How does occupational physical activity influence health? An umbrella review of 23 health outcomes across 158 observational studies

Bart Cillekens,[1] Matthias Lang,[1] Willem van Mechelen,[1] Evert Verhagen ,[1] Maaike A Huysmans,[1] Andreas Holtermann ,[2,3] Allard J van der Beek,[1] Pieter Coenen [1]

► Additional material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bjsports-2020-102587).

[1]Department of Public and Occupational Health, Amsterdam UMC, Vrije Universiteit Amsterdam, Amsterdam Public Health Research Institute, Amsterdam, The Netherlands
[2]National Research Centre for the Working Environment, Copenhagen, Denmark
[3]Department of Sport Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark

Correspondence to
Dr Pieter Coenen, Department of Public and Occupational Health, Amsterdam Public Health Research Institute, VU University Medical Centre (VUmc) Van der Boechorststraat 7, 1081 BT Amsterdam, The Netherlands;
p.coenen@amsterdamumc.nl

Accepted 13 September 2020

To cite: Cillekens B, Lang M, van Mechelen W, *et al*. *Br J Sports Med* 2020;**54**:1474–1481.

ABSTRACT

Objective Physical activity (PA) has substantial benefits across a range of health outcomes. There is uncertainty about the PA-specific health effects, and in particular, the occupational domain. In this umbrella review, we synthesised available evidence on the associations between occupational PA (OPA) and health-related outcomes (including cancer, all-cause mortality and cardiovascular disease). This work informed the development of WHO's guidelines on PA and sedentary behaviour (2020).

Design Umbrella review of systematic reviews.

Data source We performed a literature search in PubMed, Web of Science, Embase, CINAHL and Sportdiscuss from database inception to 2 December 2019.

Eligibility criteria for selecting studies We included systematic reviews if they contained a quantitative assessment of OPA and its relationship with at least one health-related outcome.

Results We summarised the evidence of 17 reviews covering 23 unique health-related outcomes. We graded most evidence as low or very low, or moderate quality. We found health benefits for those engaging in high versus low OPA for multiple cancer outcomes (including colon and prostate), ischaemic stroke, coronary heart disease and mental health (ie, mental well-being and life satisfaction). High OPA was associated with unfavourable health outcomes for all-cause mortality in men, mental ill health (ie, depression and anxiety), osteoarthritis, and sleep quality and duration.

Conclusions We found favourable associations for most health-related outcomes with high OPA levels, but we also found some evidence for unfavourable associations due to high OPA levels. At this point, there is a need for better quality evidence to provide a unequivocal statement on the health effects of OPA.

INTRODUCTION

Physical activity (PA) has significant health benefits and contributes to the prevention of a range of lifestyle-related, non-communicable diseases.[1 2] Physical inactivity is one of the global leading risk factors for all-cause mortality.[3] Both national and international PA guidelines for adults, including the 2010 guidelines by WHO, recommend at least 150 min per week of moderate-intensity PA.[1 2] The Global Action Plan on PA highlighted the need to update the 2010 WHO Global recommendations on PA for Health.[4] WHO published the guidelines on PA and sedentary behaviour in 2020, further details of which can be found in the current issue of BJSM.[4]

The 2010 WHO PA guidelines did not differentiate between domains of PA (work, commuting, household and leisure), suggesting comparable health benefits for all these PA domains.[2] Most studies reviewed by the 2010 guidelines were restricted to leisure-time PA (LTPA) domain,[2] and evidence on domain specific health benefits was largely inconclusive. Differential health effects have been reported for LTPA and occupational PA (OPA),[5–7] a phenomenon which is referred to as the PA paradox.[8] For example, a prospective cohort study showed that LTPA was associated with reduced risk of all-cause mortality, while OPA was associated with an increased risk of all-cause mortality.[6] It is not clear whether these differential associations are due to domain-specific PA characteristics (eg, differences in posture, intensity level, frequency, duration and/or recovery time between OPA and LTPA[8]) or down to methodological reasons.[9 10]

As the amount of systematic reviews and meta-analyses accumulates,[11] more advanced evidence synthesis methods such as umbrella reviews can be employed.[12] An umbrella review provides a broader picture of findings for a particular question or phenomenon, and is therefore useful to inform guidelines.[12] PA-related umbrella reviews are mostly restricted to LTPA only,[13–15] with no umbrella review on the health effects of OPA currently.

In this umbrella review, we aimed to provide an overview on the relationships between OPA and a range of health-related outcomes, including cancer, cardiovascular disease (CVD) and all-cause mortality. We also aimed to assess dose–response relationships and whether the relationship between OPA and health differs from that of LTPA.

This review builds on a report on OPA commissioned by WHO to inform the guidelines on PA and sedentary behaviour (2020).

METHODS

Literature search

This protocol was registered in PROSPERO (id: 163090).[16] We searched in PubMed, CINAHL, Web of Science, Embase and Sportdiscuss from database inception up to 2 December 2019 for systematic

reviews assessing the relationship between OPA and health-related outcomes. Searches contained keywords covering OPA, systematic reviews and meta-analyses. See online supplemental material table 1 for a detailed outline of the search strategy. We identified additional reviews by screening the reference list of included reviews and by consulting experts. Two reviewers (BC and ML) independently screened title, abstract and full text of identified references using the online Rayyan application (rayyan.qcri.org).[17] Discrepancies between the two reviewers were resolved in a consensus meeting, or by consulting a third reviewer (PC).

Review inclusion and data extraction

We included full-text systematic reviews of observational (eg, cohort, case–control, cross-sectional) and experimental studies (eg, (randomised) controlled trials) written in English. Reviews had to contain a quantitative assessment of OPA and an association with at least one health-related outcome considered relevant by WHO PA guideline advisory committee. See the full list of outcomes considered in online supplemental material table 2. We excluded articles if the OPA domain was not specifically assessed. We also excluded reviews if they focused on sedentary behaviour only or on biomechanical exposures only (ie, lifting or prolonged postures such as standing or kneeling), without considering energetic components of OPA. We excluded reviews focused on specific (clinical) populations, such as pregnant women or cohorts with an disease.

One reviewer (BC) extracted data from included reviews, which was checked by a second reviewer (ML). Potential conflicts were discussed until consensus was reached. We extracted first author, title, year of publication, outcome, study design, number of included studies, comparison group and effect sizes. If available, effect sizes of LTPA were also extracted.

Methodological quality and certainty of evidence

We rated included systematic reviews using A MeaSurement Tool to Assess systematic Reviews2 (AMSTAR2),[18] a 16-point tool for assessment of the methodological quality of systematic reviews, with good inter-rater agreement, test–retest reliability and content validity.[19] Review quality could be high, moderate, low or critically low, with cut-off values of 100%, ≥75%, ≥50% and <50%, respectively. One reviewer (BC) assessed methodological quality; the second reviewer (ML) checked these assessments. If reviews were rated critically low, they were excluded from further analyses.

We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) method[20] to rate the quality of evidence for each of the health-related outcomes. The GRADE system rates the quality of evidence as:

- High quality: further research is very unlikely to change our confidence in the estimate of effect.
- Moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
- Low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
- Very low quality: any estimate of effect is very uncertain.[20]

The starting point for the quality of the evidence was 'high'.[21 22] We decreased this grading if the reviews showed: risk of bias (ie, selection, performance, detection, attrition and/or reporting bias), inconsistency of results (ie, unexplained heterogeneity or I^2-statistics ≥50%), indirectness of evidence (ie, differences in populations, intervention, outcome measures or indirect comparisons), imprecision (ie, 95% CI includes 1.0) or publication bias (asymmetry in funnel plot). We increased the rating by one level if there was a large magnitude of the effect (eg, RR or OR ≥2.0 or ≤0.5), in case of plausible confounding (which may have reduced an observed effect), or in case of a dose–response gradient.[23]

Data analysis

If more than one review reported on a certain outcome, we only used the most recently published review (typically with the highest number of included studies) for further analyses; unless a less recent review reported higher certainty of evidence (GRADE). Online supplemental material table 3 enumerates the included studies for main and sensitivity analyses. If subgroup analyses (eg, regarding higher quality evidence or different study designs) were provided with different GRADE scores, then evidence from the highest GRADE score was synthesised. We constructed forest plots to display the relationship of high vs low OPA with health-related outcomes. We conducted sensitivity analyses to assess consistency of the synthesised evidence if there was more than one review for the same outcome.

If the original review had estimated the I^2 statistics, we synthesised this information to assess heterogeneity.[24] If reviews did not publish the I^2 statistics, we calculated this where possible.

We synthesised small-study bias or publication bias (when referring to OPA studies). Whenever a review did not provide this information, and included more than ten OPA studies we reanalysed the data and provided funnel plots to assess publication bias on visual inspection. In case no information was provided and less than 10 studies were available, we considered the review at stake to be 'at risk of bias' since a funnel plot would be inaccurate with fewer than 10 studies.[25]

If available, we provided dose–response relationships from reviews that had reported on more than two categories of OPA or on a continuous OPA scale. For the comparison of the relationships of OPA and LTPA with health, we only used already included reviews that reported on both OPA and LTPA. Differences between the effect sizes of OPA and LTPA were statistically tested[26] using a test of interaction. All analyses were conducted using Revman V.3.5.3.

RESULTS

The literature search generated 573 references. After removing duplicates and adding seven reviews from snowball searching, we screened 312 references by title and abstract (figure 1). Full texts of 73 reviews were screened, of which we excluded 37 reviews for various reasons (online supplemental material table 4).

We identified 36 reviews that examined the associations between OPA and 23 unique health-related outcomes.[27–62] The most frequently reported outcome was cancer, with 11 different cancer types (24 reviews). Other reviews evaluated CVD (n=3), osteoarthritis (n=3), all-cause mortality (n=2), hypertension (n=1), diabetes mellitus type 2 (n=1), insomnia (n=1) and mental health (n=1) (online supplemental material table 3). We did not detect any reviews on adiposity, cognitive outcomes or health-related quality of life.

Quality assessment

AMSTAR2 scores for methodological quality of the 36 included reviews are shown in online supplemental material table 5. Six reviews scored (17%) critically low which we did not use for further analyses.[30 32 35 49 55 59] Eight reviews (22%) scored

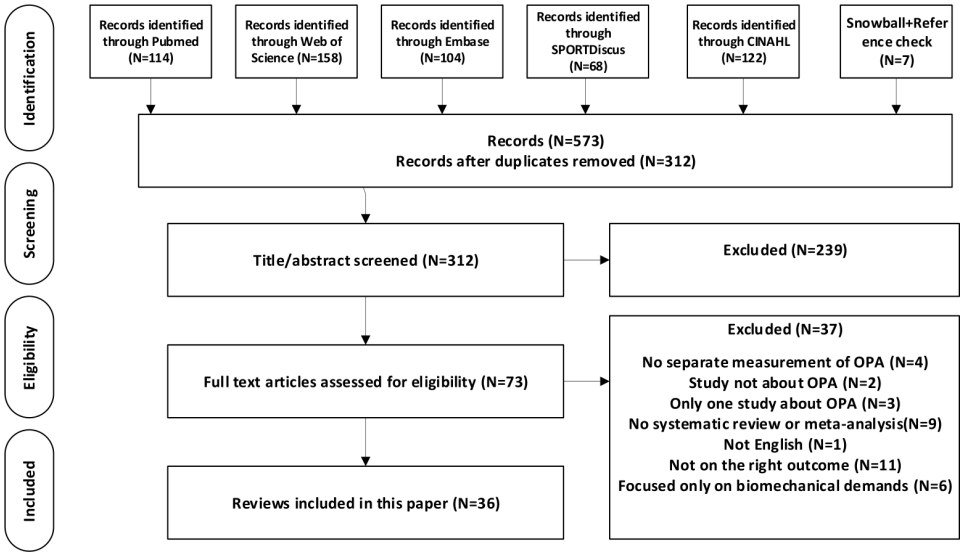


Figure 1 Flow chart depicting the review search and selection procedure. OPA, occupational physical activity.

moderate, and 22 (61%) scored low methodological quality. None of the included reviews scored high on the AMSTAR2 scale, with common methodological issues for example being lack of a priori protocol registration (only done in four reviews), not reporting a comprehensive search strategy (only performed in ten reviews) and not providing a list of excluded studies (only done in five reviews).

Evidence synthesis

Online supplemental material table 6 presents extracted data. Seventeen reviews (on 23 unique outcomes) were synthesised. These reviews reported on 158 studies: 96 (61%) longitudinal cohort studies, 60 (38%) case–control studies and 2 (<1%) cross-sectional studies, while no reviews on experimental studies met the inclusion criteria. Reviews described between three and 27 individual studies, with a median of 7.5 studies per review. We did not synthesise thirteen reviews because there was a more recent published review, or a review with a higher certainty of evidence (online supplemental material table 3).

Grading of Recommendations Assessment, Development and Evaluation

We graded none of the included reviews as high quality; overall the evidence was of moderate quality at best (online supplemental material table 6). Four reviews (17%) on colon cancer, rectal cancer, endometrial cancer and prostate cancer provided moderate quality evidence. Reviews of nine (39%) outcomes provided low quality evidence (all-cause mortality, ischaemic stroke, coronary heart disease (CHD), proximal and distal colon cancer, breast cancer, gastric cancer and renal cancer) and ten other reviews (43%) offered very low-quality evidence.

PA measurement methods varied across reviewed studies, and included self-administered questionnaires, interviews or job titles. Because PA was mostly self-reported, misclassification was reported in almost all included reviews. In some reviews PA was assessed at baseline, but a change in PA over time was not considered. Over half of the reviews reported that there was confounding bias, that the adjustment of variables widely varied between studies, or that important confounding variables were not addressed in reviewed studies. Some review reported language bias; typically only one or two languages were included in the reviews.

Of the 23 health outcomes, 14 (61%) reported an I^2 statistics <50% and seven (30%) reported an I^2 statistics ≥50% (hypertension, mental health, mental ill health, stroke, all-cause mortality, poor sleep duration and/or quality and osteoarthritis). For two outcomes (oesophageal and endometrial cancer) the reviews did not provide I^2 statitics. Re analysis showed a low heterogeneity (I^2=0%) for endometrial cancer and considerable heterogeneity for oesophageal cancer (I^2=89%) (online supplemental material figure 7). Most reviews were precise; the risk estimates of only seven (30%) outcomes had 1.0 included in their 95% CI. Although all 17 reviews used the Eggers asymmetry test to detect publication bias, in most reviews, the association between OPA and a health-related outcome was investigated in a subgroup analysis on OPA only, with the Egger test conducted for 'total PA' (including OPA). Only for four outcomes (17%) (in three reviews) a test for publication bias was conducted, addressing the OPA domain. Only one of these three reviews found a small risk for publication bias. It is likely that reviews did not conduct separate analyses because there were not enough unique OPA studies included: fourteen (61%) outcomes included less than 10 studies on OPA. We reanalysed the data of four outcomes and did not detect publication bias in these reviews (online supplemental material figure 8). One review included more than ten studies, but did not report individual study effect sizes, hence we could not perform an assessment of publication bias.[47]

Evidence

All synthesised reviews are summarised in figure 2, with quality of the evidence ranging from moderate to very low.

Moderate quality evidence

A meta-analysis of Mahmood *et al*[33] including five cohort and ten case-control studies showed a statistically significant reduction in risk of colon cancer among those with high compared with low OPA (RR 0.74, 95% CI 0.67 to 0.82). This association was comparable for men (RR 0.74, 95% CI 0.66 to 0.82) and women (RR 0.78, 95% CI 0.65 to 0.93). In the same review, authors presented pooled estimates regarding the association between OPA and rectal cancer from five cohort and seven case–control

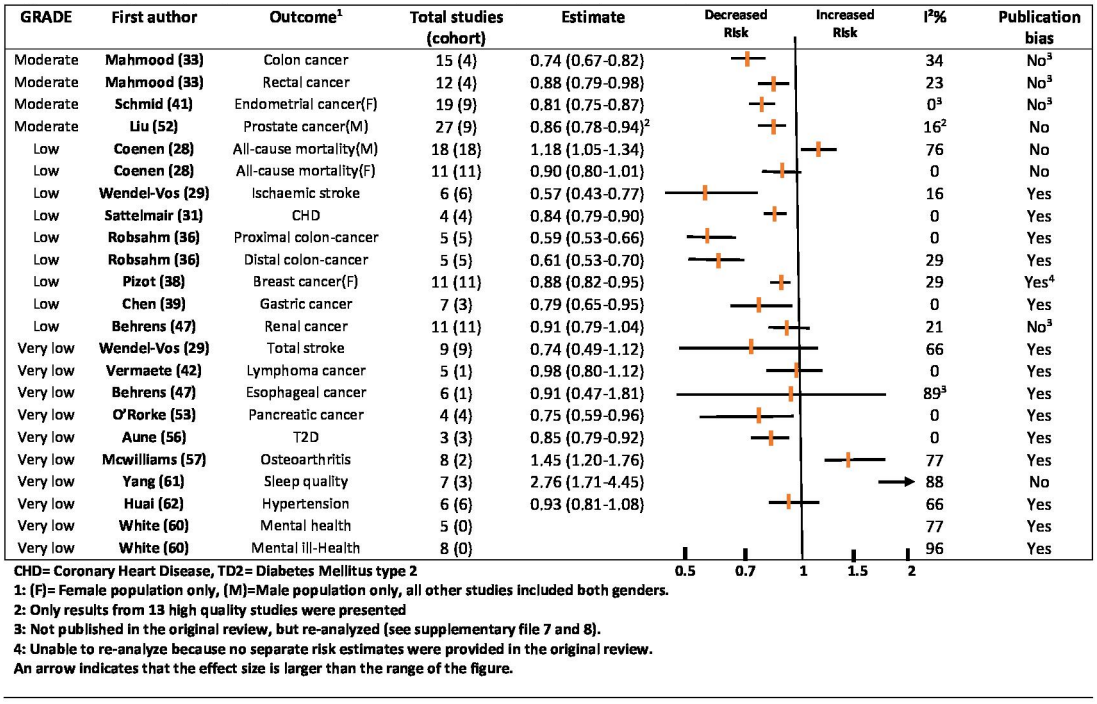


Figure 2 Forest plot depicting the evidence for the association of occupational physical activity and health. (1) (F)= Female population only, (M)=Male population only, all other studies included both genders. (2) Only results from 13 high-quality studies were presented. (3) Not published in the original review, but reanalysed (online supplemental files 7 and 8). (4) Unable to reanalyse because no separate risk estimates were provided in the original review. An arrow indicates that the effect size is larger than the range of the figure. CHD, coronary heart dsease; GRADE, Grading of Recommendations Assessment, Development and Evaluation; TD2, diabetes mellitus type 2.

studies, showing a reduced risk in those with high compared with low OPA (RR 0.88, 95% CI 0.79 to 0.98). Another systematic review that investigated colon cancer subtypes, found comparable effects for proximal (RR 0.72, 95% CI 0.61 to 0.85) and distal colon cancer (RR 0.75, 95% CI 0.63 to 0.88).[36] In our sensitivity analysis, comparable associations were found for both colon cancer (and subtypes) and rectal cancer.[34]

A review on seven cohort and twelve case–control studies found a statistically significant risk reduction of endometrial cancer for women with high compared with low OPA (RR 0.81, 95% CI 0.75 to 0.87).[41] Another review showed comparable results.[40]

A review by Liu *et al*[52] showed that OPA was significantly related with a reduced risk of prostate cancer (RR 0.81, 95% CI 0.73 to 0.91). The reduction in risk was statistically significantly lower for nine cohort studies (RR 0.91, 95% CI 0.87 to 0.95) compared with eighteen case–control studies (RR 0.73, 95% CI 0.62 to 0.87). When stratified for study quality, the higher quality studies showed a lower reduced risk (RR 0.86, 95% CI 0.78 to 0.94) compared with lower quality studies (RR 0.75, 95% CI 0.89 to 1.00). A statistically significant protective effect of OPA only existed in those studies in which the median follow-up duration was >10 years. Comparable results were found in other systematic reviews.[50 51]

Low-quality evidence

In the most recent systematic review,[28] men with high level OPA experienced a statistically significant increased risk of all-cause mortality (HR 1.18, 95% CI 1.05 to 1.34), even after adjusting for possible confounders, such as LTPA. A non-significant reduced risk was observed among women (HR 0.90, 95% CI 0.80 to 1.01). Authors reported considerable heterogeneity in the pooled study findings for men (I^2 statistic=76%), but not for women (I^2 statistic=0%), and some risk of publication bias was discussed by the authors. An earlier review, with a lower number of included studies, showed a reduction in mortality risk for both genders[27] (RR 0.66, 95% CI 0.49 to 0.89 and RR 0.94, 95% CI 0.75 to 1.19, for females and males, respectively). In the this review, high heterogeneity was reported.

A higher level OPA was related to a lower risk of stroke; although, this association was not statistically significant for total stroke (RR 0.74, 95% CI 0.49 to 1.12).[29] In the association between OPA and ischaemic stroke, statistically significant protective effects were found for high vs low OPA (RR 0.57, 95% CI 0.43 to 0.77).

Sattelmair *et al* showed, based on evidence from four studies with low heterogeneity, that high versus low OPA was related to a statistically significant reduced risk of CHD (RR 0.84, 95% CI 0.79 to 0.90).[31] Three out of four studies were based on male samples only (RR 0.87, 95% CI 0.81 to 0.99).

Pizot *et al* observed that high OPA versus low OPA was related to a statistically significantly reduced risk of breast cancer in a female population (RR 0.88, 95% CI 0.82 to 0.95).[38] These results were based on eleven cohort studies with low heterogeneity. Two other reviews showed comparable results.[37 39]

Chen *et al* showed that high versus low OPA had a statistically significantly lower risk of gastric cancer (RR 0.79, 95% CI 0.65 to 0.95).[45] Behrens *et al* observed a statistically non-significant association between OPA and oesophageal cancer (RR 0.91, 95% CI 0.46 to 1.81).[46] Two other reviews found comparable results.[43 44]

Behrens *et al* found that high versus low OPA was related to a statistically non-significant reduction in renal cancer (RR 0.91, 95% CI 0.79 to 1.04). The authors estimated these results

from data of six cohort and five case–control studies[47] with low heterogeneity. Another review showed comparable results.[48]

OPA showed no association with lymphoma (OR 0.98, 95% CI 0.80 to 1.02) from a review with one cohort and four case–control studies.[42]

One review reported on the association between OPA and pancreatic cancer.[54] Three cohort studies showed a statistically significant reduction (RR 0.75, 95% CI 0.58 to 0.96). There was low heterogeneity between the included studies.

Three cohort studies with over 9000 diabetes mellitus type 2 cases showed a lower risk on this outcome (RR 0.85, 95% CI 0.79 to 0.92) for people with high versus low OPA.[56]

Pooled results from two cohort, three cross-sectional and three case–control studies showed that high OPA was related with a statistically significant higher risk of knee osteoarthritis (OR 1.45, 95% CI 1.20 to 1.76).[57] Authors of this review reported high heterogeneity and a high likelihood of publication bias. Cohort studies showed lower risks compared with cross-sectional and case–control studies. Another review showed that cumulative physical workloads were associated with hip osteoarthritis in men; this review showed mixed evidence for physical demands and knee osteoarthritis, hip osteoarthritis and osteoarthritis in multiple other joints.[58]

For high versus low OPA, there was an statistically significant increased risk of insomnia (OR 2.76, 95% CI 1.71 to 4.45),[61] with pooled results from four cross-sectional and three cohort studies, and high heterogeneity.

In comparison with low OPA, high OPA was related with a decreased, but statistically non-significant, risk of hypertension (RR 0.93, 95% CI 0.81 to 1.08).[62] The heterogeneity among six studies was high.

OPA had a weak positive association with mental ill-health (ie, depression and anxiety) (r 0.10, 95% CI 0.04 to 0.16), but also a weak positive association with mental health (ie, mental well-being and life satisfaction) (r 0.02, 95% CI −0.09 to 0.12).[60] Both effects showed high heterogeneity.

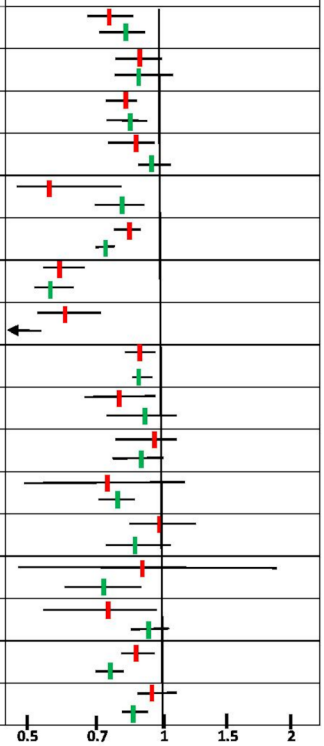
Health effects of occupational versus LTPA

In the included reviews, effect sizes of seventeen outcomes were available for both OPA and LTPA (figure 3). Effect sizes of both OPA and LTPA generally pointed into the same direction, with some differences in estimates provided for OPA and LTPA. The association between OPA and LTPA was statistically significant different for CHD, distal colon cancer and diabetes mellitus type 2. We could not compare OPA and LTPA for all-cause mortality, sleep quality and/or duration, osteoarthritis and mental (ill) health, because LTPA was not included in the reviews for these outcomes.

Dose–response associations

Only five outcomes, presented in three reviews, reported on dose–response associations (figure 4). Three outcomes (stroke, ischaemic stroke and hypertension) showed a gradual risk increase across three groups of OPA (high, moderate, low levels of OPA). For total stroke, the lowest risk reduction was shown for the moderately active vs inactive workers (RR 0.64, 95% CI 0.48 to 0.87). For ischaemic stroke, the most active workers

Outcome	Author (ref)	PA	Number of studies	Estimates
Colon Cancer	Mahmood (33) 2017	OPA	15	0.74 (0.67-0.82)
		LTPA	14	0.80 (0.71-0.90)
Rectal Cancer	Mahmood (33) 2017	OPA	12	0.88 (0.79-0.98)
		LTPA	9	0.87 (0.75-1.01)
Endometrial Cancer	Schmid (41) 2015	OPA	19	0.81 (0.75-0.87)
		LTPA	22	0.84 (0.78-0.91)
Prostate Cancer	Liu (52) 2011	OPA	27	0.86 (0.78-0.94)
		LTPA	34	0.95 (0.90-1.01)
Ischaemic stroke	Wendel-Vos (29) 2004	OPA	6	0.57 (0.43-0.76)
		LTPA	11	0.79 (0.69-0.91)
CHD	Sattelmair (31) 2011	OPA	4	0.84 (0.79-0.90)*
		LTPA	26	0.74 (0.70-0.79)*
Proximal colon	Robsahm (36) 2013	OPA	5	0.59 (0.53-0.66)
		LTPA	13	0.53 (0.44-0.64)
Distal colon	Robsahm (36) 2013	OPA	5	0.61 (0.53-0.70)*
		LTPA	13	0.40 (0.30-0.53)*
Breast cancer	Pizot (38) 2015	OPA	11	0.88 (0.82-0.95)
		LTPA	30	0.87 (0.84-0.91)
Gastric cancer	Chen (39) 2014	OPA	7	0.79 (0.65-0.95)
		LTPA	7	0.89 (0.74-1.06)
Renal cancer	Behrens (47) 2013	OPA	11	0.91 (0.79-1.04)
		LTPA	19	0.88 (0.77-1.00)
Stroke	Wendel-Vos (29) 2004	OPA	9	0.74 (0.49-1.12)
		LTPA	19	0.78 (0.71-0.85)
Lymphoma	Vermaete (42) 2013	OPA	5	0.98 (0.80-1.21)
		LTPA	8	0.86 (0.73-1.02)
Oesophageal	Behrens (47) 2014	OPA	6	0.91 (0.46-1.80)
		LTPA	10	0.72 (0.63-0.83)
Pancreatic cancer	O'Rorke (53) 2010	OPA	3	0.75 (0.59-0.96)
		LTPA	16	0.94 (0.88-1.01)
T2D	Aune (56) 2015	OPA	3	0.85 (0.79-0.92)*
		LTPA	56	0.74 (0.70-0.79)*
Hypertension	Hual (62) 2011	OPA	6	0.93 (0.81-1.07)
		LTPA	12	0.81 (0.77-0.86)



CHD= Coronary Heart Disease, T2D= Diabetes Mellitus type 2
*Effect of LTPA and OPA is statistically significantly different (p=<0.05).
An arrow indicates effect sizes that were out of range of our figure.

Figure 3 Forest plot depicting the evidence for the association of physical activity and health. Association for occupational and leisure-time physical activity are depicted. *Effect of LTPA and OPA is statistically significantly different (p≤0.05). An arrow indicates effect sizes that were out of range of our figure. CHD, coronary heart disease; LTPA, leisure-time physical activity; OPA, occupational physical activity; T2D, diabetes mellitus type 2.

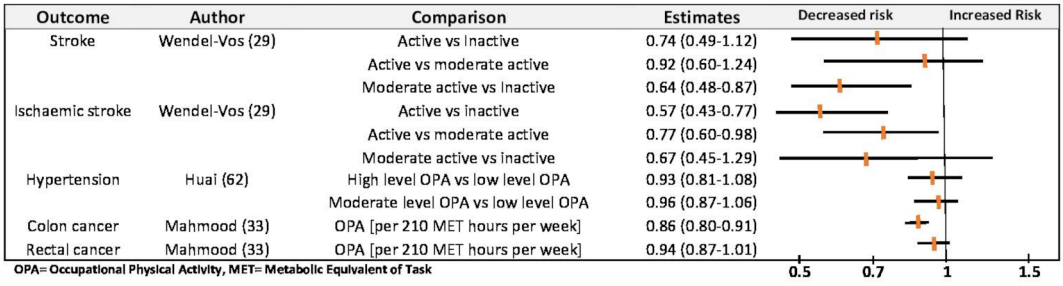


Figure 4 Dose–response associations for occupational physical activity and health. MET, metabolic equivalent of task; OPA, occupational physical activity.

category was found to have the highest reduced risk.[29] The results also showed that there was no evidence for an association between high-level or moderate-level OPA and hypertension.[62] Mahmood reported the pooled RR for colon cancer with an OPA level per 210 metabolic equivalent of task (MET) hour/week (RR 0.86, 95% CI 0.80 to 0.91). This effect was stronger for men (RR 0.82, 95% CI 0.76 to 0.88) than for women (RR 0.96, 95% CI 0.86 to 1.08). In the same review, the pooled RR with OPA level per 210 MET our/week for rectal cancer was (RR 0.94, 95% CI 0.87 to 1.01).[33]

DISCUSSION

Main findings

In this umbrella review, we summarised the evidence on the associations between OPA and 23 health-related outcomes based on 17 systematic reviews that included 158 individual studies. Engaging in high versus low OPA showed beneficial health effects for multiple cancer outcomes, stroke, CHD and mental health. In contrast, high versus low OPA showed unfavourable health outcomes regarding all-cause mortality in men, mental ill health, osteoarthritis and sleep duration and/or quality. For some outcomes, our results are inconclusive (ie, for several cancer outcomes, hypertension, all-cause mortality in females). We identified no reviews on adiposity, cognitive outcomes or health-related quality of life. The associations between OPA and health-related outcomes, for most outcomes, were not differential from that of LTPA in direction and/or magnitude. Although for three health outcomes we found a significant difference in magnitude (figure 3), LTPA showed a higher protective effect in distal colon cancer, CHD and diabetes type 2 than OPA. Reviews that reported unfavourable health outcomes for OPA (ie, all-cause mortality in men, osteoarthritis and sleep duration and/or sleep quality) did not report on LTPA, as a result of which we could not make a comparison between OPA and LTPA.

Only three reviews, addressing five outcomes, reported dose–response associations of OPA and health. We can, therefore, only make limited inferences on the health effects of the full OPA continuum. Higher OPA-specific energy expenditure was associated with a gradually reduced risk of colon cancer and to a lesser extent a reduced risk for rectal cancer. For hypertension and ischaemic stroke, the highest OPA groups were associated with the lowest risk (although non-significant for hypertension).

Interpretation of the results

In this umbrella review, we applied the GRADE method. Other criteria to evaluate the quality of evidence have been proposed in other reviews[13–15] and by other organisations.[63] Using such criteria could have possibly led to other results in the interpretation of the reviews identified in our umbrella review. None of the relationships we identified were supported by strong evidence (with moderate GRADE scores at best) and therefore results should be interpreted with caution. We only detected evidence from systematic reviews of observational studies, which bears a higher risk of selection bias and confounding.[64] All identified evidence suffers from risk of bias (eg, misclassification, publication bias and confounding bias) and reviews showed high heterogeneity and/or inconsistent results. Studies varied widely regarding the confounding variables that were considered and relevant variables such as socioeconomic status, body mass index and lifestyle factors (eg, smoking, alcohol and diet) were not addressed in every study. All reviews reported issues with the measurements of PA, specifically with the use of self-reported methods to assess OPA in all reviews and studies. Measuring OPA can be challenging as the occupational dose and intensity can fluctuate over time (eg, between days, weeks or seasons) and a general shift in OPA from physically demanding jobs to more sedentary occupations has been seen over the last decades.[65] As most studies of the current evidence base assessed OPA only at a single instance, changes over time were not considered, which could have led to misclassification. On the other hand, OPA could be less subjected to recall bias than LTPA because of the routine nature of OPA and relatively long (ie, sometimes livelong) exposure to OPA.[66] Self-reported PA may suffer from several biases[67 68] induced by socially desirable or culturally influenced answers; for example, variation across socioeconomic and demographic groups,[69] participants' inability to assess PA at different intensities and recall bias.[70] Arbitrary cut-off points (with heterogeneous definitions) to operationalise OPA categories were used and precision was reduced by using dichotomous OPA categories.

Most reviews were able to include a substantial number of studies on LTPA since reviews often had their main focus on either LTPA or total PA (ie, OPA and LTPA combined). Only limited evidence was available for OPA, sometimes from subgroup analyses only. In addition, reviews could or did not detect heterogeneity/publication bias for OPA. Some reviews did not draw any conclusions on OPA or stated that more evidence was needed on this topic. In contrast, reviews with a relatively high number of included studies on OPA showed the importance of subgroup analyses to provide more profound insight. The review about prostate cancer showed, for example, that higher quality studies had a lower reduced risk in comparison with lower quality studies; cohort studies showed a lower reduced risk in comparison with case–control studies.[52] In this review, a statistically significant beneficial health effect of OPA was only evident in studies with a long follow-up (median >10 years).[52] Coenen *et al* showed that high OPA was related to an increased risk of all-cause mortality for men, but a non-significant decreased risk for women.[28]

Sensitivity analyses were used to assess the consistency of the evidence when multiple reviews were available per health outcome. These analyses showed that almost all reviews provided comparable direction and magnitude of effect sizes. The two reviews on all-cause mortality, however, showed opposite effects. Coenen *et al* reported that the risk of all-cause mortality was higher for male workers,[28] while Samitz *et al* reported in an earlier review with fewer studies that men with higher OPA had a reduced risk of all-cause mortality.[27] While both reviews had a low GRADE-score, we synthesised the findings from the most recent review, which also included more studies.[28] The evidence was therefore considered to be more up to date. Nevertheless, while in the male population high level OPA was associated with all-cause mortality, other included reviews on the leading causes of death,[71] such as CVD and cancer outcomes, showed favourable health outcomes for high versus low OPA. The aforementioned and other methodological issues could partly explain these contradictory findings.[9 10] There are also several plausible physiological explanations as to why OPA might not confer the cardiovascular health benefits of LTPA.[8] For example, LTPA entails dynamic movements which is mostly performed voluntarily over short time periods with sufficient recovery time, while OPA is most often of too low intensity or of too long duration to be health beneficial.

Methodological strengths and limitations

We followed a systematic methodology including search strategy in electronic databases and independent study selection and extraction by two researchers. We also used standard approaches to assess the quality of methods (AMSTAR2) and to rate the quality of the evidence (GRADE). GRADE has increasingly been adopted by organisations worldwide for grading evidence and for guideline development.[20] Moreover, if a review did not report on heterogeneity (in terms of I^2 statistics) or publication bias (eg, using funnel plots), we reanalysed the available data, leading to more accurate GRADE scores.

A limitation of our umbrella review is that with the rapidly evolving body of evidence on the health effects of OPA, evidence may have only recently been published and as a consequence has not been summarised in reviews yet. For example, since the review by Coenen *et al* (with literature search until September 2017) at least six new studies reporting on all-cause mortality and OPA would have met the inclusion criteria for systematic reviews included in our umbrella review.[10] None of the systematic reviews included experimental studies, although some individual experimental studies addressed the relationship between OPA and health-related outcomes.[72 73] Experimental studies provide more insight into causality and deal with issues such as selection bias and confounding.

We included reviews that addressed OPA with at least an aerobic component and excluded reviews with only biomechanical (eg, lifting, kneeling) OPA components. We only included health-related outcomes prioritised by WHO (online supplemental material table 2); thereby excluding evidence on outcomes such as musculoskeletal and neurological disorders. The limitation of the exclusion of neurological outcomes seems to have hardly any influence on our findings. For example, Morgan *et al* could not provide any convincing evidence on the associations between OPA and dementia in later life.[74] Stephen *et al* showed that there was inconclusive evidence regarding the associations between OPA and Alzheimer's disease.[75] However, it is known that high biomechanical demands at work, such as lifting and heavy manual work, are associated with increased risk of musculoskeletal disorders such as low back, neck/shoulder and lower extremity pain.[76–78] We also reported on outcomes that are closely related (eg, colon cancer and rectal cancer) because they were addressed in separate systematic reviews.[33 34 36]

Implications for future research

WHO guidelines on PA and sedentary behaviour (2020) state that more evidence is needed on the health effects of occupational OPA.[79] We recommend that further research addressing OPA should be based on more sophisticated OPA assessments (eg, using a combination of device measured PA and a diary to distinguish domains of PA). This will help to address biases due to self-reports and can additionally measure PA metrics, such as intensity, duration and frequency.[10] Second, we recommend that reviews and prospective cohort studies examine health effects by PA domains, so that possible differential health effects of LTPA and OPA can further be explored. Third, to get a better understanding of the health-related outcomes of OPA, it is important to consider biomechanical demands at work and musculoskeletal disorders. Particularly since musculoskeletal disorders, such as (low) back and neck pain, result in considerable healthcare spending,[80] as well as substantial indirect cost due to presenteeism and absenteeism,[81] and are among the leading causes of disability worldwide.[82 83] To increase the quality of evidence, more experimental studies comparing OPA with health-related outcomes should be conducted and included in systematic reviews. Lastly, we urge researchers to conduct subgroup analyses, if possible (such as for gender), since these seem to provide a more thorough understanding of the health effects of OPA.

Implications for practice

High-quality evidence on the relationship between LTPA and the prevention of non-communicable diseases is available and has been incorporated in national and global guidelines.[3] WHO guidelines advise that some PA is better than none and recommend working age adults to engage in at least 150–300 min of moderate-intensity PA per week. The recommended amounts of PA can be done as part of leisure, transportation, work and household activities.[79]

There is inconclusive evidence of very low to moderate quality for OPA to provide comparable beneficial health effects to LTPA. At this point, there is a need for better quality evidence to provide a unequivocal statement on the health effects of OPA.

As the evidence base develops, a more nuanced message concerning the health effects of OPA may be possible. Such a nuanced message will be relevant to large parts of the working population, in particular, those from low socioeconomic groups and people in low-income and middle-income countries who do most of their daily PA at work.[84 85] Although more high-quality evidence is still needed on health effects of OPA, OPA holds many workers back from engaging in sufficient LTPA due to fatigue and exertion from work, and therefore, it may limit the beneficial health effects of engaging in LTPA for a large fraction of the adult population.[86]

CONCLUSION

We found that high OPA has favourable health associations with most health-related outcomes (multiple cancer outcomes, stroke, CHD and mental health). Other reviews showed unfavourable health associations with high OPA levels (all-cause mortality in men, mental ill health, osteoarthritis and poor sleep duration and/or quality).

Included reviews were of very low to moderate quality. To increase the quality, future research should focus on sophisticated PA measurements, include relevant confounders such as socioeconomic status, lifestyle factors and other types of PA and regular updating of existing systematic reviews. Improved research will lead to a better understanding of the associations between OPA and health-related outcomes.

What is already known

- Adequate physical activity (PA) prevents a range of lifestyle-related, non-communicable diseases.
- It is uncertain if all domains of PA have comparable health effects, with some evidence suggesting that leisure time PA (LTPA) and occupational PA (OPA) may have differential health effects.
- Methodological issues or differences posture, intensity level, frequency, duration and/or recovery time between OPA and LTPA could explain these differential health effects of different PA domains.

What are the new findings

- This umbrella review, which is the first of its kind, suggests that high occupational physical activity (OPA) was beneficial for most health outcomes including coronary heart disease and several cancers.
- High OPA showed unfavourable associations with all-cause mortality in men, mental ill health, osteoarthritis and sleep duration and/or quality.
- This review synthesised a heterogeneous evidence base of very low to moderate quality, highlighting the need for better quality research in this area.

Twitter Evert Verhagen @Evertverhagen and Andreas Holtermann @profHoltermann

Acknowledgements This review was prepared for and funded by the WHO, to contribute to the development of the Guidelines on physical activity and sedentary behaviour (2020). It was submitted to the Guideline Development Group and considered as they formulated their recommendations. The views expressed in this article do not necessarily represent the decisions, policy or views of the World Health Organization.

Contributors BC and ML conducted the literature screening and data extraction of all included reviews. All authors (BC, ML, WvM, EV, MH, AH, AJvdB, PC) reviewed the manuscript for important intellectual content. PC was the study guarantor.

Funding This paper was based on a report that was commissioned and funded by WHO. This research was furthermore funded by The Netherlands Organisation for Health Research and Development; ZonMw (grant #: 531-00141-3).

Competing interests For the avoidance of doubt, WvM wishes to declare that he is a non-executive board member of Arbo Unie B.V. WvM and AJvdB are director and advisor, respectively, of Evalua Nederland B.V. Both Arbo Unie and Evalua Nederland operate in the Dutch occupational healthcare market.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

ORCID iDs
Evert Verhagen http://orcid.org/0000-0001-9227-8234
Andreas Holtermann http://orcid.org/0000-0003-4825-5697
Pieter Coenen http://orcid.org/0000-0002-4034-7063

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