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# A systematic review of associations of physical activity and sedentary time with asthma outcomes

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## Abstract

Background: Physical inactivity and high sedentary time are associated with adverse health outcomes in several diseases. However, their impact in asthma is less clear.

Objective: We aimed to synthesise the literature characterising physical activity and sedentary time in adults with asthma, to estimate activity levels using meta-analysis, and to evaluate associations between physical activity and sedentary time and the clinical and physiological characteristics of asthma.

Methods: Articles written in English and addressing the measurement of physical activity or sedentary time in adults ≥18 years old with asthma were identified using four electronic databases. Meta-analysis was used to estimate steps/day in applicable studies.

Results: There were 42 studies that met the inclusion criteria. Physical activity in asthma was lower compared to controls. The pooled mean (95%CI) steps/day for people with asthma was 8390 (7361, 9419). Physical activity tended to be lower in females compared with males, and in older people with asthma compared with their younger counterparts. Higher levels of physical activity were associated with better measures of lung function, disease control, health status, and health care use. Measures of sedentary time were scarce, and indicated a similar engagement in this behavior between asthma participants and controls. High sedentary time was associated with higher health care use, and poorer lung function, asthma control and exercise capacity.

Conclusions: People with asthma engage in lower levels of physical activity compared to controls. Higher levels of physical activity may positively impact on asthma clinical outcomes. Sedentary time should be more widely assessed.

***Highlight box:***

1. *What is already known about this topic? Compared to controls, subjectively measured physical activity seems to be reduced in adults with asthma. Higher levels of physical activity might have a beneficial impact on asthma.*
2. *What does this article add to our knowledge? Physical activity is reduced in adults with asthma, especially in females and older people with asthma. Sedentary time did not differ between people with and without asthma. Higher levels of activity are associated with better asthma outcomes.*
3. *How does this study impact current management guidelines? These results suggest that addressing inactivity and sedentary time may be a potential nonpharmacological approach in the management of asthma. Disease severity, sex, and age should guide these approaches.*

***Key words: asthma; physical activity; sedentary time; accelerometry; questionnaire; associations; clinical outcomes; meta-analysis.***

**List of abbreviations:**

EIB: exercise-induced bronchoconstriction

COPD: chronic obstructive pulmonary disease

BMI: body mass index

RCT: randomised control trial.

MVPA: moderate and higher intensity physical activity

ST: sedentary time

6MWD: 6-minute walk distance

Hs-CRP: high sensitivity C- reactive protein

$FEV_1$: forced expiratory volume in the first second

FVC: forced vital capacity

## Introduction

Asthma is an obstructive airway disease that causes symptoms of dyspnoea, wheezing, and chest tightness. These symptoms, and the fear of provoking exercise induced bronchoconstriction (EIB), may have a negative impact on the engagement in physical activity in people with asthma[1-3].

Physical activity and sedentary time have been widely studied in the general population[4] and in chronic obstructive pulmonary disease (COPD). People with COPD are considerably less active and more sedentary than people without respiratory conditions[5, 6]. Furthermore, inactivity in COPD is associated with more exacerbations resulting in hospitalisation[7], a reduced time to readmission[8], and increased all-cause mortality[8-10]. As a result, there are well-established exercise programmes for people with COPD that seek to address physical inactivity[11, 12]. In asthma however, the role of physical activity and sedentary time is less clear[13], and thus guidelines and interventions to target these behaviors in this population are limited.

In a prior systematic review in adults and children, Eijkemans et al.[14] suggested that people engaging in higher levels of physical activity might have a lower risk of asthma incidence[14]. In adults with asthma, they also found a trend towards lower levels of physical activity compared to controls[14]. However, none of the included studies used objective measures (accelerometry) to quantify physical activity in adults, and sedentary time was not addressed. Another review found that children and adolescents with and without asthma engage in a similar amount of objectively measured physical activity[15]. Despite this evidence, there are no reviews of the literature that have evaluated the prevalence of sedentary time in adults with asthma, nor reviewed the use of accelerometry to quantify physical activity and sedentary time in this population. Additionally, the degree to which the level of physical activity and sedentary time impact on the airway symptoms or clinical outcomes in adults with asthma has not been reviewed.

Our aim therefore is to update and synthesise the evidence in relation to the prevalence of physical activity and sedentary time in adults with asthma. We conducted a meta-analysis of studies reporting steps/day in people with asthma, and sought to evaluate the associations of these behaviors with the clinical and physiological characteristics of the disease.

# Methods

## Literature search

Articles written in English, and addressing the measurement of physical activity or sedentary time in adults (≥18 years) with asthma were identified by a comprehensive search using the Medline, Embase, PEDro, and Cochrane databases. Search was conducted in April 2017, and updated in October 2017, and included all articles published until the search date.

Eligible studies were those that: examined the prevalence and patterns of these behaviors in asthma populations, or studies analysing the association of these behaviors with clinical or biological markers of the disease. We did not include a filter for study design. Details of the search strategy are provided in Table I.

## Analysis

Statistical analysis was performed using STATA 13 (Stata Corp., College Station, TX, USA). The continuous outcome (mean steps/day) from relevant studies[16-22] was pooled using the random-effect model. Authors of three studies were contacted, and provided further details of their results[16, 20, 21].

## Results

The initial search yielded 2803 references. A flow diagram[23] of the literature search is provided in Figure 1.

We identified 42 eligible studies investigating physical activity and/or sedentary time in adults with asthma. Population characteristics are presented in Table II. From these studies, 18 compared the level of these behaviors in asthma to a control group[16-19, 21, 27, 28, 30-32, 37, 39, 41, 42, 44-47]. Table III summarises the physical activity measurements utilised in these 18 studies. Three studies[20, 22, 50] without a control group were also included in Table III in order to provide further details of the activity monitors used. Associations with disease characteristics were assessed in 24 studies[16-18, 21, 22, 24, 28, 29, 31, 33, 35, 39, 40, 42, 43, 47, 49-51, 53-57] (Table IV). Additionally, two studies reported physical activity as a confounder of body mass index (BMI)[26, 34], and two studies reported physical activity prior to a randomised controlled trial (RCT) exercise intervention[20, 38]. In five studies, the association between current asthma and different levels of physical activity was assessed[25, 26, 48, 52, 58]. In general, the studies were quite heterogeneous in terms of the population and assessments of activity/sedentary time. Studies included 193,821 asthma participants and 1,417,540 controls. Most participants were women, and in 31% of the studies the mean age was under 45 years old. Twenty-three studies used a self-reported asthma diagnosis[25-33, 36, 37, 39, 44, 46-48, 52, 53, 55-58]. Disease severity or level of control was reported in 15 studies, and populations included people with mild, moderate, and severe asthma[16-18, 20-22, 26, 34, 38, 40-42, 47, 49, 56].

## Prevalence of physical activity

Among studies using a control group, eleven[16-18, 21, 28, 30, 32, 39, 41, 44, 46] (asthma sample =32,606) reported less physical activity in asthma, and six reported no difference [19,31,37,42,46,47,] (asthma sample=7824). One study[27] (asthma sample size=1,070) reported increased physical activity in younger adults with asthma (<40 years old), but decreased in older participants (>50 years old).

Activity monitors were used in 8 studies[16-22,50-]. Five of them included a control group[16-19, 21] (Table III and V). A meta-analysis (Figure 2) found that the weighted mean (95%CI) number of steps/day for people with asthma was 8390 (7361, 9419). In the four studies that compared the volume and/or intensity of activity, people with asthma tended to accumulate less physical activity than controls (Table V).

Some studies reported an effect of age and sex on activity in asthma. Three studies reported that the decrease in activity in people with asthma was mostly seen in older participants (≥50 years old)[27, 32, 46]. For instance, despite their overall results showing that people with asthma were more inactive than controls, Ford et al.[32] did not find statistically significant differences in the association between activity and asthma status in people under the age of 60. Some studies reported that males with asthma presented higher levels of activity than females with asthma or than their healthy counterparts[39, 47, 49, 51]. Furthermore, two studies demonstrated that the decrease in activity that develops in older people with asthma occurs earlier, or exclusively, in females than males[27, 30]. Dogra et al.[30] for instance, found that the levels of physical activity between middle-age and older males with asthma were similar, while older females with asthma were considerably less active than their younger counterparts.

## Reduced physical activity in people with asthma.

From the 11 studies reporting lower levels of physical activity in people with asthma compared to controls[16-18,21,28,30,32,39,41,44,46], four studies used activity monitors[16-18, 21]. Van't Hul et al.[21] found that people with asthma spent significantly less time walking, engaging in vigorous physical activity, and accumulated less steps/day than controls. Cordova-Rivera et al.[18] reported that in participants with severe asthma, steps/day and moderate and vigorous physical activity (MVPA) were reduced by 31.4% and 47.5% respectively compared to controls ($P<0.001$ both results).

From the studies using questionnaires, Teramoto et al.[44] reported that control participants spent an additional 60 minutes/week engaged in moderate physical activity and 67 minutes/week in vigorous activity compared to the asthma group ($P<0.001$). Ford et al.[32] reported that people with current asthma were more inactive (asthma=30.9%, never asthma=27.8% $P<0.001$) and engaged in less vigorous physical activity (asthma=12.7%, never asthma=14.8% $P<0.001$) than people without a history of asthma. Vancampfort et al.[46] reported that asthma was significantly associated with low physical activity (engaging in <150 min/week of moderate and vigorous physical activity), especially in people >50 years old (odds ratio (OR)(95%CI)1.67(1.33-2.10), $P<0.0001$).

The level of activity decreased with loss of asthma control[21], and increasing asthma severity[16, 17]. Bahmer et al.[16] reported that both steps/day and the time spent in MVPA in participants with severe asthma were reduced by 21% and 17% respectively, compared with participants with less severe disease ($P<0.05$).

### Maintained physical activity in people with asthma.

In six studies there were no consistent differences in the level of the activity between the asthma and control groups[19, 31, 37, 42, 45, 47]. One study used an activity monitor[19]. Verlaet et al.[47] found that the proportion of participants performing MVPA was similar among people with controlled and uncontrolled asthma compared with controls; 32%, 38.5% and 33.7% ($P>0.05$) for each group respectively. Liang et al.[37] reported that the prevalence ratio (95% CI) for young adults with asthma (<30 years old) engaging in physical activity at the recommended level was 1.09 (0.92, 1.28) compared to those without asthma.

Increased physical activity in people with asthma.

Chen et al.[27] found that younger adults with asthma achieved higher levels of activity compared to their age-matched healthy counterparts, whereas this pattern of activity reversed in the older age group, especially in females. The mean [Standard Error (SE)] energy expenditure (EE) for men in the 25-39 years age group with asthma versus their control group was 2.16 (0.22) compared to 1.72 (0.15) kcal $kg^{-1}day^{-1}$; and 1.60 (0.14) versus 1.28 (0.06) kcal $kg^{-1}day^{-1}$ in the female asthma group compared to female controls ($P$=0.02 for both). At the age of 40 this trend started to reverse, becoming statistically significant in women >55 years, and for both sexes in the ≥70 years group. In the age group ≥70 years, males with asthma reported a mean (SE) EE of 0.72 (0.34) versus age-matched controls 1.45 (0.15) kcal $kg^{-1}day^{-1}$, while females reported a mean of 0.79 (0.17) versus 1.17 (0.07) kcal $kg^{-1}day^{-1}$ ($P \leq 0.02$ both results).

## Prevalence of sedentary time

Sedentary time was reported by four studies[18, 21, 28, 47]. Two used an activity monitor[18, 21]. Van't Hul et al. reported that asthma participants spent more time lying down compared to controls (hours/day mean difference (95% CI) 0.59 (0.15, 1.03) $P$<0.01), but less time sitting than controls ($P$>0.05)[21]. Similarly, another study did not find a significant difference in sedentary time between people with severe asthma and controls (minutes/day mean ± sd 674.4 ± 71 versus 676.2 ± 65, respectively $P$>0.05)[18]. Doggett et al.[28] reported that the time spent watching TV for over 10 hours/week was 50.4% in the asthma population compared to 42.9% in the non-asthma group ($P$<0.05).

## Associations between physical activity or sedentary time and asthma health outcomes

Twenty-seven studies reported associations between the level of activity and asthma health outcomes. Five were longitudinal[53-57]. Associations with sedentary time were addressed in three studies[18, 28, 47]. Table IV reports the main findings of these studies. Further descriptions of these association are summarised in the online supplement.

The relationship between physical activity and lung function was assessed in 10 studies[16-18,21,39,40,42,50,53,55]. Weak but significant associations were reported in eight studies[16-18,39,42,50,53,55], from which two were of longitudinal design[53, 55]. Measures of asthma control or asthma related health status were reported in 13 studies, 12 of them of cross-sectional design[18,21,22,24,29,33,35,40,42,47,49,51,57]. Most of the studies found a positive association between higher physical activity and better clinical outcomes, although in some studies these associations were attenuated to the null when BMI was included as a confounder[24, 49, 51, 57]. For instance, in their longitudinal analysis, Russell et al.[57] reported that the protective effect found for light physical activity on current asthma (defined as reporting asthma symptoms, taking asthma medication, or having an asthma exacerbation in the last 12 months) was no longer significant after adjusting for BMI. Vigorous physical activity was associated with more asthma symptoms in three studies[42, 47, 57].

Measures of health care utilisation were evaluated in six studies[28, 31, 43, 51, 54, 56]. Less physical activity was associated with increased exacerbation and/or higher health care utilisation in four of them[28, 31, 43, 56]. However, contradicting results were reported in the two longitudinal cohorts[54, 56]. Positive associations between measures of exercise capacity and physical activity were reported in two cross-sectional studies[18, 40]. Higher physical activity (steps/day) was associated with lower systemic inflammation (high-sensitivity CRP) in one study[18]. No significant associations were found between physical activity and measures of eosinophilic airway inflammation[18]

Higher levels of sedentary time were associated with worse asthma clinical outcomes in two cross-sectional studies[18, 28]. In one of them, these associations were no longer significant after adjustment for physical activity[18]. Doggett et al.[28] reported an increased OR (95% CI) for general practitioner (GP) consultations 2.59 (2.34, 2.87), and hospitalisations in the past year 1.95 (1.82, 2.08) and past 5 years 1.13 (1.07, 1.18) ($P$ <0.001 for all results) for adults with asthma who reported >10 hours of television time/week compared to those who reported ≤10 hours.

## Discussion

This review summarises the literature in relation to the prevalence of physical activity and sedentary time in people with asthma, and the associations between these behaviors and different disease outcomes. We found that people with asthma undertake less physical activity than people without asthma, and that the level of activity in asthma seems to be influenced by age, sex, and disease severity.

We also found that people with asthma average 8390 steps/day. This is almost double the value observed in COPD, where an average of 4579 steps/day was reported ($FEV_1$% < 50% in 55% of studies included)[59]. This suggests that while physical activity may be reduced in asthma, the degree of reduction is not as severe as in COPD. Nevertheless, there are subgroups in the asthma population where physical activity is lower[16-18, 21]. The two studies including people with severe asthma reported a median of around 5800 step/day[16, 18]. Therefore, the estimate of 8390 steps may not be a value applicable to more severe populations. However, considering that this is the first meta-analysis of steps performed in adults with asthma, and that the objective measurement of physical activity in asthma is a fairly recent topic; this value provides a reference that can be updated and developed with future studies.

We found that physical activity seems to be influenced by sex. Several studies reported better activity outcomes in men with asthma compared to women. Similar findings have been reported in children with asthma compared to controls, suggesting that lower levels of activity are only present in women[60, 61]. In the general population it has also been found that both girls[62] and adult females[63, 64] do less activity than their male counterparts. However, the fact that the decline in activity in middle-aged and older people with asthma is seen earlier in women[27, 30], may suggest that the disease consequences are more severe, or have a greater impact on health in females. Supporting this observation is evidence suggesting that among people with similar asthma severity, women tend to have poorer self-reported measures of asthma control and health status[65] and are twice as likely to be admitted to hospital due to acute asthma[66]. From a societal perspective, this sex difference could also be due to changes in physical activity after retirement, with women retiring at an earlier age[30].

We also identified a potential effect of age on the level of physical activity, showing that the decrease in activity is more pronounced, or even exclusive, in the older asthma population[27, 32, 37, 46]. This is in line with evidence that younger people with asthma engaged in similar[15] or higher[61, 67] levels of activity compared to their age-matched controls. Plausible biological reasons could relate to the age-related changes in the lung leading to an increased work of breathing that are more extreme in people suffering from respiratory morbidity. Furthermore, older people with asthma are likely to have a longer duration of disease, therefore may have more airway remodelling resulting in incomplete reversibility of airflow limitation[68]. It is also worth mentioning that in the last 30 years, there has been a growing body of evidence that supports the adherence to exercise in people with asthma. This contradicts previous beliefs that people with asthma should avoid exercise and physical activity[69]. It is likely that the age-effect identified in this review is linked to this paradigm shift. Finally, people over 50 years of age with obstructive airway disease show a high degree of overlap in features of both asthma and COPD[68], so it is possible that the activity levels of older people with asthma could be similar to that of COPD populations[5, 6, 59]; a finding that requires further investigation, and may focus physical activity interventions to an older age group.

In terms of the associations with physical activity, there was a trend showing that higher physical activity was modestly associated with better lung function in people with asthma. In two longitudinal studies, a trend towards slower lung function decline in active people with asthma compared to inactive people was reported[53, 55]. Studies carried out in the general population[70, 71] have suggested that this positive impact may be due to the counteracting effect that physical activity may have on the age-related chest wall stiffening[70], or to a potential positive impact on inspiratory muscle endurance[72]. Among the cross-sectional studies, the results were less consistent. Interestingly, in two of the studies reporting a positive association between spirometric values and physical activity[17, 42] participants were relatively young (mean age <39 years), with moderate disease severity, whereas studies in severe or uncontrolled asthma population, did not find an association[16, 21]. A systematic review of RCTs of physical training in asthma[73] concluded that exercise was not significantly associated with spirometric parameters. Similarly, in COPD, spirometric values have shown a weak to moderate association with physical activity[74]. Bahmer et al.[16] reported that airway resistance and small airway dysfunction were better markers of physical activity than spirometric values in moderate and severe asthma participants. Whether the association between airflow limitation and physical activity is modulated by time since diagnosis or disease severity, needs further investigation.

Some studies reported a positive association between physical activity and asthma control[18, 21, 24, 35, 47] or health status[18, 33], which is in line with studies reporting the beneficial impact of exercise protocols on these clinical outcomes[75-78]. In some studies, however, the strength of these associations was attenuated to the null when confounders such as BMI were included[24, 49, 51, 57], which suggests that the association between obesity and asthma control is stronger than the association between activity and asthma control. Studies addressing the relationship between current or incident asthma, BMI and physical activity, have shown similar results[25, 58]. Nevertheless, another study found that the association between asthma control and MVPA was still significant after adjusting for BMI, among other confounders[18]. This suggests that MVPA may still have a modest but independent positive effect on asthma control, in addition to its important role in weight management[79]. Some authors also found an increase in asthma symptoms due to engagement in vigorous physical activity[42, 47, 57]. Similar findings have been previously reported, especially in females[61, 67]. A link between strenuous exercises (a component of vigorous physical activity) and the development of EIB or exercise-induced asthma symptoms has been well-documented in the literature[80, 81]. In fact, a dose-response relationship has been proposed, where both very low levels of activity (inactivity) and vigorous activity are associated with higher risk of asthma symptoms, while exercise carried out at a moderate level shows a protective effect[81].

In terms of the association with asthma exacerbation and health care use, Garcia-Aymerich et al.[56] found a longitudinal dose-related protective effect of physical activity on risk of hospital admission for asthma exacerbation. Fisher et al.[54] did not observe a significant association between activity engagement and risk of readmission in people with asthma. However, they observed the same pattern in the COPD population, and attributed this lack of association to the small number of participants with asthma and COPD at baseline. Longitudinal studies in COPD have found that physical inactivity is strongly related to acute exacerbations resulting in hospitalisation, reduced length of time until admission for an exacerbation, and increased all-cause mortality[7-10]. The body of evidence for asthma is considerably less, and unlike studies conducted in COPD[9, 10], very few have relied on objective physical activity measures to assess the associations of this behavior with disease outcomes.

Data on exercise capacity was scarce[18, 40], but the available evidence suggests that physical activity, especially steps, is positively associated with functional exercise capacity. Interestingly, a weaker effect was observed for MVPA which may suggest that the biggest benefits are obtained by engaging in light to moderate, but more continuous physical activity, rather than shorter but intense periods[18]. Exercise training in patients with asthma can improve cardiopulmonary fitness, assessed by the direct oxygen consumption[73], and exercise capacity measured by the 6MWD improves immediately after a 6-week exercise program (3 weekly supervised sessions of walking training and strength exercises) and at three months follow-up[77]. In an RCT, improvement in aerobic capacity and weight loss were independently associated with improvements in asthma control[82]. This highlights the potential benefit of promoting physical activity as a way to improve different impairments in asthma, which despite of being assessed as different clinical outcomes, still affect the person in multiple dimensions of the disease.

Fewer studies have examined sedentary time in asthma. Both studies using activity monitors did not find significant differences between people with asthma and controls[18, 21], but both groups were highly sedentary. A third study[28] reported that people with asthma had higher time watching television than controls. However, in this study a self-reported proxy of sedentary time was used. Higher sedentary time was associated with decreased exercise capacity, lung function, and asthma control[18], but these associations were attenuated to the null when physical activity was included as a confounder. This suggests that the deleterious effect of sedentary time may be overcome when engaging in some physical activity[83]. Nevertheless, promoting frequent and longer breaks of sedentary time may be a more achievable goal than increasing activity levels in people with obstructive airway disease. In COPD, there are data linking objectively measured sedentary behavior as an independent predictor of mortality[84]. Studies measuring sedentary time with postural-based accelerometers[85] are required to explore to what extent sedentary time is occurring in asthma and whether it is associated with poorer asthma outcomes.

## Strength and limitations

This review followed a structured search protocol and used several electronic databases. Since the review of Eijkemans et al.[14], there have been a growing number of studies addressing the prevalence of physical activity in asthma. Additionally, the use of activity monitors in asthma is a relatively new topic, and was not addressed in the previous review. Our review also adds to the literature summarising the evidence of the impact of physical activity on different asthma outcomes. Furthermore, to our knowledge, there is no review reporting measures of sedentary time in people with asthma. However, there are some limitations that need to be considered. Our analysis was restricted to studies published in English, and thus we may have missed literature published in other languages. Additionally, since we only included studies conducted in adults, these results should not be generalised to children. In terms of the studies included, there was a great deal of heterogeneity in the clinical asthma and activity outcomes measures, as well as population characteristics. Furthermore, most of the studies were of cross-sectional design. Therefore, reverse causation of the associations reported must be considered as a possibility. Finally, most of the studies were performed either in mild or moderate asthma populations, or severity was not reported. As such, the severe asthma population may be underrepresented in this review, but this highlights the need for further research in this more complex population. Nevertheless, this review provides a complete update of prevalence and associations of these two behaviors in people with asthma and provides insight of the gaps in the literature that need to be addressed in future studies.

## Conclusions

People with asthma appear to engage in lower levels of physical activity compared to controls. Disease outcomes seem to improve as the volume or intensity of physical activity increase. However, studies that use objective measures of activity, participants with asthma diagnosed according to guidelines[1], and more standardised measures of clinical asthma outcomes are needed. Also, further studies addressing sedentary time in asthma might help to understand whether this behavior is present, and to what extent is associated with poorer asthma outcomes. Specifics subgroups, such as those over 50 years old, and those with severe asthma are under researched, and an understanding of how age and severity interact in the relationship between activity and asthma clinical or biological outcomes is needed. Longitudinal studies and RCTs exploring the direction of the relationships between physical activity and asthma outcomes are also needed to improve the consistency of the evidence. The results of this review strongly support the need to undertake this research.

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*Table I: Terms Search*

| Search strategy: (#1) AND (#2 OR #3) | |
|---|---|
| **#1** | Asthma* or wheez* or “bronchoconstriction” |
| **#2** | “physical activity” or (“physical exercise” or “exercise”) or “walking” or “motor activity” |
| **#3** | ("sedentary behaviour" OR "sedentary behavior" OR "sedentary time") OR ("sedentary lifestyle") OR ("internet time") OR ("computer time") OR ("television watching" OR "television viewing" OR "television time") OR ("TV watching" OR "TV viewing" OR "TV time") OR ("screen time") OR "sitting time" OR "reading time" |

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*Table II: Demographic characteristics of studies included*

| | | ***Asthma participants*** | | | | | ***Controls*** | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Cross-sectional studies*** | | | | | | | | | |
| | **Country** | **n** | **Female (%)** | **Age** | **Current smoking (%)** | **Disease severity (%)** | **n** | **Female (%)** | **Age** |
| *Bacon 2015*[24] | Canada | 643 | 60 | 53.4 ± 15.4 | 8.7 | n/r | n/a | n/a | n/a |
| *Bahmer 2017*[16] | Germany | 146 | 51 Severe<br>53 Mild to mod. | 55.5<br>48.1 | 22<br>24 | 43.1<br>56.8 | 29 | 38 | 42.1 |
| *Beckett 2001*[25] | USA | 4547 | 52 | 18 to 30 | 41.1 | n/r | 4131 | 55.2 | 18-30 |
| *Barros 2017*[26] | Portugal | 2578 | 62 | 20 to >85 | 21.4 | Current: 44<br>Persist: 38<br>Severe:18 | 30066 | 52.4 | 20 to >85 |
| *Bruno 2016*[17] | Italy | 24 | 66 | 38.5 ± 14.2 | n/r | Mild to mod. | 18 | 55 | 43.1±14.3 |
| *Chen 2001* [27] | Canada | 1070 | 61.7 | 12 to >70 | 26.7 | n/r | 15743 | 55 | 12 to >70 |
| *Cordova-Rivera 2017*[18] | Australia | 61 | 52.5 | 59 [43 – 68] | 6.6 | Severe | 61 | 52.5 | 54 [34 – 63] |
| *Doggett 2015* [28] | Canada | 1830 | 69.2 | 20 to >55 | 33.1 | n/r | 18978 | 54.4 | 20 to >55 |
| *Dogra 2006*[29] | Canada | 11243 | 62 | 40 to 44 | n/r | n/r | n/a | n/a | n/a |
| *Dogra 2008*[30] | Canada | 1772[$]<br>3123[^] | 63[$]<br>68[^] | 45 to 79 | n/r | n/r | 19864 | 57 | 65 to 79 |
| *Dogra 2009*[31] | Canada | 6835 | 62 | 20 to 64 | 28.5 | n/r | 78051 | 51 | 20 to 64 |
| *Ford 2003*[32] | USA | 12489 | 64 | 18 to >70 | n/r | n/r | 147742 | 48.9 | 18 to >70 |
| *Ford 2004* [33] | USA | 12111 | 63.7 | 44.2 (0.3) | 26 | n/r | n/a | n/a | n/a |
| *Grammatopoulou 2010*[34] | Greece | 100 | 79 | n/r | 20 | Mild: 58<br>Mod:32<br>Severe: 10 | n/a | n/a | n/a |
| *Iikura* | Japan | 437 | 53.3 | 64 [51–74] | 7.1 | n/r | n/a | n/a | n/a |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *2013*[35] | | | | | | | | | |
| *Kilpelainen 2006*[36] | Finland | 10023 | 61 | 18-25 | 3.4 $^{\beta}$ | n/r | n/a | n/a | n/a |
| *Liang 2015*[37] | Australia | 723 | 51$^{\beta}$ | 18 to 29 | 2.7 | n/r | 1891 | 51 $^{\beta}$ | 18 to 29 |
| *Ma 2016*[38] | USA | 330 | 10.6 | 47.6 ± 12.4 | 5.8 | UA | n/a | n/a | n/a |
| *Malkia 1998*[39] | Finland | 178 | 59 | 30 to 89 | n/r | n/r | 7015 | 30 to 89 | n/r |
| *Mancuso 2007*[40] | USA | 258 | 75 | 42 ± 12 | 11 | Mild to mod | n/a | n/a | n/a |
| *Moore 2015*[19] | Canada | 16 | 38 | 27.8 ± 6.1 | n/r | n/r | 16 | 50 | 26.6 ± 5.2 |
| *Ramos 2015*[41] | Brazil | 20 | 70 | 44 ± 6.0 | n/r | Mod to severe | 15 | 93 | 39 ± 6.0 |
| *Ritz 2010*[42] | USA | 20 | 70 | 28 ± 6.8 | n/r | Mod | 20 | 70 | 31.6 ± 5.9 |
| *Scott 2013*[20] | Australia | 14 | 78.6 | 43.3 [37-7.8] | 30.8 | Mild inter: 8<br>Mild persist:23<br>Mod: 54<br>Severe: 15 | n/a | n/a | n/a |
| *Strine 2007*[43] | USA | 11962 | 65.5 | 18 to >75 | 23.6 | n/r | n/a | n/a | n/a |
| *Teramoto 2011*[44] | USA | 880 | 57.2 | 18 to >70 | n/r | n/r | 2960 | n/r | 18 to >70 |
| *Tsai 2011*[45] | Taiwan | 27 | 44 | 60.8 ± 10.2 | 11 | n/r | 27 | 37 | 56.8 ± 1.1 |
| *Vancampfort 2017*[46] | LMICs | 11857 | 50.8 $^{\beta}$ | 18 to >65 | n/r | n/r | 216167 | 50.8 $^{\beta}$ | n/a |
| *Van 't Hul 2016*[21] | The Netherlands | 226 | 62 | 47.3 ± 15.3 | n/r | CA:17<br>PC:18<br>UA: 65 | 201 | 75.6 | 42.3 ± 16.3 |
| *Verlaet 2013*[47] | Portugal | CA:125<br>UA:78 | 53<br>85 | 43 ± 28<br>54 ± 21.5 | 33 | 61.6<br>38.4 | 606 | 50.5 | 53 ± 24 |
| *Vermeulen 2016*[22] | Belgium | 20 | 65 | 39.0 ± 11.9 | n/r | CA: 10<br>PC: 10<br>UA: 80 | n/a | n/a | n/a |
| *Vogt 2008*[48] | USA | 311 | 72.3 | 18 to > 75 | n/r | n/r | 4420 | n/a | n/a |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Westermann 2008*[49] | USA | | 258 | 75.9 | 42 ± 12 | n/r | Mild to mod | n/a | n/a | n/a |
| *Yamasaki 2017*[50] | Japan | | 18 | 55.6 | 63 ± 11 | 0 | n/r | n/a | n/a | n/a |
| *Yawn 2015*[51] | USA | | 533 | 76 | 40.6 | 15.4 | n/r | n/a | n/a | n/a |
| *Zahran 2013*[52] | USA | | 74779 | 76 | 18 to >65 | 19.5 | n/r | 869519 | 51.3 | 18 - 65+ |
| ***Longitudinal studies*** | | | | | | | | | | |
| | **Country** | **Follow-up** | **n** | **Female (%)** | **Age*** | **Current smoking (%)** | **Disease severity (%)** | **n** | **Female (%)** | **Age*** |
| *Bedard 2017*[58] | France | Up to 11 years | 15353 | 100 | 59.2 ± 6.3 | 8.5 | n/r | n/a | n/a | n/a |
| *Brumpton 2017*[53] | Norway | Mean 11.6 years | 1329 | 51.6 | 44.1 ± 12.9 | 25.1 | n/r | n/a | n/a | n/a |
| *Fisher 2016*[54] | Denmark | Mean 16 years | 1347 | 61.8 | 57.1 ± 4.5 | 34.9 | n/r | n/a | n/a | n/a |
| *Garcia-Aymerich 2007*[56] | Denmark | Mean 11 years | 153 | n/r | 52.4 ± 11.6 | n/r | n/r | n/a | n/a | n/a |
| *Garcia- Aymerich 2009*[57] | USA | Mean 2 years | 2818 | 100 | 62.7 ± 6.9 | 5.8 | Mild inter: 20.3<br>Mild persist:35.6<br>Mod: 34.6<br>Severe: 9.5 | n/a | n/a | n/a |
| *Russell 2017*[46] | Norway | Mean 10 years | 209&<br>947* | n/r<br>n/r* | n/r<br>n/r* | n/r<br>n/r* | n/r<br>n/r* | n/a | n/a | n/a |

*Age reported as mean± sd or (SE), or median [IQR], or range.*
*# Cross-sectional data from a longitudinal cohort. B: % reported for the whole sample; & only participants with asthma at baseline. $ Values for older adults; ^ values for middle aged adults, * results reported correspond to cross-sectional data. n/a: not assessed; n/r: not reported; Inter: intermittent; Persist: persistent; Mod: moderate asthma; CA: controlled asthma; PC: partially controlled; UA: uncontrolled asthma; LMICs: low and medium income countries.*

*Table III: Physical activity measurements in studies with a control group*

| Study | Asthma definition | PA or ST measurement | PA or ST domain | Recall period | Outcome |
|---|---|---|---|---|---|
| | ***Studies using questionnaires*** | | | | |
| *Chen 2001*[27] | Self-reported asthma diagnosed by a health professional | PA questionnaire from National Population Health Survey Canada | LTPA | 12-month | Mean daily energy expenditure (EE) (kcal kg$^{-1}$day$^{-1}$) |
| *Doggett 2015*[28] | Self-reported physician-diagnosed asthma and use of asthma medication. | Questionnaire | LTPA<br>Television-viewing time (TVT) | PA: 1-week<br>TVT: typical week in last 3 months | PA: frequency and intensity of (measured as increase of heart rate and breathing)<br>TVT: >10 hours/week as high TVT; ≤ 10 hours/week as low TVT. |
| *Dogra 2008*[30] | Self-reported physician-diagnosed asthma | Questionnaire from CCHS cycle 2.1 | LTPA | n/r | Active (≥ 1.5 kcal/kg/day) Inactive (<1.5 kcal kg/day) (estimated from EE) |
| *Dogra 2009*[31] | Self-reported physician-diagnosed asthma | From CCHS cycle 3.1 | LTPA | n/r | Active (>3.0 kcal/kg/day), "Moderately active" (1.5–3.0 kcal/kg/day), "inactive" (<1.5 kcal/kg/day) |
| *Ford 2003*[32] | Self-reported physician-diagnosed asthma | Questionnaire from 2000 BRFSS | LTPA | 1-month | Frequency and duration.<br>EE/week, and PA Index |
| *Liang 2015*[37] | Self-reported asthma | Questionnaire from Australian National Health Survey 2007-08 | PA | 1-week | Intensity and frequency<br>≥ 800 MET: meeting PA guidelines |
| *Malkia 1998*[39] | Self-reported physician-diagnosed asthma and spirometry. | Questionnaire | LTPA, PA at work and during commuting. | n/r | Intensity and frequency METs at work and spare time.<br>PA during commuting |
| *Ramos 2015*[41] | Asthma diagnosed by a physician | IPAQ - short form | LTPA | Average day in the last week | PA from EE + duration [METs- min/week] |
| *Ritz 2010*[42] | Asthma diagnosed by a physician | Electronic diary | PA in the past 30 minutes | 3 times/day for 21 days | Frequency and intensity |
| *Teramoto 2011*[44] | Self-reported current or lifetime asthma diagnosed by a health professional | Questionnaire from 2009 Nevada BRFSS | LTPA | 1-month | Engagement on PA, meet PA guidelines.<br>Minutes/ week of MVPA |
| *Tsai 2011*[45] | Asthma diagnosed by a physician | Stanford 7-Day Physical Activity Recall | LTPA | 1-week | Frequency and Intensity<br>METs |
| *Vancampfort 2017*[46] | Self-reported lifetime diagnosis of asthma | Extract from IPAQ | LTPA | 1-week | Volume of MVPA (<150 minutes/week = low PA) |
| *Verlaet 2013*[47] | Self-reported asthma | IPAQ - short form | LTPA<br>Daily sitting time | Average day in the last week | LTPA: MET-min/week<br>Volume of daily sitting time in minutes. |

| | *Studies using activity monitors* | | | | |
|---|---|---|---|---|---|
| | ***Asthma definition*** | ***PA or ST measurement*** | ***PA or ST domain*** | ***Wear- time protocol*** | ***Outcome*** |
| *Bahmer 2017*[16] | Physician-diagnosed asthma, and in specialist care for > 3 months. | SenseWear Pro Armband | Total PA | Worn for 1 week. Inclusion: ≥5 days of 22.5 h | Steps/day Average minutes of at least moderate activity/day (EE>3 METs) |
| *Bruno 2016*[17] | Recruited according the ATS criteria | SenseWear Armband | Total PA | Worn over triceps area for 4 days, 24 h/day (excluded water-based activities) Inclusion: n/r | PA level (mins/day); Active EE (kcal/day); steps/day; Total EE (kcal/day) |
| *Cordova-Rivera 2017*[18] | Asthma diagnosed by a respiratory physician according to GINA guidelines. | ActiGraph wGT3X-BT | Sedentary time Total PA | Worn on dominant hip for 14-consecutive days, 24 h/day (sleeping and non-wear time excluded) | Minutes/day of: sedentary time, light PA and moderate and vigorous and very vigorous PA. Steps/day |
| *Moore 2015*[19] | History of asthma and any of the following: positive spirometry, positive methacholine challenge, ≥10% decrease in $FEV_1$ after an exercise challenge | SenseWear Pro3 Armband | Total PA | Worn over triceps area of dominant arm for 3 days, 24 h/day. Inclusion: preferably 2 weekdays, 1 weekend day. | Steps/day Energy expenditure |
| **Scott 2013*[20] | Physician-diagnosed asthma, and history of airway hyperresponsiveness | Pedometer | Steps | Worn for 7 days, recording steps a diary, (prior randomization) | Steps/day |
| *Van't Hul 2016*[21] | Asthma diagnosed by a respiratory physician and use of asthma medication. | DynaPort MoveMonitor | Total PA Sitting and lying time | Worn on lower lumbar spine for 7 consecutive days, 24 h/day (excluded water-based activities). Inclusion: ≥2 (PA) and ≥5 (lying) days of ≥22.5 h. | Hours/day in walking, sitting, and lying. Steps/day D. PA level (total EE/day): >1.70 active, 1.40 - 1.69 predominantly sedentary, <1.40 very inactive. |
| **Vermeulen 2016*[22] | Previous asthma diagnosis, asthma exacerbation. | SenseWear Armband | Total PA | Worn for 7 days Inclusion: n/r | Steps/day, % of time at an intensity: < 3 METs, 3 to 6 METs, 6 to 9 METs and ≥ 9 METs |
| **Yamasaki 2017*[50] | Asthma diagnosed by a respiratory physician. | Actiwatch 2 | Total PA | Worn for 7 days Inclusion: n/r | Activity counts |

*PA: physical activity; LTPA: leisure time physical activity; ST: sedentary time; EE: energy expenditure; CCHS: Canada community health survey; kcl: kilocalorie; BRFSS: Behavioral risk factor surveillance system; MET: metabolic equivalent task; IPAQ: International physical activity questionnaire; MVPA: moderate to vigorous PA; n/r: not reported.*
**These studies did not have a control group but were included in this table to provide further details of the activity monitors used.*

*Table IV: Association between physical activity or sedentary time with asthma outcomes*

| *Citation* | *Outcome measures* | *Conclusions* |
|---|---|---|
| *Bacon 2015*[24] | PA, ACQ and AQLQ | Participants engaging in high levels of PA (20.1±8.9 METs-h/week) were nearly 2.5 times more likely to have good control (ACQ ≤ 0.8) compared with inactive patients [AOR (95% CI) 2.47 (1.06–5.73)]. Results for AQLQ were not significant. |
| **Bahmer 2017*[16] | Steps, spirometry, body plethysmography, impulse oscillometry. | Decreased PA in asthma is associated with airway resistance and small airway dysfunction, but not with airway limitation. |
| *Brumpton 2016*[53] | PA, lung function decline. | Less decline in $FEV_1$/FVC in active asthma participants than inactive asthma participants [$FEV_1$/FVC (%): -0.14 (-0.27, -0.01) (P= 0.03)] |
| **Bruno 2016*[17] | PA, FEV1/FVC, fat free mass (FFT) and Intracellular water (ICW). | PA positively correlated with $FEV_1$/FVC. [Rho = 0.34 (P < 0.05)] |
| **Cordova-Rivera 2017*[18] | ST, MVPA, Steps, 6MWD, spirometry, ACQ, AQLQ, hs-CRP, FeNO, sputum eosinophilia. | Higher levels of PA and lower levels of ST were positively associated with most of the clinical/biological outcomes, especially for Steps and exercise capacity (coeff (95% CI) 0.02 (0.00 to 0.04); *P* < .01) and systemic inflammation, and MVPA and ACQ (coeff (95% CI) -1.94 (-3.69 to -0.18); *P*= 0.032). |
| *Doggett 2015*[28] | ST (TV time), PA, health care use. | High levels of TV time associated with: more consultations (AOR (95% CI) 2.59 (2.34 2.87), hospital stays in the last year (AOR 1.95 (1.82, 2.08) and in the past 5 years (AOR = 1.13 (1.07, 1.18)<br>Insufficient PA associated with higher health care use: hospital stays in the past year (AOR 1.16 (1.08, 1.23) or past 5 years (AOR 1.22 (1.16, 1.28) |
| *Dogra 2006*[29] | PA (EE), self-reported measures of health. | Higher PA associated to better self-reported health outcomes. |
| *Dogra 2009*[31] | PA (EE), health care use. | Lower PA levels associated with higher health care use in people with asthma: Overnight hospital stays (AOR (95%CI) 1.78 (1.31, 2.41); ≥3 GP consultations (AOR 1.26 (1.03, 1.55) |
| *Fisher 2016*[54] | PA, asthma readmission. | No association between PA and asthma hospital readmissions in people with asthma. |
| *Ford 2004*[33] | PA, QoL. | Physical inactivity (compared to VPA) significant independent predictor of impaired QoL: Poor or fair health OR (95% CI)2.36 (1.72, 3.22); >14 days with activity limitation: 2.76 (1.89 4.02); >14 days physically or mentally limited: 1.90 (1.59 2.32) |
| *Garcia-Aymerich 2009*[56] | PA (METs-h/week), asthma exacerbation. | Higher levels of PA associated with a lower risk of asthma exacerbation. |
| *Garcia-Aymerich 2007*[55] | Levels of PA, lung function decline. | MVPA in participants with asthma improved lung function decline by gaining 10 ml and 7 ml/ year of $FEV_1$ and FVC respectively, compared to the low PA group (significance not reported) |
| *Ikura* | PA and asthma control test (ACT) | In MVRA, periodical PA (>3 METs-h/week) was significantly associated with better asthma outcome |

| | | |
|---|---|---|
| *2013* [35] | | (coefficient = 0.152, P= 0.002) |
| *Mancuso 2007*[40] | PA (EE), 2MWT, CRT, asthma control (ACQ), severity, and lung function (spirometry). | PA positively correlated with physical performance in both test (2MWT Rho = 0.38; CRT Rho= - 0.39). In MVRA, better asthma control associated with more EE from walking, but not with total EE. $FEV_1$ associated with PA only in SLRA. |
| *Malkia 1998*[39] | PA Intensity (METs), lung function (spirometry). | Weak but significant positive correlations of PA intensity and lung function in men only (Rho $FEV_1$=0.26; PEF=0.35) |
| *Ritz 2010*[42] | PA intensity, lung function (spirometry), SOB, social activity, inhaler use. | Higher PA levels associated with higher PEF, higher $FEV_1$ in the morning and evening only, and more SOB. |
| *Russell 2016*[57] | PA with follow-up current asthma (CA) and asthma symptoms (AS) | LPA ≥3 times/week at baseline associated with less follow-up CA [OR (95%CI) 0.44(0.22 0.89)]. Result attenuated by BMI. Result for VPA > 0.05 |
| | | Asthma participants with normal BMI show a significant reduction of AS associated with PA, while the overweight and obese category did not. |
| *Strine 2007*[43] | Inactivity and measures of asthma severity. | People with asthma who were inactive had significantly poorer control compared to those who were not: >3 ER/year (AOR (95%CI):2.4 (1.6, 3.6); GP visit/year (AOR:1.5 (1.1, 2.0); Abseeintism >2 weeks/year: (AOR: 1.7 (1.3, 2.0); daily symptoms (AOR: 2.5 (1.9, 3.4); Inhaler 30+ times/month (AOR: 1.9 (1.5, 2.5) |
| **Van't Hul 2016*[21] | PA, ACQ, AQLQ and lung function (spirometry). | Low PA was correlated with poorer asthma control. No correlation between spirometry and PA (value not reported) Nil reference regarding AQOL. |
| **Vermeulen 2016*[22] | Steps/day, activity limitation (ACQ question 3) | No correlation found between PA and activity limitation. |
| *Verlaet 2013*[47] | PA or daily sitting time (ST), and asthma control (CARAT Questionnaire) | MPA and ST predictor of controlled asthma in men: (AOR (95% CI) 1.84 (1.02, 3.30); (OR: 1.87 (1.06, 3.28) respectively. VPA doubled the risk of uncontrolled asthma in women: AOR: 1.94 (1.13-3.35). |
| *Westermann 2008*[49] | Exercise habits, asthma severity and asthma control (ACQ) | Higher BMI was more closely associated with exercise habits than were asthma control and severity, after adjusting for demographic variables. |
| *Yamasaki 2017*[50] | PA, measures of oxidative stress and antioxidants in blood, spirometry, FeNO, serum levels of vitamins, dietary vitamin intake, | Significant correlations only for PA (Activity counts/minute) and $FEV_1$/FVC. |
| *Yawn 2015*[51] | Volume and intensity of PA, asthma control (APGAR), exacerbations. | Low PA associated with asthma control only in SLRA. |

** Studies using activity monitors. PA: physical activity, ST: sedentary time; PAL: physical activity level; LTPA: leisure-time PA; LPA: light PA; VPA: vigorous PA; MVPA: moderate and vigorous PA; Steps: average steps/day; ACQ: asthma control questionnaire; AQLQ: asthma quality of life questionnaire; QoL: quality of life; 6MWD: -minute walk distance; hs-CRP: high sensitivity C-reactive protein, FeNO: fraction of exhaled nitric oxide; SOB: shortness of breath; 2MWT: 2-minute walk test; CRT: chair raise test; EE: energy expenditure; METs: metabolic equivalent task; RM: repetition maximum; $FEV_1$: forced expiratory volume in the first second; ER: emergency room; GP: general practitioner; AOR: adjusted odd ratio; CI: confidence interval; SLRA: simple linear regression analysis; MVRA: multi-variable regression analysis; OR: odds ratio; AHR: adjusted hazards ratios.*

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*Table V: Activity outcomes from monitors*

| | | Steps per day | | | Volume/Intensity of PA or Sedentary time (minutes+ or hours^/ day) | | |
|---|---|---|---|---|---|---|---|
| | **N** | **Asthma** | **Controls** | ***P-value*** | **Asthma** | **Controls** | ***P-value*** |
| Bahmer 2017[16] | SA: 63<br>MA: 83<br>C:29 | SA: 6174 [4822-9277]<br>MA: 7841 [6534 - 10252] | 8,912<br>[6800 - 11127] | **< 0.001** | MVPA+<br>SA:125 [68 - 172]<br>MA:151 [99 - 197] | 163 [110 – 207] | **<0.05** # |
| Bruno 2016[17] | A: 24<br>C: 18 | 10,434 ± 3,813 | 10860 ± 3042 | > 0.05 | PA+: 69.7 ± 84.2<br>AEE: 335 [380]& kcal/day | 93.2 ± 101<br>486.7 [435] | **0.04**<br>**0.04** |
| Cordova-Rivera 2017[18] | SA: 61<br>C: 61 | 5362 [3999 - 7817] | 7817<br>[6072 - 10014] | **0.0002** | ST+ 674.4 ± 71<br>LPA+ 193 ± 57.5<br>MVPA+ 21.9 [12.8 - 37.9] | 676.2 ± 65<br>171 ± 50.6<br>41.7 [29.3, 65.8] | > 0.05<br>**0.029**<br>**<0.0001** |
| Moore 2015[19] | A: 16<br>C: 16 | 11125 ± 5487 | 10711 ± 2675 | > 0.05 | n/a | n/a | |
| Scott 2013[20] | A: 33 | 8341 ± 3377 | n/a | | n/a | n/a | |
| Van't Hul 2016[21] | A: 226<br>C: 201 | 7593 [7155 - 8030] | 8,795<br>[8326 - 9263] | **0.001** | Sitting^: 8.21 [7.95 - 8.48]<br>PAL: 1.53 [1.51 - 1.55]<br>LPA^: 1.7 [1.65 - 1.88]<br>MPA^: 1.66 [1.58 - 1.74]<br>VPA^: 0.34 [0.30 - 0.38] | 8.6 [8.29 - 8.86]<br>1.57 (1.55-1.59)<br>1.91 [1.80-2.02]<br>1.64 [1.55-11.7]<br>0.45 [0.41-0.49] | > 0.05<br>**0.034**<br>> 0.05<br>> 0.05<br>**<0.001** |
| Vermeulen 2016[22] | A:20 | 10159 ± 3751 | n/a | | MET 0-3 (% time): 87.2<br>MET 3-6 (% time): 12.07 | n/a | |
| Yamasaki 2017[50] | A: 18 | n/a | n/a | | +Activity counts: 283.3 ± 81.1 | n/a | |

*SA: severe asthma, MA: mild to moderate asthma. A: asthma, C: controls. Results expressed as mean ± standard deviation or median [IQR]. + reported as minutes/day. ^ Reported as hours/day. # P value for whole asthma sample compared to healthy control. &: reported as median [IQR] by the authors. PA: physical activity; AEE: active energy expenditure; kcal: kilocalories; PAL: physical activity level; MVPA: minutes of at least moderate PA/day. LPA: light physical activity, MPA: moderate PA, VPA: vigorous PA, ST: sedentary time, n/a: not assessed; MET 0-3: metabolic equivalent task of light PA; MET 3-6: moderate PA. Statistically significant results in bold.*

*Figure 1. PRISMA Flow Diagram Literature search. Updated 31 October 2017*

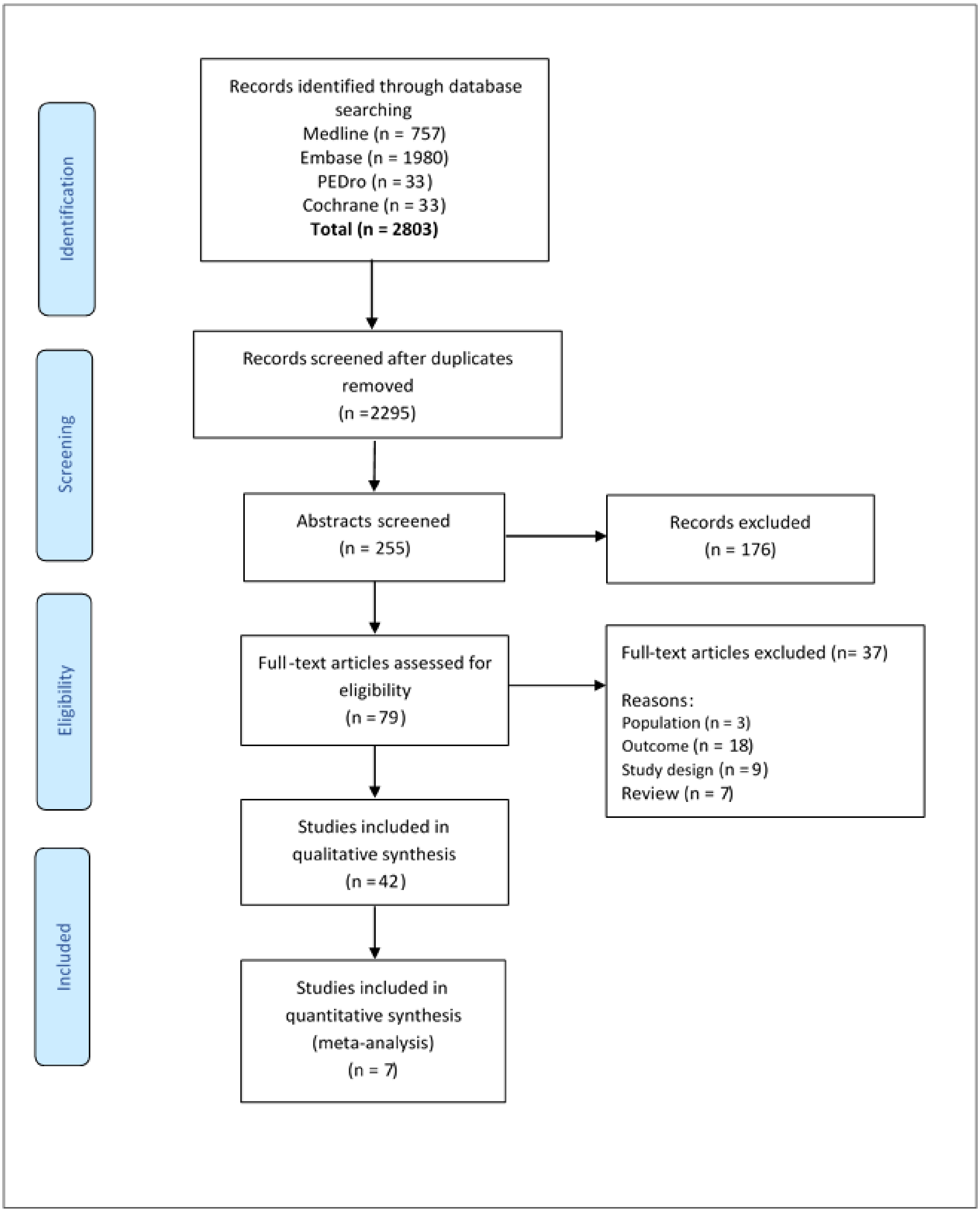
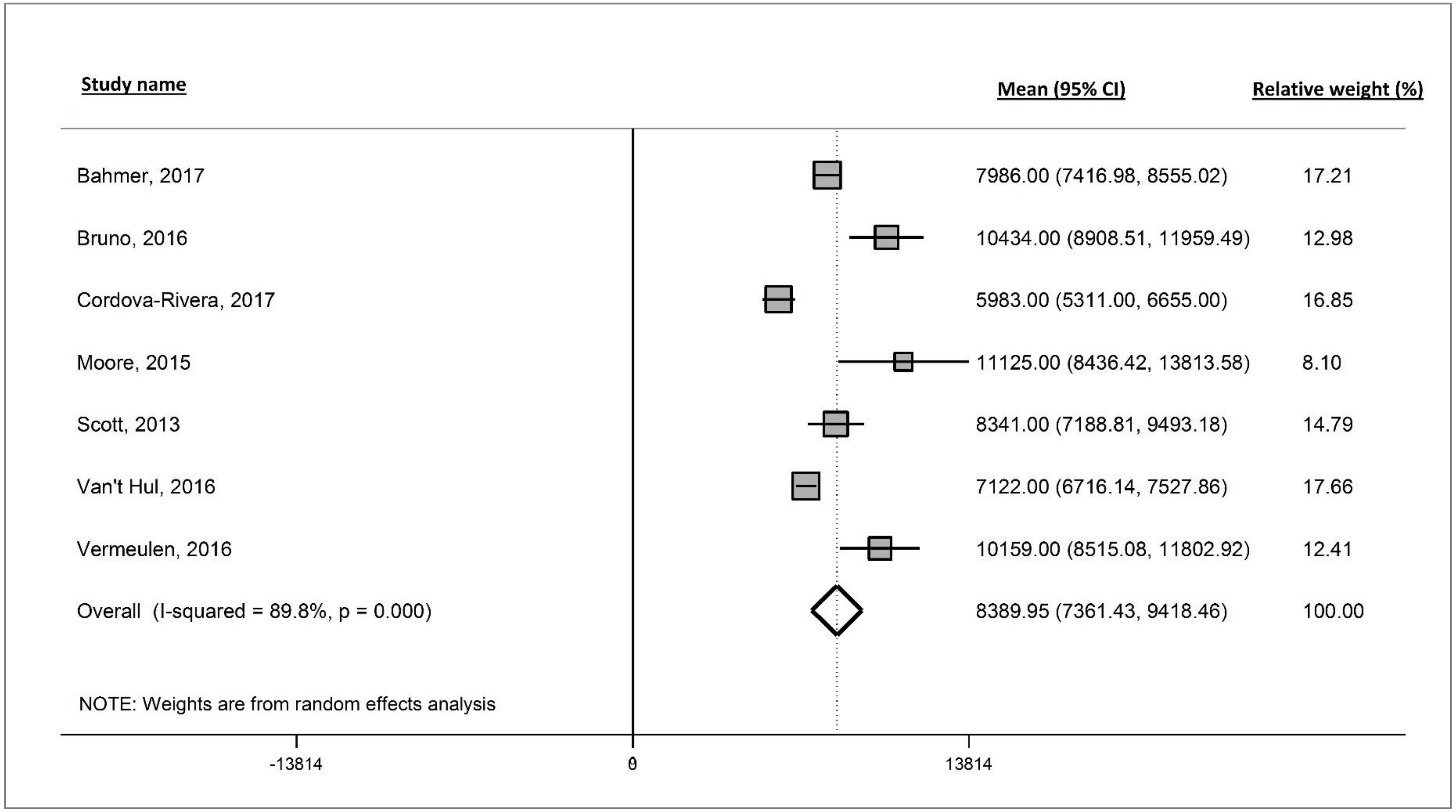


*Figure 2: Forest plot of standardised mean (95% confidence intervals) for steps/day*




*Authors: Bahmer et al., Scott et al., and Van't Hul et al. were contacted and provided the mean and standard deviation of their results.*