Review

Physical activity lowers the risk for acute respiratory infections: Time for recognition

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Abstract

Physical inactivity is a well-established risk factor for chronic diseases, such as cardiovascular disease, cancer, and diabetes mellitus. There is a growing awareness that physical inactivity should also be regarded as a risk factor for acute respiratory infections (ARIs). ARIs, such as the common cold, influenza, pneumonia, and coronavirus disease 2019 (COVID-19), are among the most pervasive diseases on earth and cause widespread morbidity and mortality. Evidence in support of the linkage between ARIs and physical inactivity has been strengthened during the COVID-19 pandemic because of increased scientific scrutiny. Large-scale studies have consistently reported that the risk for severe COVID-19 outcomes is elevated in cohorts with low physical activity and/or physical fitness, even after adjusting for other risk factors. The lowered risk for severe COVID-19 and other ARIs in physically active groups is attributed to exercise-induced immunoprotective effects, including enhanced surveillance of key immune cells and reduced chronic inflammation. Scientific consensus groups, including those who submitted the Physical Activity Guidelines for Americans, have not yet given this area of research the respect that is due. It is time to add “reduced risk for ARIs” to the “Exercise is Medicine” list of physical activity-related health benefits.

Keywords: Acute respiratory infections; COVID-19; Immune system; Physical activity; Pneumonia

1. Acute respiratory infections (ARIs)

ARIs such as the common cold, pneumonia, influenza, coronavirus disease 2019 (COVID-19), and bronchitis are major contributors to the burden of global disease and mortality rates. ARIs rank among the top 4 causes of death and disability for both children and adults worldwide. Common ARI viral pathogens include rhinoviruses, respiratory syncytial virus, influenza viruses, parainfluenza viruses, metapneumovirus, adenovirus, and coronaviruses.

The World Health Organization and U.S. Department of Health and Human Services recommend that adults move more and sit less, with a goal of 150–300 min of moderate-to-vigorous physical activity (MVPA) per week. Many health-related benefits have been listed for those who meet these MVPA guidelines, but noticeably absent from this list are the positive influences on immune function and corresponding reductions in ARI incidence, severity, and mortality.

This narrative review will summarize the strongest and most pertinent published literature on the linkage between MVPA and ARI outcomes, including symptom severity and mortality rates. ARI outcomes are the primary focus of this review, with some reference to chronic respiratory infections when relevant. Articles included in Tables 1 and 2 were chosen by the authors based on the overall strength of their research designs and their relevance for this narrative review. The COVID-19 pandemic has increased scientific scrutiny of the influence of MVPA on the immune system and ARIs, and more has been published in this area during the last few years than during any other time period. The data consistently support a diminished risk for ARIs among those adhering to MVPA guidelines, and the time has now arrived for scientific consensus groups to acknowledge and recognize this health-related benefit.

1.1. Total infectious disease and respiratory disease mortality rates and MVPA

Several epidemiological studies and a recent review show evidence of significant reduction in risk for total infectious disease and respiratory disease incidence and mortality among those adhering to MVPA guidelines. Table 1 summarizes the primary studies in this area. One of the first studies to assess this relationship was the National Walkers’ and Runners’ Health Study. Risk for respiratory disease mortality...
was 45% lower in both runners and walkers who exceeded recommended exercise levels by more than 2-fold.8 Higher doses of running and walking in study participants with diabetes mellitus were also associated with a lower risk of pneumonia mortality, sepsis-related deaths, and influenza-related deaths in a dose-dependent manner.9 Other studies established a graded inverse and independent association of cardiorespiratory fitness (CRF) with risk for respiratory diseases (both incidence and mortality) (Table 1).10,14 Data from the large National Health Interview Survey prospective cohort supported a 71% reduction in risk for chronic lower respiratory tract disease in adults meeting MVPA guidelines with both aerobic and muscle strengthening physical activities.12 Chronic lower respiratory tract diseases include chronic obstructive pulmonary disease, chronic bronchitis, emphysema, and asthma.

Two large prospective cohort studies showed that risk for total infectious disease mortality was 36%–40% lower in adults who met MVPA guidelines compared to those who were physically inactive (Table 1).11,12 Data from the Health Survey for England and the Scottish Health Survey supported an adjusted hazard ratio of 0.60 for infectious disease mortality in adults meeting MVPA guidelines compared to those who were relatively inactive.11 Adjusted hazard ratio of 0.46 and 0.48 were estimated between these contrasting physical activity groups for infectious disease mortality when stratified for bacterial and viral origins, respectively. Data from an even larger prospective cohort from the UK Biobank (UKBB) study confirmed this finding with an adjusted hazard ratio of 0.64 for risk of infectious disease mortality when comparing adults who met MVPA guidelines with those who were inactive.13 Risk for infectious disease mortality was also reduced in adults with low (≤4 h/day) compared to high (>7 h/day) levels of sedentary behavior (hazard ratio = 0.79).

Taken together, these data support a strong MVPA-related risk reduction in community-acquired bacterial and viral infectious disease mortality.15 These findings are consistent with the acute and chronic exercise-related influences on the immune system resulting in augmented immunosurveillance against pathogens and diminished systemic inflammation, as reviewed elsewhere.16–18

### 1.2. The common cold and MVPA

The inverse relationship between MVPA and risk for the common cold was reviewed recently in this journal.16 The common cold is caused by many types of viruses and occurs at a relatively high frequency compared to other ARIs. Thus, the common cold has been the focus of many exercise-related studies in both the general community and athletic groups. Community-based randomized controlled trials19–24 and epidemiological studies25–28 have consistently shown significantly lower incidence rates, illness severity, and relative risk for the common cold in adults adhering to MVPA guidelines.16

The magnitude of MVPA-related reductions in common cold incidence and risk in the general community varies substantially between studies due to differences in study designs and methodologies.16 In one 12-week study of 1002 male and female adults, participants recorded daily symptoms using the validated Wisconsin Upper Respiratory Symptom Survey.27,29 Higher versus lower physical fitness ratings and physical activity.

### Table 1: Epidemiological research on the relationship between MVPA, CRF, and risk for total infectious disease and respiratory disease incidence and mortality. Sorted by year of publication.

| Study            | Study population                                      | Research design                                                                 | Key findings                                                                 |
|------------------|-------------------------------------------------------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| Williams (2014)  | 109,352 runners, 40,798 walkers, 11.4 years follow-up| Running and walking history, and demographic and lifestyle habits were entered into a Cox proportional hazards model. CRF assessed using graded exercise testing with a metabolic cart. HRs estimated using Cox proportional hazard models. | Risk for respiratory disease mortality decreased 7.9% and for pneumonia, 13.1% per MET-h per day run or walk. Adjusted HR for respiratory disease was 27% lower for higher vs. lower CRF (graded dose—response association across CRF quartiles). 40% reduced risk for infectious disease mortality, and 48% and 46% reduced risk for viral- and bacteria-related infectious disease, respectively, with sufficient MVPA (>150 min/week) compared to physical inactivity. Adjusted HR for chronic lower respiratory tract diseases in adults meeting MVPA guidelines with aerobic and muscle strengthening activities vs. insufficient activity was 0.29. Infectious disease mortality was 36% lower in adults who were physically active (≥150 min/week) vs. inactive, 21% lower in those with low (<4 h/day) vs. high (>7 h/day) sedentary behavior, and 71% lower in those with a healthy lifestyle profile based on 6 factors. Risk for all respiratory disease mortality reduced 14% per one MET difference in CRF. |
| Kunutsor et al. (2017) | 1974 middle-aged men, 25.7 years follow-up, n = 382 incident cases of respiratory disease. | CRF assessed using graded exercise testing with a metabolic cart. Cox proportional hazards regression models used to estimate associations of MVPA, smoking, alcohol, and BMI with infectious disease mortality. |  |
| Hamer et al. (2019) | 97,844 adults, 9027 deaths from infectious disease, 9.4 years follow-up. | CRF assessed using graded exercise testing with a metabolic cart. Cox proportional hazards regression models used to estimate associations of MVPA, smoking, alcohol, and BMI with infectious disease mortality. |  |
| Zhao et al. (2020) | 479,856 adults, National Health Interview Survey, 8.75 years follow-up; with 59,819 deaths. | Cox proportional hazards models used to calculate HR for associations between levels of PA and cause-specific mortality. |  |
| Ahmadi et al. (2021) | Prospective cohort of 468,469 adults, UKBB study, ages 40–69 years; 4176 deaths from infectious disease, 11.3 years follow-up. | HRs estimated using Cox proportional hazards regression models for risk factors (PA, sedentary behavior, sleep quality, diet quality, alcohol intake, and smoking status) with infectious disease. |  |
| Gonzales et al. (2021) | Prospective cohort of 42,351 women and 37,650 men from the UKBB, 9.9 years follow-up, 2670 deaths. | HRs estimated using Cox proportional hazards regression models for associations between CRF and health/disease outcomes. | Risk for respiratory disease mortality decreased 7.9% and for pneumonia, 13.1% per MET-h per day run or walk. Adjusted HR for respiratory disease was 27% lower for higher vs. lower CRF (graded dose—response association across CRF quartiles). 40% reduced risk for infectious disease mortality, and 48% and 46% reduced risk for viral- and bacteria-related infectious disease, respectively, with sufficient MVPA (>150 min/week) compared to physical inactivity. Adjusted HR for chronic lower respiratory tract diseases in adults meeting MVPA guidelines with aerobic and muscle strengthening activities vs. insufficient activity was 0.29. Infectious disease mortality was 36% lower in adults who were physically active (≥150 min/week) vs. inactive, 21% lower in those with low (<4 h/day) vs. high (>7 h/day) sedentary behavior, and 71% lower in those with a healthy lifestyle profile based on 6 factors. Risk for all respiratory disease mortality reduced 14% per one MET difference in CRF. |

Abbreviations: BMI = body mass index; CRF = cardiorespiratory fitness; HR = hazard ratio; MET = metabolic equivalent; MVPA = moderate-to-vigorous physical activity; UKBB = United Kingdom Biobank.
| Study | Study population with country and year of data collection for COVID-19 | Research and statistical design | Key findings |
|-------|---------------------------------------------------------------------|--------------------------------|--------------|
| Brawner et al. (2021)60 | Total of n = 246 adult patients with maximal exercise capacity test, positive for SARS-CoV-2. USA, 2020 | Logistic regression, COVID-19 hospitalization and peak METs, with adjustment for covariates. | Peak METs lower among hospitalized patients (6.7 ± 2.8) vs. not hospitalized (8.0 ± 2.4) (OR, adjusted model, 0.87). |
| Hamer et al. (2020)63 | Prospective cohort of n = 387,109 adults, UKBB study, UK, 2020 | Regression models fitted to estimate RR for associations between PA, obesity, smoking, and alcohol consumption (baseline questionnaires) and severe COVID-19. | RR adjusted for age, sex, and each lifestyle factor were raised for physical inactivity (1.32), smoking (1.42), and obesity (2.05), but not heavy alcohol intake (1.12). |
| Ho et al. (2020)64 | Prospective cohort, n = 235,928 adults, UKBB study; Participants tested for SARS-CoV-2, with n = 397 confirmed for COVID-19. UK, 2020 | Logistic regression analysis of PA (objectively, subjectively measured) and COVID-19 outcomes; test of causality using MR. | Protective effect (20%–26%) of objectively measured PA on COVID-19 outcomes after adjustment (age, sex, obesity, smoking). MR analyses did not support a causal association. |
| Zhang et al. (2020)60 | Prospective cohort, n = 500,000 adults, UKBB study; n = 1746 with COVID-19, n = 399 deaths. UK, 2020 | HRs estimated using Cox proportional hazards regression models for risk factors (PA, sedentary behavior, sleep quality, diet quality, alcohol intake, and smoking status) and healthy lifestyle index with infectious disease outcomes, including COVID-19. | Contrasts of the healthiest and least healthy groups showed 58% lower mortality rates for COVID-19 in the healthiest group. COVID-19 mortality was 30% lower in those who were physical active (≥150 min/week) vs. inactive. |
| Ahmadi et al. (2021)13 | Prospective cohort of n = 468,469 adults, UKBB study; n = 4176 deaths due to infectious diseases, n = 3170 deaths due to pneumonia, and n = 387 deaths due to COVID-19. UK, 2006–2020 | Logistic regression modeling used to calculate OR for predictors of severe COVID-19, with adjustments for related variables. | Two-fold higher odds of severe COVID-19 between the lowest and highest groups (VO2max < 32 mL/min/kg vs. VO2max ≥ 46 mL/min/kg). |
| Hamrouni et al. (2021)44 | Prospective cohort of n = 259,397 adults, UKBB study. UK, 2020–2021 | Adjusted logistic regression models for associations between high (>3000 MET-min/week), moderate (≥600 MET-min/week), and low PA, obesity, and COVID-19 mortality. | Compared with highly active individuals with a normal BMI (reference group), the ORs for COVID-19 mortality were 1.61 for highly active individuals with obesity, 2.85 for lowly active individuals with obesity, and 1.94 for lowly active individuals with a normal BMI. |
| Lee et al. (2022)15 | Observational study of n = 76,395 South Korean adults who were tested for SARS-CoV-2 and had general health examination data. Republic of Korea, 2020 | Modified Poisson regression modeling, adjusted RR. | Those who met MVPA guidelines had a 15% lower risk of SARS-CoV-2 infection, 58% lower risk for severe COVID-19 illness, and 76% lower risk for COVID-19-related death than those who did not. |
| Rowlands et al. (2021)56 | Retrospective observational study of n = 82,253 adults, UKBB study; n = 2388 with confirmed COVID-19, n = 425 severe. UK, 2020–2021 | Logistic regression used to analyze associations of PA with COVID-19 outcomes, with adjustment for potential confounding factors. | Odds of severe COVID-19 were 25% lower for every 30 min/day MVPA. |
| Rowlands et al. (2021)57 | Prospective cohort of n = 91,248 adults, UKBB study; n = 207 with confirmed COVID-19, n = 124 severe. UK, 2020 | Logistic regression, severe COVID-19 with PA (accelerometer data) and sleep/rest variables, with adjustment for age, sex, ethnicity, diet, smoking, and other factors. | Higher daytime activity related to lower risk for severe COVID-19 (OR = 0.75). Higher movement during sleep/rest linked to higher risk (OR = 1.26). Proper balance of activity and sleep/rest linked to a 30% lower risk of severe COVID-19. |
| Sallis et al. (2021)58 | Retrospective observational cohort of n = 48,440 adult patients in Kaiser Permanente, California with confirmed COVID-19. USA, 2020 | Logistic regression, ORs estimated for COVID-19 outcomes, covariates, and PA categories (consistently inactive, 0–10 min/week; some activity, 11–149 min/week; consistently active, ≥150 min/week). | Patients with COVID-19 who were consistently inactive compared to physically active: OR = 2.26 for hospitalization, OR = 1.73 for admission to the ICU, and OR = 2.49 for death. |
| Cunningham (2021)62 | Data were collected from publicly available data sources for 3142 counties in the U.S. PA data gleaned from the Behavioral Risk Factor Surveillance Survey. USA, 2020 | Two-level random effect regression models were used to probe hypotheses. | PA at the county level in the U.S. was negatively associated with both COVID-19 cases and deaths per 100,000 county residents. |
activity levels were associated with 43%–46% fewer days with illness symptoms. Several randomized controlled trials have also reported similar MVPA-related reductions in common cold incidence and symptomatology.19–24 These findings have been extended using epidemiological methods to other ARIs, including influenza, pneumonia, and COVID-19.1,6,30–34

### 1.3. Influenza, pneumonia, and MVPA

Influenza and pneumonia are ARIs that cause significant morbidity and mortality throughout the world. Influenza A and B viruses cause seasonal epidemics of disease. Influenza A viruses can cause global pandemics and are classified into subtypes according to the combinations of the surface proteins hemagglutinin and neuraminidase. Pneumonia is an ARI caused by many types of pathogens, including viruses, bacteria, and fungi. The most common are Streptococcus pneumoniae, Haemophilus influenzae type b, and respiratory syncytial virus. Influenza and pneumonia are often grouped together in studies and mortality statistical reports. In the United States, for example, influenza and pneumonia rank together as the ninth leading cause of death.35

A nationally representative sample of U.S. adults was followed for an average of 8.75 years.12 In agreement with many other large cohort studies, this one found that adults who performed MVPA at recommended levels experienced a sizeable decrease in risk for all-cause mortality (a 40% reduction for those engaging in both aerobic and muscle strengthening activities). What is interesting about this study is that a risk reduction estimate for influenza and pneumonia mortality was included and contrasted with chronic disease data. For adults engaging in both aerobic and muscle strengthening activities (compared to insufficient activity), mortality risk reduction (adjusted for 9 demographic, lifestyle, and disease conditions) for influenza/pneumonia was 54% compared to 40% for all-cause mortality, 50% for cardiovascular disease (CVD), 40% for cancer, 53% for diabetes mellitus, and 71% for chronic lower respiratory tract diseases (Fig. 1). This study confirmed that physical activity-related health benefits extend to both chronic and infectious diseases and that a “total fitness” approach is superior to aerobic or muscle strengthening activities alone.

Numerous epidemiological studies have focused on the relationship between MVPA and pneumonia.8,10,11–14,32–44 A review of 10 prospective cohort studies with over one million participants concluded that the risk for pneumonia (incidence and mortality) was 31% lower when comparing the most and least physically active groups.32 These findings have been extended to those with diabetes33 and CVD.43 A large population-based cohort study with more than one million Korean patients with CVD demonstrated a negative dose–response association of MVPA on mortality and hospitalization attributable to lower respiratory tract infections, including pneumonia, bronchitis, and tuberculosis.43 Each 500-metabolic equivalent of task (MET) min/week increase of MVPA was associated with a 22% and 13% reduced risk of lower respiratory tract infection mortality and hospitalization, respectively. CVD patients with the highest MVPA levels (>1500 MET min) experienced a 46% reduction in lower respiratory tract infection mortality. This dose–response association was more evident in older patients with CVD.

Fewer studies have investigated the relationship between MVPA and influenza.45–49 Risk for influenza incidence, hospitalization, and mortality is modestly reduced (about 20%) in those who meet MVPA guidelines, but more data are needed to explore and confirm this inverse relationship.45

### 1.4. COVID-19 and MVPA

Scientific investigations on the relationship between ARIs and MVPA increased during the COVID-19 pandemic. Table 2 summarizes the publications that focused on physical activity and COVID-19 outcomes.13,39,50–63 The findings from these studies consistently supported a significant inverse relationship between
MVPA and risk for severe COVID-19 outcomes, including hospitalization, intensive care unit admission, and mortality.33

Many of the publications summarized in Table 2 are based on the large UKBB prospective cohort.13,39,51,53–56,59,60 These reports indicated that risk for severe COVID-19 outcomes was elevated 32% in physically inactive participants53 and reduced 20%–30% when MVPA guidelines were met.13,56,57,60 Higher levels of leisure television watching were related to 55% and 85% risk elevations in COVID-19 hospitalization and disease severity, respectively.61 Among 2690 UKBB older adults who were assessed for CRF, those with moderate (adjusted relative risk = 0.43) and high fitness (adjusted relative risk = 0.37) had a significantly lower risk of dying from COVID-19 than those with low CRF.51 However, testing positive for COVID-19 was not related to CRF. *p < 0.05. COVID-19 = coronavirus disease 2019; CRF = cardiorespiratory fitness; NS = non-significant; UKBB = United Kingdom Biobank.

Other epidemiological studies supported these findings from the UKBB cohort, but risk estimates for the MVPA–COVID-19 relationship varied widely (Table 2). A retrospective analysis of a large group of adults in South Africa with confirmed COVID-19 showed that meeting MVPA guidelines was associated with a 34%–42% lower risk for severe outcomes when compared to physically inactive participants (Fig. 3).59 In comparison, investigators following a similar cohort of adults in the California Kaiser Permanente system reported 73% to 149% elevations in risk for severe outcomes in those who were physically inactive compared to those meeting MVPA guidelines.58 An observational study of Korean adults showed that those who met MVPA guidelines had a 58%–76% lower risk for severe outcomes of COVID-19 illness as well as a small 15% reduction in risk for testing positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection.52 A case-control study in Sweden demonstrated that the odds of severe COVID-19 were 2-fold higher when contrasting the lowest and highest CRF groups.52

1.4.1. MVPA: One spoke in the COVID-19 prevention wheel

In general, the data summarized in Table 2 support a robust reduction in risk for severe COVID-19 outcomes for those with high CRF or those who meet MVPA guidelines and avoid sedentary behavior. Few studies have addressed the issue of MVPA’s influence on reducing the risk for testing positive with SARS-CoV-2, and the results from 2 investigations indicate a small effect at best.51,55 However, there are major methodological challenges in testing this relationship due to widespread but uneven vaccination rates, the large proportion of asymptomatic cases, new SARS-CoV-2 variants, and the cost and lack of availability of polymerase chain reaction (PCR)-based testing. Nonetheless, MVPA’s influence on COVID-19 may have more to do with reducing the magnitude and duration of the viral load rather than infection prevention, as summarized in Fig. 4.

COVID-19 vaccines have strong effects in reducing morbidity and mortality from SARS-CoV-2.64–67 The worldwide Omicron surge revealed, however, that COVID-19 vaccines provided less protection against SARS-CoV-2 infection than they did for the Delta variant,67 underscoring the need for a multi-faceted public health approach in mitigating...
transmission. The Centers for Disease Control and Prevention in the United States now recognizes obesity and physical inactivity as lifestyle risk factors for severe COVID-19 outcomes (https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-care/underlyingconditions.html). Data from the UKBB cohort supported a 58% reduction in severe COVID-19 outcomes when comparing the most and least healthy participants using a lifestyle index based on physical activity, sedentary behavior, sleep quality, diet quality, alcohol intake, and smoking status. Another analysis from the UKBB study indicated a 2.85-fold difference in odds for COVID-19 mortality between highly active individuals with a normal BMI compared to lowly active individuals with obesity (Fig. 5). Thus, the combination of leanness and fitness with other good lifestyle habits, public health mitigation activities, and vaccination is the best strategy for limiting COVID-19 severity.

Data collected during the COVID-19 pandemic reveal that highly stringent governmental containment measures were a barrier to physical activity, especially for those who needed it the most, which includes those suffering with chronic health problems. During the early part of the pandemic, many areas of the country closed gyms, sports clubs, rehabilitation centers, and swimming pools. Some local public health agencies even shut down beaches, golf courses, and walking, running, and mountain biking trails. Much has been learned during the COVID-19 pandemic. In retrospect, every attempt should have been made by public health officials to encourage physical activity by keeping outdoor exercise facilities open and facilitating home-based physical activity programs. In areas of the country with relatively low COVID-19 case rates, indoor exercise facilities should have been allowed to remain open if they operated under strict mitigation guidelines. COVID-19 has weakened global health, but the restrictions that were imposed inadvertently multiplied the public health cost by creating undue barriers to physical activity with related downturns in mental, social, and physical health.

2. MVPA reduces the risk for ARIs: Inclusion as a health-related benefit

Data from the studies included in this narrative review support the growing awareness that MVPA reduces risk for ARI symptomatology (Fig. 6). COVID-19, influenza, pneumonia, and the common cold are among the most ubiquitous infectious diseases on earth, and physical inactivity has been established as an important risk factor for ARI morbidity and mortality. The linkage between ARI severe outcomes and physical inactivity has been strengthened during the COVID-19 pandemic because increased scientific scrutiny has lent evidence to this viewpoint. As reviewed elsewhere, the lowered risk for severe COVID-19 and other ARIs in physically active groups is attributed to exercise-induced immunoprotective effects, including enhanced surveillance of key immune cells and reduced chronic inflammation. Lines of evidence in support of these underlying mechanisms come from cell culture, animal, and human studies showing that MVPA has a positive impact on the immune system.

The 2018 Physical Activity Guidelines for Americans included a list of MVPA-related health benefits, including lowered risk of all-cause mortality and CVD mortality, hypertension, type 2 diabetes mellitus, adverse blood lipid profiles, most of the major cancers, anxiety and depression, dementia, and...
falls and related injuries in older adults. MVPA was also linked to improved cognition, quality of life, sleep quality, weight management, bone health, and physical function. Inexplicably absent from this list was any recognition of MVPA-related improvements in immune function and lowered risk for ARIs.

The time has arrived for scientific consensus groups to recognize the health-related benefit that MVPA offers by reducing risk for various ARI outcomes. The MVPA—ARI studies summarized in this narrative review included large cohorts from many different countries that reported strong risk reductions with a magnitude similar to those reported for common chronic diseases (Fig. 1). Taken together, the data suggest that transient and chronic MVPA effects on immune cell recruitment, augmented immunosurveillance, anti-pathogen activity, and reduced systemic inflammation translate to an independent and robust reduction in the morbidity and mortality burden from ARIs.6,10,14

Authors’ contributions

DCN and CAS drafted and edited the manuscript. Both authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

Both authors declare that they have no competing interests.

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