies and no consistent evidence of benefit. Manual therapy differs from massage therapy in that it is performed by a health professional such as a chiropractor, osteopath or physiotherapist and usually focuses on breathing structures such as mobilising ribs and thoracic cage and improving blood flow to lungs. Two studies compared manual therapy to sham manual therapy and found no effect between the two groups for any outcome measured. The other trial compared massage therapy to relaxation control and found a favourable effect of massage therapy for lung function and decreasing anxiety; however, this was a study conducted in children. Overall, Hondras *et al.* [68] do not recommend manual therapy, including massage therapy, for adults with asthma; however, they recommended that further trials are needed to investigate this lifestyle intervention in asthma. There may be some benefit in children, and no harm has been demonstrated for massage therapy in either an adult or child population.

Acupuncture

Acupuncture is a form of Chinese medicine that involves the use of needles to stimulate various anatomical points on the body. A recent systematic review of nine studies found some evidence that acupuncture combined with conventional treatment could improve asthma. The five studies that reported symptom response rate found a significantly favourable effect for the acupuncture combined group compared to conventional treatment alone, which they found remained significant in sub-analysis of acute and chronic treatment of asthma [69]. In the five studies reporting lung

function measures, there was no improvement in the acupuncture combined group; however, in two studies that reported systemic inflammation, there was a significantly lower level of IL-6 in the acupuncture group compared to conventional treatment. The review did not assess quality of life but rather highlighted the need for more research addressing these outcomes on asthma with acupuncture therapy, with the aim of creating a standard method of acupuncture for asthma.

In children, the evidence is similarly contradictory. In a systematic review of seven studies, in the six studies that reported lung function parameters, two studies found a significant improvement in peak expiratory flow and a third study found an improvement in anxiety levels [70]. Quality of life was reported in three of the seven studies but there was no significant impact of the acupuncture intervention. There is a need for further research in this area, particularly as there is large variation in both adult and child studies in acupuncture methods, such as in use of traditional needle or laser, in needle placement, depth, time and number of sessions.

Herbal medicine

Herbal medicine is a key component of complementary and alternative medicine. In a systematic review of 26 studies, there were over 20 compounds investigated, including traditional Chinese, Indian and Japanese herbs. Most studies reported no differences; however, there were some herbal medicine compounds (boswellia, Mai-Men-Dong-Tang, Pycnogenol, Jia-Wei-Si-Jun-Zi-Tang and *Tylophora indica*) that showed an increase in lung function [71]. 1.8-Cineol (the main therapeutic component of eucalyptus) showed a reduction in oral steroid use in asthma. At this point in time, the data are not definitive enough to make recommendations for herbal remedies in the treatment of asthma, either in children or adults.

Conclusion

Asthma is a complex inflammatory disease that places a significant burden on sufferers. While predominant treatment is *via* asthma medications, there is growing evidence that lifestyle interventions can help people with asthma live well. Improving nutrition and exercising regularly has many health benefits for people with asthma; however, more research is needed to determine the best dietary and exercise components for improving asthma. In obese asthmatic patients, weight loss has clear benefits. Other lifestyle interventions such as meditation, yoga and breathing exercises may be beneficial for adults with asthma, while massage therapy may be more promising for children with asthma. However, more high-quality studies are needed to make definitive recommendations. Overall, lifestyle interventions are inexpensive therapies that can improve the quality of life and other outcomes of asthma in both adults and children. Lifestyle interventions should be considered a key component of asthma management.

Self-evaluation questions

1 Which of the following dietary strategies would best benefit someone with asthma?
   a) Increasing pizza, ice cream and chip intake
   b) Increasing fruit, vegetable and wholegrain food consumption
   c) Avoiding probiotics
   d) Taking vitamin D supplements
2 Which of the following can prevent exercise-induced bronchoconstriction?
   a) Eating before training
   b) Avoiding exercising
   c) Pre-treating with reliever medication
   d) Avoiding food before exercising
3 What weight loss strategy should be recommended for a patient with mild asthma and BMI of 28 $kg \cdot m^{-2}$?
   a) Bariatric surgery
   b) None
   c) Pharmacotherapy
   d) Dietary restriction and exercise programme
4 Which of the following other lifestyle factors has been shown to benefit children with asthma, but not adults?
   a) Yoga
   b) Acupuncture
   c) Caffeine
   d) Massage

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Conflict of interest

I. Stoodley has nothing to disclose. L. Williams has nothing to disclose. C. Thompson has nothing to disclose. H. Scott has nothing to disclose. L. Wood reports research grants and non-financial/other support (travel

Suggested answers

1. b.
2. c.
3. d.
4. d.

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References

1. Global Initiative for Asthma (GINA). Global Strategy for Asthma Management and Prevention. 2018. Available from: https://ginasthma.org
2. Viswanathan RK, Busse WW. Biologic therapy and asthma. *Semin Respir Crit Care Med* 2018; 39: 100–114.
3. Peters U, Dixon AE, Forno E. Obesity and asthma. *J Allergy Clin Immunol* 2018; 141: 1169–1179.
4. Barros R, Moreira P, Padrão P, *et al.* Obesity increases the prevalence and the incidence of asthma and worsens asthma severity. *Clin Nutr* 2017; 36: 1068–1074.
5. Westermann H, Choi TN, Briggs WM, *et al.* Obesity and exercise habits of asthmatic patients. *Ann Allergy Asthma Immunol* 2008; 101: 488–494.
6. Groth SW, Rhee H, Kitzman H. Relationships among obesity, physical activity and sedentary behavior in young adolescents with and without lifetime asthma. *J Asthma* 2016; 53: 19–24.
7. Brigham EP, Kolahdooz F, Hansel N, *et al.* Association between Western diet pattern and adult asthma: a focused review. *Ann Allergy Asthma Immunol* 2015; 114: 273–280.
8. Barros R, Moreira A, Fonseca J, *et al.* Adherence to the Mediterranean diet and fresh fruit intake are associated with improved asthma control. *Allergy* 2008; 63: 917–923.
9. Papamichael MM, Itsiopoulos C, Susanto NH, *et al.* Does adherence to the Mediterranean dietary pattern reduce asthma symptoms in children? A systematic review of observational studies. *Public Health Nutr* 2017; 20: 2722–2734.
10. Pogson Z, McKeever T. Dietary sodium manipulation and asthma. *Cochrane Database Syst Rev* 2011; 3: CD000436.
11. Milan SJ, Hart A, Wilkinson M. Vitamin C for asthma and exercise-induced bronchoconstriction. *Cochrane Database Syst Rev* 2013; 10: CD010391.
12. Williams NC, Johnson MA, Shaw DE, *et al.* A prebiotic galactooligosaccharide mixture reduces severity of hyperpnoea-induced bronchoconstriction and markers of airway inflammation. *Br J Nutr* 2016; 116: 798–804.
13. Wood LG, Berthon BS, Zapirain R, *et al.* Asthma control, airway inflammation and gut microbiome are improved by soluble fibre supplementation. *Respirology* 2017; 22: Suppl. 2, TO-008.
14. Sexton P, Black P, Metcalf P, *et al.* Influence of Mediterranean diet on asthma symptoms, lung function, and systemic inflammation: a randomized controlled trial. *J Asthma* 2013; 50: 75–81.
15. Ma J, Strub P, Lv N, *et al.* Pilot randomised trial of a healthy eating behavioural intervention in uncontrolled asthma. *Eur Respir J* 2016; 47: 122–132.
16. Hirota SA, Janssen LJ. Sodium and asthma: something borrowed, something new? *Am J Physiol Lung Cell Mol Physiol* 2007; 293: L1369–L1373.
17. Guo CH, Liu PJ, Lin KP, *et al.* Nutritional supplement therapy improves oxidative stress, immune response, pulmonary function, and quality of life in allergic asthma patients: an open-label pilot study. *Altern Med Rev* 2012; 17: 42–56.
18. Wood LG, Garg ML, Powell H, *et al.* Lycopene-rich treatments modify noneosinophilic airway inflammation in asthma: proof of concept. *Free Radic Res* 2008; 42: 94–102.
19. Wood LG, Garg ML, Smart JM, *et al.* Manipulating antioxidant intake in asthma: a randomized controlled trial. *Am J Clin Nutr* 2012; 96: 534–543.
20. Gao J, Gao X, Li W, *et al.* Observational studies on the effect of dietary antioxidants on asthma: a meta-analysis. *Respirology* 2008; 13: 528–536.
21. Lee SC, Yang YH, Chuang SY, *et al.* Reduced medication use and improved pulmonary function with supplements containing vegetable and fruit concentrate, fish oil and probiotics in asthmatic school children: a randomised controlled trial. *Br J Nutr* 2013; 110: 145–155.
22. McLoughlin RF, Berthon BS, Jensen ME, *et al.* Short-chain fatty acids, prebiotics, synbiotics, and systemic inflammation: a systematic review and meta-analysis. *Am J Clin Nutr* 2017; 106: 930–945.
23. Berthon BS, Macdonald-Wicks LK, Gibson PG, *et al.* Investigation of the association between dietary intake, disease severity and airway inflammation in asthma. *Respirology* 2013; 18: 447–454.
24. Garcia-Larsen V, Del Giacco SR, Moreira A, *et al.* Asthma and dietary intake: an overview of systematic reviews. *Allergy* 2016; 71: 433–442.
25. West CE, Jenmalm MC, Kozyrskyj AL, *et al.* Probiotics for treatment and primary prevention of allergic diseases and asthma: looking back and moving forward. *Expert Rev Clin Immunol* 2016; 12: 625–639.
26. van de Pol MA, Lutter R, Smids BS, *et al.* Synbiotics reduce allergen-induced T-helper 2 response and improve peak expiratory flow in allergic asthmatics. *Allergy* 2011; 66: 39–47.
27. Halnes I, Baines KJ, Berthon BS, *et al.* Soluble fibre meal challenge reduces airway inflammation and expression of GPR43 and GPR41 in asthma. *Nutrients* 2017; 9: E57.
28. Calder PC. Marine omega-3 fatty acids and inflammatory processes: effects, mechanisms and clinical relevance. *Biochim Biophys Acta* 2015; 1851: 469–484.
29. Papamichael MM, Shrestha SK, Itsiopoulos C, *et al.* The role of fish intake on asthma in children: a meta-analysis of observational studies. *Pediatr Allergy Immunol* 2018; 29: 350–360.
30. Schindler T, Sinn JK, Osborn DA. Polyunsaturated fatty acid supplementation in infancy for the prevention of allergy. *Cochrane Database Syst Rev* 2016; 10: CD010112.
31. Thien FCK, De Luca S, Woods RK, *et al.* Cochrane Review: Dietary marine fatty acids (fish oil) for asthma in adults and children. *Evidence-Based Child Health: A Cochrane Review Journal* 2011; 6: 984–1012.
32. Wood LG. Diet, obesity, and asthma. *Ann Am Thorac Soc* 2017; 14: Suppl. 5, S332–S338.
33. Wood LG, Garg ML, Gibson PG. A high-fat challenge increases airway inflammation and impairs bronchodilator recovery in asthma. *J Allergy Clin Immunol* 2011; 127: 1133–1140.
34. Wood LG, Li Q, Scott HA, *et al.* Saturated fatty acids, obesity, and the nucleotide oligomerization domain-like receptor protein 3 (NLRP3) inflammasome in asthmatic patients. *J Allergy Clin Immunol* 2019; 143: 305–315.
35. Riverin BD, Maguire JL, Li P. Vitamin D supplementation for childhood asthma: a systematic review and meta-analysis. *PLoS One* 2015; 10: e0136841.
36. Hall SC, Agrawal DK. Vitamin D and bronchial asthma: an overview of data from the past 5 years. *Clin Ther* 2017; 39: 917–929.
37. Martineau AR, Cates CJ, Urashima M, *et al.* Vitamin D for the management of asthma. *Cochrane Database Syst Rev* 2016; 9: CD011511.
38. Weiler JM, Anderson SD, Randolph C, *et al.* Pathogenesis, prevalence, diagnosis, and management of exercise-induced bronchoconstriction: a practice parameter. *Ann Allergy Asthma Immunol* 2010; 105: Suppl. 6, S1–S47.
39. Eijkemans M, Mommers M, Draaisma JM, *et al.* Physical activity and asthma: a systematic review and meta-analysis. *PLoS One* 2012; 7: e50775.
40. Morton AR, Fitch KD. Australian association for exercise and sports science position statement on exercise and asthma. *J Sci Med Sport* 2011; 14: 312–316.

41. Lu KD, Billimek J, Bar-Yoseph R, *et al.* Sex differences in the relationship between fitness and obesity on risk for asthma in adolescents. *J Pediatr* 2016; 176: 36–42.
42. Eichenberger PA, Diener SN, Kofmehl R, *et al.* Effects of exercise training on airway hyperreactivity in asthma: a systematic review and meta-analysis. *Sports Med* 2013; 43: 1157–1170.
43. Pakhale S, Luks V, Burkett A, *et al.* Effect of physical training on airway inflammation in bronchial asthma: a systematic review. *BMC Pulm Med* 2013; 13: 38.
44. Geiger KR, Henschke N. Swimming for children and adolescents with asthma. *Br J Sports Med* 2015; 49: 835–836.
45. Grande AJ, Silva V, Andriolo BN, *et al.* Water-based exercise for adults with asthma. *Cochrane Database Syst Rev* 2014; 7: CD010456.
46. Bonini M, Silvers W. Exercise-induced bronchoconstriction: background, prevalence, and sport considerations. *Immunol Allergy Clin North Am* 2018; 38: 205–214.
47. Aparecido da Silva R, Rocco PGL, Mazzucatto F, *et al.* High intensity interval training increases the clinical control, aerobic fitness and decreases dyspnea in severe asthmatics. *Eur Respir J* 2016; 48: Suppl. 60, PA1560.
48. Varray AL, Mercier JG, Terral CM, *et al.* Individualized aerobic and high intensity training for asthmatic children in an exercise readaptation program. Is training always helpful for better adaptation to exercise? *Chest* 1991; 99: 579–586.
49. Emtner M, Finne M, Stålenheim G. High-intensity physical training in adults with asthma. A comparison between training on land and in water. *Scand J Rehabil Med* 1998; 30: 201–209.
50. Carson KV, Chandratilleke MG, Picot J, *et al.* Physical training for asthma. *Cochrane Database Syst Rev* 2013; 9: CD001116.
51. Joschtel B, Gomersall SR, Tweedy S, *et al.* Effects of exercise training on physical and psychosocial health in children with chronic respiratory disease: a systematic review and meta-analysis. *BMJ Open Sport Exerc Med* 2018; 4: e000409.
52. Toennesen LL, Meteran H, Hostrup M, *et al.* Effects of exercise and diet in nonobese asthma patients – a randomized controlled trial. *J Allergy Clin Immunol Pract* 2018; 6: 803–811.
53. Moreira A, Bonini M, Garcia-Larsen V, *et al.* Weight loss interventions in asthma: EAACI evidence-based clinical practice guideline (part I). *Allergy* 2013; 68: 425–439.
54. National Institutes of Health, National Heart, Lung, and Blood Institute, North American Association for the Study of Obesity. The Practical Guide: Identification, Evaluation, and Treatment of Overweight and Obesity in Adults. NIH Publication Number 00-4084. Bethesda, National Institutes of Health, 2000.
55. National Health and Medical Research Council. Clinical Practice Guidelines for the Management of Overweight and Obesity in Adults, Adolescents and Children in Australia. NHMRC reference code N57. Melbourne, National Health and Medical Research Council, 2013.
56. Okoniewski W, Lu KD, Forno E. Weight loss for children and adults with obesity and asthma. A systematic review of randomized controlled trials. *Ann Am Thorac Soc* 2019; 16: 613–625.
57. Dias-Júnior SA, Reis M, de Carvalho-Pinto RM, *et al.* Effects of weight loss on asthma control in obese patients with severe asthma. *Eur Respir J* 2014; 43: 1368–1377.
58. Dixon AE, Pratley RE, Forgione PM, *et al.* Effects of obesity and bariatric surgery on airway hyperresponsiveness, asthma control, and inflammation. *J Allergy Clin Immunol* 2011; 128: 508–515.
59. Boulet LP, Turcotte H, Martin J, *et al.* Effect of bariatric surgery on airway response and lung function in obese subjects with asthma. *Respir Med* 2012; 106: 651–660.
60. Orfanos S, Jude J, Deeney BT, *et al.* Obesity increases airway smooth muscle responses to contractile agonists. *Am J Physiol Lung Cell Mol Physiol* 2018; 315: L673–L681.
61. Welsh EJ, Bara A, Barley E, *et al.* Caffeine for asthma. *Cochrane Database Syst Rev* 2010; 1: CD001112.
62. Yang ZY, Zhong HB, Mao C, *et al.* Yoga for asthma. *Sao Paulo Med J* 2016; 134: 368.
63. Paudyal P, Jones C, Grindey C, *et al.* Meditation for asthma: systematic review and meta-analysis. *J Asthma* 2018; 55: 771–778.
64. Galantino ML, Galbavy R, Quinn L. Therapeutic effects of yoga for children: a systematic review of the literature. *Pediatr Phys Ther* 2008; 20: 66–80.
65. Freitas DA, Holloway EA, Bruno SS, *et al.* Breathing exercises for adults with asthma. *Cochrane Database Syst Rev* 2013; 10: CD001277.
66. Macedo TM, Freitas DA, Chaves GS, *et al.* Breathing exercises for children with asthma. *Cochrane Database Syst Rev* 2016; 4: CD011017.
67. Wu J, Yang XW, Zhang M. Massage therapy in children with asthma: a systematic review and meta-analysis. *Evid Based Complement Alternat Med* 2017; 2017: 5620568.
68. Hondras MA, Linde K, Jones AP. Manual therapy for asthma. *Cochrane Database Syst Rev* 2001; 1: CD001002.
69. Jiang C, Jiang L, Qin Q. Conventional treatments plus acupuncture for asthma in adults and adolescent: a systematic review and meta-analysis. *Evid Based Complement Alternat Med* 2019; 2019: 9580670.
70. Liu CF, Chien LW. Efficacy of acupuncture in children with asthma: a systematic review. *Ital J Pediatr* 2015; 41: 48.
71. Clark CE, Arnold E, Lasserson TJ, *et al.* Herbal interventions for chronic asthma in adults and children: a systematic review and meta-analysis. *Prim Care Respir J* 2010; 19: 307–314.