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Leisure-time physical activity, occupational physical activity and the physical activity paradox in healthcare workers: A systematic overview of the literature

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Background: Physical activity positively influences cardiovascular health. Results from male-dominated physically active occupations suggest that a high level of occupational physical activity may be detrimental to cardiovascular health. This observation is referred to as the physical activity paradox. Whether this phenomenon can also be observed in female-dominated occupations remains unknown.
Objective: We aimed to provide an overview of (1) leisure-time and occupational physical activity in healthcare workers. Therefore, we reviewed studies (2) to assess the relationship between the two physical activity domains and analyzed (3) their effects on cardiovascular health outcomes in relation to the paradox.
Methods: Five databases (CINAHAL, PubMed, Scopus, Sportdiscus, Web of Science) were systematically searched. Both authors independently screened the titles, abstracts, and full texts and assessed the quality of the studies using the National Institutes of Health's quality assessment tool for observational cohort and cross-sectional studies. All studies that assessed leisure-time and occupational physical activity in healthcare workers were included. The two authors independently rated the risk of bias using the ROBINS-E tool. The body of evidence was evaluated using the GRADE approach.
Results: The review included 17 studies that assessed the leisure-time and occupational physical activity of people working in healthcare, determined the relationship between the domains (n = 7) and/or examined their effects on the cardiovascular system (n = 5). Measurements for leisure-time and occupational physical activity varied between studies. Leisure-time physical activity typically ranged between low and high intensity, with a short duration (approx. 0.8–1.5 h). Occupational physical activity was typically performed at light to moderate intensity with a very long duration (approx. 0.5–3 h). Moreover, leisure-time and occupational physical activity were almost negatively related. The few studies investigating effects on cardiovascular parameters revealed a rather unfavorable effect of occupational physical activity, while leisure-time physical activity was beneficial. The study quality was rated as fair and the risk of bias was moderate to high. The body of evidence was low.
Conclusions: This review confirmed that leisure-time and occupational physical activity of healthcare workers are opposed in their duration and intensity. Moreover, leisure-time and occupational physical activity seem to be negatively related and should be analyzed according to their relation to each other in specific occupations. Furthermore, results support the relationship between the paradox and cardiovascular parameters.
Registration: Preregistered on PROSPERO (CRD42021254572). Date of registration on PROSPERO: 19 May 2021.
Tweetable abstract: Does occupational physical activity adversely affect the cardiovascular health of healthcare workers in comparison to leisure-time physical activity?

What is already known

- Overall, physical activity has positive effects on cardiovascular health, such as blood pressure.
- Physical activity during work might rather unfavorably affect cardiovascular health parameters, compared to physical activity during leisure time, a phenomenon referred to as the physical activity paradox.
- In occupationally active male-dominated groups such as blue-collar workers, clearly negative effects on cardiovascular health effects

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(physical activity paradox) have been demonstrated; while studies on females have returned unclear results in relation to the physical activity paradox.

What this paper adds

- The occupational physical activity level of healthcare workers is mainly in the range of light to moderate-intensity over a long duration, whereas leisure-time physical activity varies greatly and is performed at light- to high-intensity levels for a short duration.
- A negative association between leisure-time and occupational physical activity was identified, i.e., a high occupational physical activity level is typically accompanied by low leisure-time physical activity and vice versa.
- The physical activity paradox with unfavorable effects of occupational physical activity and favorable effects of leisure-time physical activity on cardiovascular health can, according to the trend, also be attributed to the female-dominated profession of healthcare workers, although the current results need to be interpreted carefully.

1. Background

Non-communicable diseases such as cardiovascular diseases, diabetes, and metabolic syndrome are, at present, one of the major global health challenges (World-Health-Organization, 2022). The World Health Organization (WHO) reported that cardiovascular diseases are the leading cause of death worldwide (World-Health-Organization, 2022) even though it is well-known that a healthy lifestyle can protect the cardiovascular system (Kariuki et al., 2019). The lifestyle factors known to promote cardiovascular health include a balanced diet, adequate sleep, and sufficient physical activity (Bull et al., 2020; Cash et al., 2021; Lichtenstein et al., 2021). In this vein, the longitudinal study results of the Framingham Heart Study, for example, have revealed that sustained physical activity, rather than more sedentary time, leads to lower mortality rates in people with cardiovascular diseases (Shortreed et al., 2013; Nayor et al., 2021) and the incidence of cardiovascular diseases can be reduced through persistent physical activity over the life span (Shortreed et al., 2013). Based on the clear relationship between physical activity and health, the WHO recommends at least 150–300 min of moderate-intensity activity, or 75–150 min of vigorous-intensity activity per week to maintain health (Bull et al., 2020). A combination of activities at different intensities for appropriately adjusted durations is also effective in maintaining health (Bull et al., 2020). However, it is strongly recommended that people engage in physical activity beyond this minimum in order to gain additional benefits for cardiovascular health as well as other health outcomes, such as weight stabilization (Byambasukh et al., 2021). Conversely, physical inactivity or sedentary time is associated with an increased risk of cardiovascular disease (Manson et al., 2002). In addition to calculating the physical activity level in terms of active minutes at a specific intensity, it can also be quantified using the metabolic equivalent, which attributes certain scores to different activities. Metabolic equivalent reporting is typically made in either minutes or hours, either per day or per week. The minimum recommendation is 500 metabolic equivalent/min (or 8.3 metabolic equivalent/h) per week (Kaminsky and Montoye, 2014).

Physical activity behavior is not only a lifestyle factor, but an inevitable demand of many occupations. However, it is interesting that the findings of studies on people in highly active occupations seem to contradict the findings on people who have a physically active lifestyle outside of work (Strippoli et al., 2021). While it has been shown that high levels of leisure-time physical activity have beneficial effects on cardiovascular health it has also been demonstrated that occupational physical activity may not benefit cardiovascular health (Holtermann et al., 2018; Cillekens et al., 2020). This unexpected relationship between physical activity behavior and cardiovascular health in the two different domains is referred to as the physical activity paradox (Holtermann et al., 2018, 2012; Temporelli, 2021).

According to this paradox, occupational physical activity negatively impacts cardiovascular health and thus contradicts traditional physical activity research, which suggests that physical activity provides various health benefits. However, the WHO recommends a general physical activity level per day or week that does not stipulate domain specifications or characteristics for physical activity (Coenen et al., 2018). A possible explanation for the paradox is that occupational physical activity is typically performed at a low-intensity level over a long duration and with inadequate breaks and recovery time (Holtermann et al., 2021) as has been suggested by Holtermann et al.. Therefore, occupational physical activity is not expected to have the same beneficial effects on the cardiovascular system as leisure-time physical activity, which is typically performed in shorter bouts and mostly at higher intensities (Cillekens et al., 2020; Holtermann et al., 2021). An inadequate recovery time associated with prolonged occupational physical activity may cause fatigue and exhaustion, in addition to sustained inflammation that may, in turn, increase the likelihood of cardiovascular diseases (Krause et al., 2015; Kasapis and Thompson, 2005). A second possible explanation for the physical activity paradox is that heavy lifting, static loading, and monotonous and awkward working postures typically associated with physically demanding jobs lead to unfavorable cardiovascular and musculoskeletal stress (Clays et al., 2013).

In contrast, leisure-time physical activity is typically performed more at the moderate- to vigorous-intensity level for shorter bouts. Furthermore, there is usually sufficient time for recovery before the next activity is executed (Holtermann et al., 2018). Therefore, regular leisure-time physical activity induces changes in the respiratory (Sorokin et al., 2011) and cardiovascular systems (Hernáez et al., 2020) that may induce positive long-term physiological adaptations (Harber et al., 2017; Whelton et al., 2002).

Occupational physical activity also seems to be directly related to leisure-time physical activity. Thus, highly active occupation groups (as determined by activity trackers) with low leisure-time physical activity typically report a higher number of sick days than workers with high leisure-time physical activity (and low occupational physical activity) (Gupta et al., 2020).

Various studies have been carried out to analyzes the effects of the two domains on health. For example, a stronger autonomic imbalance was detected by measuring heart rate variability during sleep in people with high occupational physical activity (% of physical activity during work in moderate-to-vigorous activity) (Hallman et al., 2017). Furthermore, high occupational physical stress was associated with a lower hippocampal volume than was found in people with low occupational physical stress (Burzynska et al., 2020). Similarly, for C reactive protein, a marker for systemic inflammation, leisure-time physical activity showed protective effects, whereas occupational activity did not. Moreover, a global physical activity questionnaire classified occupational physical activity as a potential risk factor for this inflammatory marker (Lee et al., 2021). Only a high amount of leisure-time physical activity, not occupational physical activity (both assessed using metabolic equivalent scales), has been shown to have a positive effect on maximum oxygen uptake, a key indicator of cardiovascular fitness (Mundwiler et al., 2017). In contrast, while controlling for leisure-time physical activity, high occupational activity (measured using a questionnaire about typical occupational physical patterns) has been shown to be a protective factor against chronic diseases (Probert et al., 2008). This suggests that it is both feasible and necessary to examine and assess the roles of leisure-time and occupational physical activity independently, to understand the reasons for the physical activity paradox.

To date, most of the studies that have analyzed leisure-time physical activity and occupational physical activity patterns have been conducted in occupational groups that are dominated by men, primarily manual and blue-collar workers (Sato et al., 2018; Korshøj et al., 2021). These professions involve a high level of physical activity. Furthermore, female-dominated sectors are currently underrepresented in the examination of the physical activity paradox and studies investigating the health effects and mortality rates associated with occupational physical activity have returned less clear results for female subjects (Coenen et al., 2020). In particular, with regard to cardiovascular diseases, females seem to be more frequently undiagnosed, undertreated, understated in their typical symptoms, or incorrectly diagnosed (Hyun et al., 2017).

The healthcare sector is one professional context that has a much greater proportion of female than male employees (Boniol et al., 2019). This includes hospitals or other care facilities. We assume that this sector is characterized by a high occupational physical activity level at light intensity combined with a high physical workload (e.g., lifting and standing for long periods). For example, nurses have been shown to be primarily active in the light-intensity range and rarely in the moderate activity zone (Chappel et al., 2017). Nevertheless, the cardiovascular health of nursing occupational groups has been shown to be insufficient (Sovová et al., 2020; Orr et al., 2013).

This review has (1) evaluated the leisure-time and occupational physical activity as well as inactivity (sedentary time) of healthcare workers as representatives of female-dominated occupations, and (2) assessed the interaction between leisure-time and occupational physical activity. So far, this interaction has only been investigated sporadically, so researchers can only speculate about the relationship between leisure-time and occupational physical activity in healthcare workers. Based on the results for male-dominated occupations, we expected a negative relation between both domains. (3) In addition, this review systematically summarizes the effects of leisure-time and occupational physical activity on cardiovascular health and, thereby, contributes to untangling the physical activity paradox in relation to healthcare workers.

2. Methods

This review evaluated the literature on leisure-time and occupational physical activity of healthcare workers.

2.1. Search strategy: databases and inclusion criteria

The studies were selected through a systematic search of the following five databases: CINAHAL, PubMed, Scopus, Sportdiscus, and Web of Science. The literature search was performed on September 30th, 2021. The earliest paper found was published in 1963. We have continued to check for new publications regularly (until November 2022) in case other studies became available that could be included in the search. No further studies were identified that met the inclusion criteria. The review was registered on PROSPERO (CRD42021254572), where the search protocol is documented. The three key elements (list of occupational keywords, keywords for occupational physical activity, and keywords for leisure-time physical activity) were combined with the AND operator to build the final formula (see also PROSPERO and the supplementary material). Reviews and other overview articles found by the search were screened for further studies that were included as secondary references. Studies were included in the review if they met the following criteria: (i) the studies were conducted on people currently working in the healthcare sector, (ii) physical activity was reported for leisure-time and occupational time, (iii) publications were written in English or German, and (iv) samples included adults of working age, that is 18–67 years of age. (v) Intervention studies were only included if baseline values for leisure-time and occupational physical activity were available. Reporting of the search and search results followed the PRISMA guidelines.

2.2. Selection process and data extraction

After duplicates were removed, the titles and abstracts were analyzed by both reviewers using the inclusion criteria described above. The remaining studies were then screened for fit a second time based on the inclusion criteria and the full text. In cases where there was disagreement, a third external reviewer was consulted, and a consensus was reached on the study selection. Finally, the reference lists of the studies and reviews selected for inclusion were also scanned for further potentially relevant studies. Studies that analyzed a mixed population, including healthcare workers, were included in the sample. When these mixed population studies reported results for healthcare workers separately, the results were included. When no separate values were available in a mixed occupation, the collected values were included when primarily female individuals were analyzed. Studies were included if they assessed physical activity in both dimensions, leisure-time and occupational physical activity, either by use of subjective (e.g., questionnaires) or objective tools (e.g., accelerometers). Results for both physical activity domains were used to assess the interaction of the two dimensions as well as their individual effect on cardiovascular health.

Data on the sample population, including the number of participants, age, sex, country, and occupation, were extracted when available to describe the samples and identify possible confounding factors and differences between the studies. All available data on the parameters of physical activity in the two domains and the respective measurement tools were extracted to quantify physical activity. Physical activity was quantified based on the named components of the physical activity paradox and exercise science (intensity, duration, body positioning, movement patterns, and recovery time). The relationship between leisure-time and occupational physical activity was similarly extracted from the data. In order to facilitate the comparability of the physical activity data, units were adjusted to each other where applicable. For example, if the same values were reported, but in different units, they were converted (e.g., metabolic equivalent/h per day to metabolic equivalent/min per week). When results were available on the association between leisure-time and occupational physical activity, they have been listed. Furthermore, if physical activity levels were reported in relation to cardiovascular health parameters (e.g., relative risk for cardiovascular diseases, cardiovascular fitness, blood pressure), they were extracted to verify the physical activity paradox. If there was any uncertainty about the results of the study or any data was not provided, the authors were contacted. Data extraction and data recalculation were conducted by TIJ and confirmed by CVR.

2.3. Outcome data

The extracted data were prepared in tabular form and narrative descriptions of the extracted data were used (cf. Table 1). If the reporting of the study differed, e.g., by reporting further subcategories, this was adjusted according to the WHO guidelines (e.g., *high*-intensity occupational physical activity was referred to as *vigorous*-intensity). As previously mentioned, the adjustment of the metabolic equivalent units was also equalized for the studies that reported metabolic equivalents in order to increase the comparability of this value. In addition to physical activity, leisure-time and occupational sedentary time were extracted as indicators of physical inactivity. Subsequently, interactions/associations between the physical activity domains were extracted. The relationship as well as their impact on cardiovascular health were described.

2.4. Quality assessment, risk of bias, and body of evidence

The quality of the studies was evaluated using the Quality Assessment Tool for Observational Cohort and Cross-sectional Studies by the National Heart, Lung and Blood Institute (Health, 2015) by two independent reviewers. The tool includes the following 14 criteria: (1) Research question, (2) Study population, (3) Participation rate at least 50%, (4) Groups recruited from the same population and uniform eligibility criteria, (5) Sample size justification, (6) Exposure assessed prior to outcome measurement, (7) Sufficient timeframe to see an effect, (8) Different levels of exposure of interest, (9) Exposure measures and assessment, (10) Repeated exposure assessment, (11) Outcome measures (12) Blinding of outcomes assessors, (13) Follow-up rate, and (14) Statistical analysis. For analyzing the risk of bias, the Tool Risk of Bias in Non-randomized Studies of Exposure (ROBINS-E) was used (Bero et al., 2018). ROBINS-E includes seven criteria: (1) Risk of bias due to confounding, (2) Risk of bias arising from the measurement of the exposure, (3) Risk of bias in the selection of participants into the study, (4) Risk of bias due to post-exposure interventions, (5) Risk of bias due to missing data, (6) Risk of bias in the measurement of the outcome, and (7) Risk of bias in section of the reported results. Further, the body of evidence was rated by the two reviewers independently using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach (Granholm et al., 2019). In the GRADE approach, the following criteria are used to evaluate the certainty of the evidence based on the following aspects: (1) Inconsistency, (2) Indirectness, (3) Imprecision, (4) Publication Bias, (5) Large effect, (6) Dose–response, and (7) All other possible confounding. Applying this method would demonstrate a reduced effect/suggest a spurious effect when results show no effect.

3. Results

3.1. Search results

The complete process of the study selection is visualized in Fig. 1 and extraction is summarized in Table 1. Seventeen studies met the inclusion criteria. As the three studies by Allesoe et al. referred to the same study sample, the sample was only counted once in the calculation of the sample size in this review (Allesøe et al., 2015; Allesoe et al., 2016, 2017). However, the results of the three studies were reported separately as they focused on different cardiovascular outcomes.

The total number of participants across all studies included here amounted to 18,971 healthcare professionals, all of whom reported on their leisure-time and occupational physical activity levels. The majority (n = 14) of the study pool reported a mean age between 33 and 48 years. All studies included more female than male subjects. The studies were conducted in the following countries: Australia (n = 3), Denmark (n = 3), Hungary (n = 1), Ireland (n = 1), Lithuania (n = 1), the Netherlands (n = 1), New Zealand (n = 3), Saudi Arabia (n = 1), Thailand (n = 1), and the United States of America (n = 3). Among the occupational groups, the majority were nursing staff and assistants (n = 15), followed by physicians (n = 3), midwives (n = 2), and other healthcare professionals (n = 5). Seven of the studies also integrated information on other professions including teachers, housewives, and telephone personnel (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Alquaiz et al., 2015; Malinauskiene et al., 2019; Wilbur et al., 1999; Wolff et al., 2021). Six studies evaluated the relationship between leisure-time and occupational physical activity using different statistical methods (correlation analysis (n = 3), student's t-test, logistic regression, or linear mixed model (n = 1 each). The effect of leisure-time or occupational physical activity on cardiovascular health was assessed using the hazard ratio (n = 3), a correlation analysis (n = 1), or linear regression (n = 1) (see Table 1).

3.2. Physical activity behavior

The leisure-time and occupational physical activity parameters were evaluated using subjective (e.g., questionnaires) (n = 14) and objective (e.g., pedometer or accelerometer devices) measurements (n = 5) (see Table 1). Two of the studies assessed both subjective and objective parameters (Umukoro et al., 2013; Yu, 2020). Accordingly, leisure-time and occupational physical activity were reported in different units and based on different data. Some studies reported both domains as a percentage of intensity level based on their typical leisure-time or occupational physical activity patterns (n = 4 leisure-time, n = 3 occupational). However, most studies reported intensity levels and the duration spent in these levels in either minutes or hours per day or per week (n = 5 for both domains) or in hours per day off work (n = 1 occupational). Other studies transformed the data from questionnaires into metabolic equivalents (n = 5 leisure-time, n = 4 occupational), referencing either the WHO recommendations (n = 1 for both domains) or Gobin recommendation for leisure-time (n = 3 leisure-time), or reported in terms of specific activities (e.g., stepping, standing) (n = 2 both domains). Two studies used a score to quantify occupational physical activity. Some studies also reported sedentary behavior (n = 8 for both domains).

3.3. Leisure-time physical activity

Sedentary time. Eight studies (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Malinauskiene et al., 2019; Yu, 2020; Chappel et al., 2020; Jirathananuwat and Pongpirul, 2017; Loef et al., 2018) examined sedentary time. Sedentary time ranged from 5% to 60% distribution of the typical activity level as reported in a questionnaire (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Malinauskiene et al., 2019) or 60% per week assessed with an accelerometer (Loef et al., 2018). Three studies presented sedentary time in objectively measured minutes per day rather than as percentage values. They found durations ranged between 3.1 h (Chappel et al., 2020) and 4.3 h (258 min) per day (Jirathananuwat and Pongpirul, 2017) and up to 19 h per day on days off work (including sleep) (Yu, 2020).

Light-intensity. Five of the 17 studies (Alquaiz et al., 2015; Yu, 2020; Chappel et al., 2020; Jirathananuwat and Pongpirul, 2017; Wilbur et al., 1998) assessed light-intensity physical activity using subjective measures and found 56% to 77% of physical activity was performed at a light-intensity level per week or for 26 to 42 min per day (Alquaiz et al., 2015; Wilbur et al., 1998). Objectively measured durations of activity in the light-intensity level ranged from 41 to 56 min per day (Chappel et al., 2020; Jirathananuwat and Pongpirul, 2017) or 3 h per day on days off work (Yu, 2020).

Moderate-intensity. Eleven studies assessed moderate-intensity physical activity (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Alquaiz et al., 2015; Malinauskiene et al., 2019; Umukoro et al., 2013; Yu, 2020; Jirathananuwat and Pongpirul, 2017; Wilbur et al., 1998; Henwood et al., 2012; Mc Carthy et al., 2018). Subjective reporting included ranges from 21% to 66% of the week/day/typical pattern (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Alquaiz et al., 2015; Malinauskiene et al., 2019; Wilbur et al., 1998). The objectively measured moderate-intensity levels varied from nine to 135 min per day or per week (Umukoro et al., 2013; Jirathananuwat and Pongpirul, 2017; Henwood et al., 2012; Mc Carthy et al., 2018) or 42 min on a day off work (Yu, 2020).

Vigorous-intensity. Vigorous-intensity physical activity was measured in ten studies (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Alquaiz et al., 2015; Malinauskiene et al., 2019; Umukoro et al., 2013; Jirathananuwat and Pongpirul, 2017; Wilbur et al., 1998; Mc Carthy et al., 2018) and included durations ranging from no time to 34 min per day (Yu, 2020; Jirathananuwat and Pongpirul, 2017; Mc Carthy et al., 2018) or 17 min (~ 0.28 h) per week (Umukoro et al., 2013) (all objectively measured except in (Mc Carthy et al., 2018)). Subjective proportions of vigorous-intensity ranged from less than 2% to 35% of leisure-time per week (Alquaiz et al., 2015; Malinauskiene et al., 2019; Wilbur et al., 1998) or 27% of general leisure time (Allesøe et al., 2015; Allesoe et al., 2016, 2017). Chappel et al. also summarized the objectively measured moderate- to vigorous-intensity physical activity and reported an average of 13 min of moderate- to vigorous-intensity physical activity per day (35% of leisure time per day) (Chappel et al., 2020).

Metabolic equivalent. In four studies, the questionnaire data was transformed into metabolic equivalent values to quantify the level of physical activity (Wilbur et al., 1999; Wolff et al., 2021; Tuckett and Henwood, 2015; Rovo et al., 2020). Three studies (Wilbur et al., 1999;

Table 1
Selected studies that evaluated leisure-time and occupational physical activity in healthcare workers.

Authors	Participants, sex, age,	Country, occupation	Leisure-time physical activity tool	Occupational physical activity tool	Effect measure	Results: Leisure-time physical activity	Results: Occupational physical activity	Results: Relationship between leisure-time physical activity and occupational physical activity	Results: Effect on cardiovascular health
(Allesøe et al., 2015)	N = 12,093 female/male = 12,093/0 age = > 45 years	Denmark, nurses	Saltin & Grimby questionaire	Saltin & Grimby questionaire	Harzard risk for ischemic heart disease in a Cox model	Distribution of intensity level during leisure time: vigorous: 27.2%, moderate: 66.7%, sedentary: 5.4%	% of working time vigorous: 46.3%, moderate: 34.3%, sedentary: 19.2%		People with high sedentary leisure-time and high occupational sedentary time showed a higher risk for ischemic heart disease. People with high vigorous leisure-time physical activity and high vigorous occupational physical activity showed a higher risk for ischemic heart disease.
(Allesoe et al., 2016)					Hazard risk for ischemic heart disease in a Cox model				People with hypertension and high vigorous occupational physical activity showed a higher risk for ischemic heart disease.
(Allesoe et al., 2017)					Hazard risk for ischemic heart disease in a Cox model				High vigorous occupational physical activity adjusted for lifestyle (included leisure-time physical activity as confounder showed a higher risk for ischemic heart disease).
(Alquaiz et al., 2015)	N = 365 female/male = 365/0 age = 40.1 years (SD = 8.8)	Saudi Arabia, housewives, teachers, administrative officers, others (doctors, technicians, nurses, etc.)	Godin Leisure-Time exercise Questionnaire	Caregiving Index of the Kaiser Physical Activity Survey	Pearson's chi-square test; Stepwise univariate linear regression	% of participants performing exercise in the intensity level/week vigorous: 35%, moderate: 57%, light: 56% Meeting Gobin recommendation: moderate active: 24.6%, light active: 22.9% insufficient: 52.6%	Caregiving activities/week: 3.0 (SD = 0.74) (1 = 0–1 h/week, 2 = >1 to <20 h/week, 3 = >20 h/week)		Occupational physical activity is negatively correlated with higher risk for cardiovascular disease.
(Chappel et al., 2020)	N = 49 female/male = 44/5 age = 33 years (SD = 17)	Australia, nurses	Accelerometer; inclinometer	Accelerometer; inclinometer	Generalized linear latent and mixed models	Accelerometer data per day: moderate-to-vigorous physical activity: 35%/13 min, light: 26%/56 min inclinometer data per day: stepping: 64%/54 min standing: 24%/1.5 h sitting: 55%/3.1 h accelerometer data during leisure[a]: moderate-to-vigorous physical activity: 5%/0.2 h light: 23%/0.9 h sedentary: 72%/2.8 h Inclinometer data during leisure[a]: stepping: 16%/0.9 h standing: 27%/1.5 h sitting: 56%/3.1 h	Accelerometer data per day: moderate-to-vigorous physical activity: 65%/24 min light: 74%/2.5 h inclinometer data per day: stepping: 36%/29 min standing: 76%/4.8 h sitting: 45%/2.5 h accelerometer data during work[a]: moderate-to-vigorous physical activity: 4%/24 min light: 28%/2.5 h sedentary: 67%/5.8 h Inclinometer data during work[a]: stepping: 6%/0.5 h standing: 62%/4.8 h sitting: 32%/2.5 h	Moderate-to-vigorous leisure-time physical activity in the morning/before shift leads to lower occupational physical activity in the afternoon/after shift High occupational physical activity in the morning/before shift leads to lower leisure-time physical activity in the afternoon/after shift.	

(continued on next page)

Table 1 (*continued*)

Authors	Participants, sex, age,	Country, occupation	Leisure-time physical activity tool	Occupational physical activity tool	Effect measure	Results: Leisure-time physical activity	Results: Occupational physical activity	Results: Relationship between leisure-time physical activity and occupational physical activity	Results: Effect on cardiovascular health
(Henwood et al., 2012)	N = 2264 female/male = not reported age = 42.51 years (SD = 0.21)	Australia and New Zealand, nurses, midwives	International Physical Activity Questionnaire (IPAQ)	International Physical Activity Questionnaire (IPAQ)	Pearson's chi-square test	Minutes/day during leisure-time: moderate: 19.16 min	Minutes/day during work: moderate: 39.95 min	High occupational physical activity group has low leisure-time physical activity and vice versa	
(Jirathananuwat and Pongpirul, 2017)	N = 289 female/male = 283/6 age = 35.87 years (SD = 10.87)	Thailand, nurses, nurse manager	Activity tracker	Activity tracker	Paired Student's t test	During leisure time minutes/day: vigorous: 0.12 min, moderate: 7.49 min, light: 41.83 min, sedentary: 258.17 min	During work minutes/day: vigorous: 0.05 min, moderate: 8.50 min, light: 80.80 min, sedentary: 495.56 min	Mean occupational physical activity differs from mean leisure-time physical activity.	
(Loef et al., 2018)	N = 479 female/male = 87.1%/ 12.9% age = shift worker = age = 40.9 years (SD = 12.2) non-shift worker age = 47.3 years (SD = 10.8)	Netherlands, healthcare workers: nurses, other occupations (physicians, dieticians, physiotherapists, etc.)	Accelerometer	Accelerometer		During leisure per week: standing: 27.4%/20.6 h walking: 8.7%/6.5 h running: 0.3%/0.23 h stair-climbing: 0.77%/0.58 h cycling: 2.3%/1.6 h sedentary: 60.5%/45.7 h	During work per week: standing: 31.85%/11 h walking: 10.85%/3.5 h running: 0.01%/0.004 h stair-climbing: 0.33%/0.08 h cycling: 0.22%/0.05 h sedentary: 56.8%/16 h		
(Malinauskiene et al., 2019)	N = 1241 female/male = 1241/0 nurses = 613 age nurses = 45.94 years (SD = 8.85)	Lithuania, secondary-school teachers, family physicians, internal medicine department nurses	Godin Leisure-Time Exercise Questionnaire	Job-related physical activity questionnaire		Only nurses, meeting Gobin recommendation: highly active: 10.5%, moderate active: 30.9%, Inactive: 58.6%	Unknown (no author's reply).		
(Mc Carthy et al., 2018)	N = 200 female/male = 192/8 age = 39.78 years (SD = 9.38)	Ireland, nurses	International Physical Activity Questionnaire (IPAQ)	International Physical Activity Questionnaire (IPAQ)	Univariate logistic regression analysis (Odds Ratio)	During leisure minutes/week: vigorous: 26.73 min moderate: 17.79 min Reached the World Health Organization recommendations: 9%	During work minutes/week: vigorous: 34.72 min moderate: 61.67 min Reached the World Health Organization recommendations: 41%	Negative correlation between WHO recommended leisure-time physical activity and occupational physical activity.	
(Rovo et al., 2020)	N = 285 female/male = 247/38 age = 44.37 years (SD = 10.38)	Hungary, health professionals	International Physical Activity Questionnaire (IPAQ)	International Physical Activity Questionnaire (IPAQ)		Metabolic equivalent/minutes/week[a]: 720 MET	Metabolic equivalent/minutes/week[a]: 2000 MET		
(Tuckett and Henwood, 2015)	N = 676 female/male = 608/68 age = 42.76 years (SD 0.38)	Australia and New Zealand, nurses, midwives	International Physical Activity Questionnaire (IPAQ)	International Physical Activity Questionnaire (IPAQ)		Metabolic equivalent/minutes/week[a]: healthy lifestyle: 1630.01 MET unhealthy lifestyle: 666.78 MET	Metabolic equivalent/minutes/week[a]: healthy lifestyle: 1657.54 MET, unhealthy lifestyle: 2319.83 MET	Healthy lifestyle subjects compared to unhealthy lifestyle subjects have lower occupational physical activity and higher leisure-time physical activity.	
(Umukoro et al., 2013)	N = 48 female/male = 41/7 age = 42 years (SD = 12)	United States of America, nurses, patient care assistants	Behavioral Risk Factor Surveillance System questionnaire; accelerometer	Behavioral risk factor Surveillance System questionnaire; accelerometer	Nonparametric Spearman's correlations	*accelerometer data* minutes per week: vigorous: 17.6 min, moderate: 135 min	accelerometer data minutes per week: vigorous: 0.4 min, moderate: 30 min, light: 1084 min, sedentary: 1308 min	Moderate objective leisure-time physical activity and vigorous subjective occupational physical activity are negatively correlated. Vigorous objective leisure-time physical activity and vigorous subjective occupational physical activity	

								are negatively correlated. Moderate, objective leisure-time physical activity and sitting subjective occupational physical activity are negatively correlated.	
(Wilbur et al., 1998)	N = 176 female/male = 176/0 age groups= 35–43 years = 34.9% 44–52 years = 30.9% ≥53 years = 34.3%	United States of America, academic faculty, telephone personnel, nurses, and nursing assistant	Taylor Leisure Time Questionnaire	Tecumseh Occupational Activity Questionnaire		During leisure % per week vigorous:<2% moderate: 21% light: 77%	During work % per week vigorous: <2% moderate: 33% light: 63%	Mean leisure-time physical activity was lower than mean occupational physical activity.	
(Wilbur et al., 1999)	N = 163 female/male = 163/0 age = 47.0 years (SD = 8.24)	United States of America, academic faculty, telephone personnel, nurses, nursing assistants	Minesota Leisure Time Activities Questionnaire;	Tecumseh Occupational Activity Questionnaire	Pearson's chi-square test	Only nursing professions data Metabolic equivalent/minutes/week[a]: 1738.8 MET	Only nursing professions data Metabolic equivalent/minutes/week[a]: 1335.6 MET		Total cholesterol and occupational energy expenditure are negatively correlated Total cholesterol and leisure-time energy expenditure are negatively correlated. High density lipoprotein cholesterol and occupational energy expenditure are positively correlated.
(Wolff et al., 2021)	N = 550 female/male = 419/131 age = 35.72 years (SD = 9.56)	United States of America, physicians, nurses, technologist, research assistants, coders, billers, analysts	Godin Leisure-Time Exercise Questionnaire	Baecke Physical Activity Questionnaire		Metabolic equivalent/minutes/week[a]: 284.4 MET	Baecke score: 2.59 (SD: 0.86) (scale from 1 to 5)		
(Yu, 2020)	N = 93 female/male = 68/28 age = 33.9 years (SD = 9.6)	New Zealand, nurses	Physical activity frequency questionnaire, accelerometer	Physical activity frequency questionnaire, accelerometer		Accelerometer data hours on day off: vigorous: 0.0 h moderate: 0.7 h light: 3.2 h sedentary: 19.5 h	Accelerometer data hours per 12-h shift: vigorous: 0.0 h moderate: 0.8 h light: 4.1 h sedentary: 7.4 h		

Notes.
[a] Recalculated for comparability by the authors.

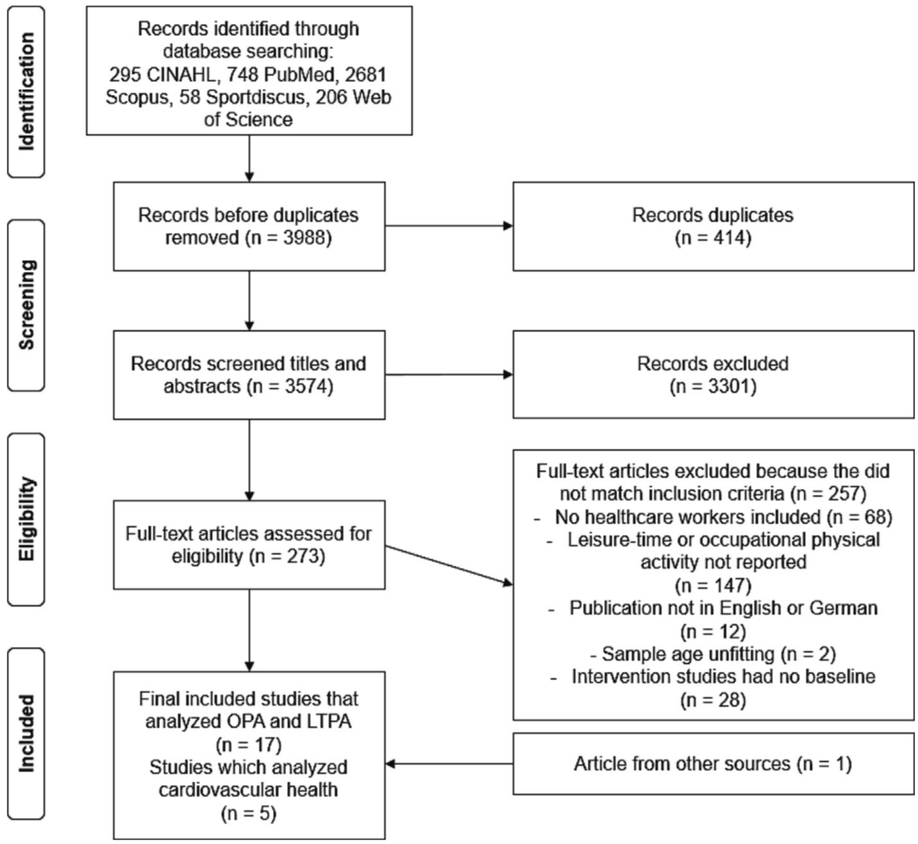

Fig. 1. PRISMA flow chart of the search process.

Tuckett and Henwood, 2015; Rovo et al., 2020) reported metabolic equivalent values above 500 metabolic equivalent/min per week during leisure time (corresponding to the WHO recommendation). Wolff et al. (2021) reported only 284 metabolic equivalent/min per week.

Others. Two studies (Alquaiz et al., 2015; Mc Carthy et al., 2018) described whether the subjects reached the recommendations for physical activity during leisure time based on the Gobin questionnaire and WHO recommendations. Alquaiz et al. determined that more than half of the subjects were insufficiently active, a quarter were classified as active and the remaining quarter were moderately active (Alquaiz et al., 2015). Mc Carthy also found that only 10% of nurses met the WHO's recommended level of physical activity (Mc Carthy et al., 2018). Chappel et al. and Loef et al. specified data by quantifying additional types of activity and body positioning using objective tools (Chappel et al., 2020; Loef et al., 2018). Their participants stood for 24% per day (~1.5 h) or 27% of their leisure-time and were walking/stepping for between less than 1% to over 64% of their leisure time per day (~ 54 min). Loef et al. also reported on running and cycling, which accounted for less than 3% of leisure-time (Loef et al., 2018).

To summarize the results for leisure-time physical activity, high heterogeneity was found among healthcare workers who range from being very sedentary to more active. The active period during leisure time, based on objective data, was relatively short (approx. 0.8–1.5 h), mostly at a light-intensity, while the subjective data indicated a light- to moderate-intensity level. However, of the four studies that used metabolic equivalent assessments, three did report sufficient levels of leisure-time physical activity.

3.4. Occupational physical activity

3.4.1. Sedentary time

In eight studies (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Umukoro et al., 2013; Yu, 2020; Chappel et al., 2020; Jirathananuwat and Pongpirul, 2017; Loef et al., 2018), sedentariness was subjectively assessed and ranged from 19% to 57% of the working period (Allesøe et al., 2015; Allesoe et al., 2016, 2017), or from 150 to 1308 min (~2.5 to ~21.8 h) per day/week (Umukoro et al., 2013; Chappel et al., 2020; Jirathananuwat and Pongpirul, 2017). Using objective tools, sedentary time was 7.4 h per 12-h shift (Yu, 2020). Moreover, Loef et al.'s objective assessment determined that people working in the healthcare sector typically spend 16 h per week sitting (Loef et al., 2018).

3.4.2. Light-intensity

Light intensity during working hours was considered in five studies (Umukoro et al., 2013; Yu, 2020; Chappel et al., 2020; Jirathananuwat and Pongpirul, 2017; Wilbur et al., 1998) and results ranged between a subjectively measured 63% per week (Wilbur et al., 1998) and an objectively measured 74% per day (Chappel et al., 2020). The duration of the objectively measured light-intensity activity, recorded in minutes, was very heterogeneous and ranged from 80 to 150 min (~1.3 to 2.5 h) per day/during work (Chappel et al., 2020; Jirathananuwat and Pongpirul, 2017). Other studies reported 1084 min (~18 h) per week (Umukoro et al., 2013) and 7 h per 12-h shift (Yu, 2020).

3.4.3. Moderate-intensity

Moderate-intensity levels were reported in nine studies (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Umukoro et al., 2013; Yu, 2020; Jirathananuwat and Pongpirul, 2017; Wilbur et al., 1998; Henwood et al., 2012; Mc Carthy et al., 2018). In four studies, moderate physical activity accounted for 34% of working time or 33% per week (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Wilbur et al., 1998). Other studies objectively measured moderate-intensity at 30 min to 48 min per week or per 12-h shift (Umukoro et al., 2013; Yu, 2020). Eight to 40 min per day of moderate-intensity was reported in the studies by Henwood (based on subjective data) and Jirathananuwat (based on objective data) (Jirathananuwat and Pongpirul, 2017; Henwood et al., 2012).

3.4.4. Vigorous-intensity

Seven studies reported vigorous physical activity among health workers (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Umukoro et al., 2013; Yu, 2020; Jirathananuwat and Pongpirul, 2017; Wilbur et al., 1998) with a duration of 0 h to approximately 0.5 h per day/week/shift (Umukoro et al., 2013; Yu, 2020; Jirathananuwat and Pongpirul, 2017). Wilbur et al. (1998) assessed found less than 2% per week of vigorous intensity during their occupation. In contrast, a study of a Danish cohort reported that 46% of working patterns was typically spent in vigorous activities (Allesøe et al., 2015; Allesoe et al., 2016, 2017).

Chappel's study combined objective moderate-to-vigorous intensities and determined a value of 24 min during work time. This amounted to 65% of all moderate-to-vigorous physical activity per day (Chappel et al., 2020).

3.4.5. Metabolic equivalent

Three studies transformed the questionnaire data into metabolic equivalents and detected values ranging from 1335 to 2319 metabolic equivalent/min, per week for nurses and midwives (Tuckett and Henwood, 2015), health professionals (Rovo et al., 2020), and a mixed occupational group of women (Wilbur et al., 1999). The recommended minimum of 500 metabolic equivalent/min per week, was clearly exceeded during occupational activity in all three studies (Wilbur et al., 1999; Tuckett and Henwood, 2015; Rovo et al., 2020).

3.4.6. Others

Mc Carthy et al. assessed whether their participants reached the WHO recommendation using the same references for leisure-time physical activity and occupational physical activity (Mc Carthy et al., 2018). The team determined that 41% of nurses met this recommendation at work (Mc Carthy et al., 2018). Two studies gave values for specific activities, such as standing or cycling, based on objective measures (Chappel et al., 2020; Loef et al., 2018). Standing comprised 31% of the working time or 76% per day (~4.8 h). Additional objective reports included 36% (~4.8 h) stepping per day (Chappel et al., 2020), 11% (~3.5 h) walking, and less than 0.4% of the weekly working time was spent running, climbing stairs, and cycling (~0.1 h) (Loef et al., 2018). Two studies assessed occupational physical activity using scores based on the subcategory household and caregiving index of the Kaiser physical activity survey (Alquaiz et al., 2015) or the Baecke physical activity questionnaire (Wolff et al., 2021). Both studies reported a mean value close to three, which equates to more than 20 h per week (Alquaiz et al., 2015) and is considered, on a scale of 1–5, moderately active (Wolff et al., 2021).

Overall, most studies that reported occupational physical activity, split the results into different intensity levels without providing information about the duration within each intensity level or the total duration. The objective data measured between 1.5 and 3 h of mostly light-intensity activity during work. However, results varied substantially depending on the assessment tool used and the study sample. Most occupational physical activity was classified as light intensity. This stands in contrast to the subjective data reporting of the metabolic equivalent that shows sufficient occupational physical activity.

3.5. Relation between leisure-time and occupational physical activity

Six studies analyzed the relationship between leisure-time and occupational physical activity (Umukoro et al., 2013; Chappel et al., 2020; Jirathananuwat and Pongpirul, 2017; Wilbur et al., 1998; Henwood et al., 2012; Tuckett and Henwood, 2015) using different statistical approaches. Henwood's team used a between-group comparison and found that higher occupational physical activity was negatively associated with leisure-time physical activity (Henwood et al., 2012). A similar observation was made by Chappel et al. who used both a linear latent and mixed model (Chappel et al., 2020). They found that high occupational physical activity was a determining factor for lower leisure-time physical activity, especially when leisure-time physical activity was conducted after work in the afternoon and evening and vice versa (Chappel et al., 2020). In the comparative study of lifestyles by Tuckett's team, a significantly lower level of occupational physical activity and a higher level of leisure-time physical activity was identified in the healthy lifestyle group (Tuckett and Henwood, 2015). Wilbur et al. (1998) and Jirathananuwat and Pongpirul (2017) compared mean leisure-time to occupational physical activity and found that leisure-time physical activity was significantly lower than occupational physical activity in both their mixed study population (Wilbur et al., 1998) and their healthcare worker sample (Jirathananuwat and Pongpirul, 2017).

Overall, leisure-time and occupational physical activity seem to be negatively related. However, this may also be mediated by other factors.

3.6. The association of leisure-time and occupational physical activity with cardiovascular health

Five of the studies evaluated one or more cardiovascular health parameters (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Alquaiz et al., 2015; Wilbur et al., 1999). The three studies by Allesoe et al., based on the Danish Nurse Cohort Study, evaluated the risk for ischemic heart disease by investigating the incidence of ischemic heart disease over a 15-year period (Allesøe et al., 2015; Allesoe et al., 2016, 2017). The first study reported a higher risk of ischemic heart disease in subjects with a high sedentary leisure-time and low occupational physical activity compared to moderate leisure-time physical activity and moderate occupational physical activity groups. However, the groups with vigorous leisure-time and high occupational physical activity had the highest risk of ischemic heart disease when compared to both moderate activity level groups (Allesøe et al., 2015). The second study by Allesoe and colleagues included blood pressure as an additional factor. Subjects with hypertension and high occupational physical activity showed the highest risk of ischemic heart disease in the adjusted model for lifestyle factors (including leisure time) (Allesoe et al., 2016). In the third study, Allosoe et al. reported that the subjects who were classified as vigorously active at their workplace had the highest risk of ischemic heart disease, even after adjusting for lifestyle (including leisure-time physical activity) (Allesoe et al., 2017). Alquaiz and colleagues, on the contrary, reported a negative correlation between occupational physical activity and the risk of cardiovascular disease (Alquaiz et al., 2015). Furthermore, the study by Wilbur et al. established a negative correlation between total cholesterol level, occupational physical activity energy expenditure, and leisure-time physical activity energy expenditure. They also identified a negative correlation between high-density lipoprotein cholesterol and occupational physical activity energy expenditure (Wilbur et al., 1999).

Overall, more than half of the studies suggested that high occupational physical activity may have unfavorable effects on cardiovascular health while leisure-time physical activity has favorable/compensatory effects.

3.7. Quality assessment, risk of bias, and body of evidence

The results of the qualitative evaluation of the individual studies are presented in Table 2. No study was rated as *good* quality (11–14 points), thirteen were rated as *fair* (5–10 points), and four were rated as *poor* quality (0–4 points) (Malinauskiene et al., 2019; Wilbur et al., 1998; Mc Carthy et al., 2018; Tuckett and Henwood, 2015). The most common violations were a lack of repetition in the measurement of the exposure (Question 10) and the legitimization of the sample size (Question 5). Moreover, many categories could not be applied to the studies because of their poor quality (Malinauskiene et al., 2019; Wilbur et al., 1998; Mc Carthy et al., 2018; Tuckett and Henwood, 2015). To improve the quality of literature, the following aspects should be addressed: dropout rate (Malinauskiene et al., 2019), the selection of study participants (because

Table 2
Study quality of The National Heart, Lung and Blood Institute quality assessment tool for observational cohort and cross-sectional studies (Health, 2015).

	(1) Research question	(2) Study population	(3) Participation rate at least 50%	(4) Groups recruited from the same population and uniform eligibility criteria	(5) Sample size justification	(6) Exposure assessed prior to outcome measurement	(7) Sufficient timeframe to see an effect	(8) Different levels of exposure of interest	(9) Expose measures and assessment	(10) Repeated exposure assessment	(11) Outcome measures	(12) Blinding of outcomes assessors	(13) Follow-up rate	(14) Statistical analysis	Rating
(Allesøe et al., 2015)	Y	Y	Y	Y	N	Y	N	Y	Y	N	Y	N	NA	Y	9
(Allesoe et al., 2016)	Y	Y	Y	Y	N	Y	N	Y	Y	N	Y	N	NA	Y	9
(Allesoe et al., 2017)	Y	Y	Y	Y	N	Y	N	Y	Y	N	Y	N	NA	Y	9
(Alquaiz et al., 2015)	Y	Y	Y	N	N	N	N	Y	N	N	Y	N	NA	Y	6
(Chappel et al., 2020)	Y	Y	Y	Y	N	NA	NA	Y	N	N	NA	NA	NA	NA	6
(Henwood et al., 2012)	Y	Y	NR	Y	N	NA	NA	Y	Y	N	NA	NA	NA	NA	5
(Jirathananuwat and Pongpirul, 2017)	Y	Y	Y	Y	Y	NA	NA	Y	Y	N	NA	NA	NA	NA	7
(Loef et al., 2018)	Y	Y	N	Y	N	NA	NA	Y	Y	N	NA	NA	NA	NA	5
(Malinauskiene et al., 2019)	Y	Y	N	N	N	NA	NA	Y	Y	N	NA	NA	NA	NA	4
(Mc Carthy et al., 2018)	Y	Y	Y	Y	N	NA	NA	N	N	N	NA	NA	NA	NA	4
(Rovo et al., 2020)	Y	Y	NR	Y	N	NA	NA	Y	Y	N	NA	NA	NA	NA	5
(Tuckett and Henwood, 2015)	Y	Y	NR	N	N	NA	NA	Y	Y	N	NA	NA	NA	NA	4
(Umukoro et al., 2013)	Y	Y	NR	Y	N	NA	NA	Y	Y	N	NA	NA	NA	NA	5
(Wilbur et al., 1998)	Y	Y	NR	N	N	NA	NA	Y	Y	N	NA	NA	NA	NA	4
(Wilbur et al., 1999)	Y	Y	NR	N	N	N	N	Y	Y	N	Y	N	NA	Y	6
(Wolff et al., 2021)	Y	Y	NR	N	Y	NA	NA	Y	Y	N	NA	NA	NA	NA	5
(Yu, 2020)	Y	Y	N	Y	Y	NA	NA	Y	Y	N	NA	NA	NA	NA	6

Notes. Y: Yes, N: No, CD: Cannot be determined, NA: Not applicable, NR: Not reported, Good quality = 11–14 points, Fair quality = 5–10 points, poor quality = 0–4 points.

mixed cohorts and locations were used) (Malinauskiene et al., 2019), the reporting of physical activity as one dimension (more dimensions were provided in communication with the authors) (Mc Carthy et al., 2018), and a clearer definition of the exposure (Wilbur et al., 1998).

The results of the risk of bias and the rating of the body of evidence are presented in Table 3. Regarding the risk of bias, six studies were classified as moderate (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Chappel et al., 2020; Jirathananuwat and Pongpirul, 2017; Allesoe et al., 2015) and eleven were classified as high risk (Alquaiz et al., 2015; Malinauskiene et al., 2019; Wilbur et al., 1999; Wolff et al., 2021; Umukoro et al., 2013; Yu, 2020; Loef et al., 2018; Wilbur et al., 1998; Henwood et al., 2012; Tuckett and Henwood, 2015; Rovo et al., 2020; Waldersen et al., 2017), with the “Risk of bias due to confounding” and “Risk of bias in section the reported results” being the most common issues evident in the literature.

The current confidence of evidence following the Grading of Recommendations, Assessment, Development and Evaluation approach (GRADE) was quantified as low. The primary reasons for this result were that 1) the study designs were limited to cross-sectional and observational approaches, 2) the studies did not directly control for confounding variables, and 3) there was a lack of dose–response relationship determined in the literature.

4. Discussion

This review provides an overview of studies that assessed leisure-time and occupational physical activity as well as sedentary behavior in healthcare workers. Overall, occupational physical activity was primarily conducted at light to moderate-intensity and leisure-time physical activity at light- to high intensity, however, reporting and measurement tools, as well as results, were very heterogeneous. No clear information on duration and intensity could be provided. The duration of leisure-time physical activity differed and was rather short, while the duration of occupational physical activity was relatively long – up to 3 h with a high variation. Furthermore, a negative association between physical activity in the two domains was identified. With regard to cardiovascular health, a trend in the direction of the physical activity paradox was determined. However, systematic research and objective data relating cardiovascular health to leisure-time and occupational physical activity were not available. Due to the low body of evidence and the high likelihood of risk of bias, the results have to be interpreted carefully in relation to the question of causality.

4.1. Leisure-time physical activity

The heterogeneous picture of leisure-time physical activity ranged from insufficient physical activity to excessive physical activity which exceeded the recommendations. The intensity of leisure-time physical activity varied greatly across studies although it was mainly in the range of light to moderate. Activities tended to be short in duration. These results are similar to the results of studies that focused on more male-dominated occupational groups in the blue-collar sector (Myrtek et al., 1999). Such studies also reported very heterogeneous results and the activity levels ranged from mostly sedentary to moderate-to-vigorous active (Hallman et al., 2015). Consequently, the leisure-time physical activity of employees cannot be clearly derived from their occupation. It should be noted that not all studies included here recorded and/or reported how many days their subjects worked, nor were they very clear about the amount of leisure time. Consequently, some studies, for example, determined leisure-time physical activity per week even though some participants had more days off than others or, alternatively, worked all week long. To avoid this in future studies, workers should be observed for a longer time or tasked with recording their work plan. The distribution of work across days and the distribution of days off should also be considered in order to generate a comprehensive

Table 3
Risk of Bias in Non-randomized Studies of Exposure (ROBINS-E) (Bero et al., 2018) and GRADE approach to grade the quality of evidence (Granholm et al., 2019).

	ROBINS-E							
	(1) Risk of bias due to confounding	(2) Risk of bias arising from measurement of the exposure	(3) Risk of bias in selection of participants into the study	(4) Risk of bias due to post-exposure interventions	(5) Risk of bias due to missing data	(6) Risk of bias in measurement of the outcome	(7) Risk of bias in section of reporting	Overall risk of bias
(Allesøe et al., 2015)	−	−	+	NA	+	−	−	Moderate
(Allesoe et al., 2016)	−	−	+	NA	+	−	−	Moderate
(Allesoe et al., 2017)	−	−	+	NA	+	−	−	Moderate
(Alquaiz et al., 2015)	−	−	−	NA	+	−	−	High
(Chappel et al., 2020)	−	−	+	NA	+	NA	−	Moderate
(Henwood et al., 2012)	−	−	+	NA	?	NA	−	High
(Jirathananuwat and Pongpirul, 2017)	−	−	+	NA	+	NA	−	Moderate
(Loef et al., 2018)	−	−	+	NA	−	NA	−	High
(Malinauskiene et al., 2019)	−	−	−	NA	−	NA	−	High
(Mc Carthy et al., 2018)	−	−	+	NA	+	NA	−	Moderate
(Rovo et al., 2020)	−	−	+	NA	?	NA	−	High
(Tuckett and Henwood, 2015)	−	−	−	NA	?	NA	−	High
(Umukoro et al., 2013)	−	−	+	NA	?	NA	−	High
(Wilbur et al., 1998)	−	−	−	NA	?	NA	−	High
(Wilbur et al., 1999)	−	−	−	NA	?	NA	−	High
(Wolff et al., 2021)	−	−	−	NA	?	NA	−	High
(Yu, 2020)	−	−	+	NA	−	NA	−	High
Overall body of evidence by the GRADE approach	(1) Inconsistency	(2) Indirectness	(3) Imprecision	(4) Publication Bias	(5) Large effect	(6) Dose–response	(7) All possible confounding would reduce a demonstrated effect/would suggest a spurious effect when results show no effect	Final quality of the body of evidence
	−1	−1	0	−1	0	0	0	Low

Notes. Low risk of bias (+), high risk of bias (−), unclear risk of Bias (?), NA = Not applicable, 0 = criteria not up or downrated, −1 = criteria downrated, −2 criteria strongly downrated, +1 = criteria uprated, +2 = criteria strongly uprated.

picture. This is particularly important as work-related fatigue, obesity, and stress at work have been shown to reveal negative effects on leisure-time physical activity (Bláfoss et al., 2019). Further moderating factors on leisure-time physical activity, such as socioeconomic status, or other lifestyle components, such as nutrition (Coenen et al., 2020; Rottensteiner et al., 2010), should be assessed in addition to leisure-time physical activity in the future.

Furthermore, it should be considered that the studies included in this review assessed leisure-time physical activity using both, subjective and objective measurement tools. The two studies in this review that used both types found that objective tools were more accurate and confirmed what is already known (Umukoro et al., 2013; Yu, 2020). This points to the need for objective measurement tools for physical activity (Coenen et al., 2020).

Overall, more information is needed about leisure-time physical activity beyond intensity and duration to test for occupation-related effects. Moreover, measurement tools should be standardized across studies to facilitate comparisons between studies.

4.2. Occupational physical activity

Occupational physical activity was also assessed and reported very heterogeneously, which again makes it difficult to compare the data of the different studies. Overall, the data suggests that occupational physical activity had a longer duration than physical activity during leisure time, ranging from 1.5 h to 3 h of physical activity while working. With regard to intensity, physical activity during work tends to be in the light-intensity range most of the time. This intensity level is in line with Chappel's et al. study on nurses. They also reported a high proportion of light-intensity occupational physical activity (Chappel et al., 2017). Similarly, studies that analyzed the typical energy expenditure of different work activities revealed that most of the activities in the healthcare sector are in the area of light- to moderate-intensity (Brückner et al., 2021). The results for the health sector differ from studies that focus on more male-dominated occupations such as blue-collar workers. Clay et al. revealed that blue-collar workers spent more than five hours on their feet and more than one hour in the moderate to vigorous-intensity range per day (Clays et al., 2020). As for blue-collar workers, similarly high values were returned for construction workers (Arias et al., 2015). Thus, overall, it seems that occupational physical activity levels in the healthcare sector are significantly lower than the physical workload of the previously studied male-dominated professions and the cleaning sector.

Furthermore, occupational physical activity results differed depending on whether subjective or objective tools were used. Again, there is a clear need for an objective assessment of occupational physical activity to facilitate comparisons between studies and the role in the paradox (Coenen et al., 2020; Chappel et al., 2017).

4.3. Relationship between leisure-time and occupational physical activity

In this review, only six of the 17 studies directly compared leisure-time and occupational physical activity. Six studies determined that leisure-time and occupational physical activity are dissimilar and/or potentially influence each other. Leisure-time and occupational physical activity seem to be negatively related; that is, a higher activity level at work is typically associated with lower leisure-time physical activity, and vice versa. As of yet, no comparison between the two domains of physical activity for other professions has been identified. Rasmussen et al. related leisure-time and occupational physical activity to each other in a mixed occupation group and revealed that physical activity behavior at work was negatively associated with leisure-time physical activity on a daily basis (Rasmussen et al., 2021). One might expect that, in the healthcare sector, occupational physical activity influences leisure-time physical activity on a daily basis, particularly for those healthcare workers doing shiftwork. This time factor might also have a mediating effect on both domains (Peplonska et al., 2014), meaning that occupational physical activity may be lower in certain shifts or might differ between shifts (Chappel et al., 2017). Similar results were shown for blue-collar workers in a shift system. Nightshift blue-collar workers showed a higher sedentary time during work compared to non-shift workers. In relation to leisure-time physical activity, blue-collar nightshift workers showed comparable results to dayshift workers (Hulsegge et al., 2017). Rasmussen et al. found a positive relation in blue-collar workers between occupational walking and leisure-time standing for women. For males, the relationship between specific occupational physical activity (e.g., stepping) and leisure-time physical activity elements was lower (Rasmussen et al., 2019). This illustrates that sex and the type of activity could be relevant intermediating factors.

Moreover, the overall energy expenditure during work seems to influence leisure-time physical activity. Kaleta et al. revealed that males who expended over 4000 kcal/week in occupational physical activity were more likely to lead an inactive lifestyle during leisure time. Similar results were identified for women with a limit of 3500 kcal/week in occupational physical activity (Kaleta et al., 2007). In contrast, Kruger et al. showed that people who were already active at work were also more active during their leisure time (Kruger et al., 2006).

Overall, the results highlight a mostly negative relationship between both domain-specific patterns. However, it is possible that the findings may be influenced by other factors outside of the measured domains. A more accurate specification of the two physical activity dimensions in different occupations, while controlling for confounding factors, would help generate clearer results.

4.4. Leisure-time and occupational physical activity and their association with cardiovascular health

Only five studies assessed the effects of leisure-time and occupational physical activity on cardiovascular health parameters (Allesøe et al., 2015; Allesoe et al., 2016, 2017; Alquaiz et al., 2015; Wilbur et al., 1999). Four out of the five studies identified a trend that suggests leisure-time physical activity could have beneficial effects on cardiovascular outcomes and occupational physical activity might have unfavorable effects on healthcare workers. This trend also suggests the existence of the physical activity paradox in the female-dominated healthcare sector. Therewith, the results are in line with studies and reviews of other professions. Reviews have revealed that leisure-time physical activity has a preventive effect against the risk of cardiovascular diseases in mixed occupations (Li et al., 2013). In addition, higher leisure-time physical activity was shown to be beneficial for the health of all types of occupational groups, particularly for workers in more inactive occupations (Prince et al., 2019). Prince et al. included various health outcomes in their review and determined the highest evidence of the physical activity paradox for the outcomes' cardiovascular mortality and metabolic syndrome (Prince et al., 2019). The accelerometer-based evaluation by Ketels' team identified the favorable effects of moderate- to vigorous-intensity physical activity in leisure time. However, they could not be established for occupational physical activity in relation to cardiovascular fitness (Ketels et al., 2020). Similar conclusions regarding the physical activity paradox were drawn by Ryu et al. who analyzed the impact of leisure-time and occupational physical activity on hypertension in women (Ryu et al., 2020). Further, studies stated that occupational lifting, as an often feature in blue-collar work, has an adverse effect on cardiovascular function and cardiovascular structures (Korshøj et al., 2021). Thus, although only five studies assessed the effects on cardiovascular health, the findings of this and other reviews speak in favor of the paradox. However, which component (duration, intensity, type of movement, or movement prosperities) produces the detrimental impact of occupational physical activity on cardiovascular health remains unclear.

One could speculate that factors other than occupational physical activity, such as stress, might contribute to the physical activity paradox as they are known to be detrimental to cardiovascular health. Thus, Ferrario et al. revealed that people with job strain, in particular, benefited from leisure-time activities such as cardiovascular activity (Ferrario et al., 2019). People with high levels of job strain have been shown to have an increased risk of cardiovascular diseases (measured using arterial wave reflection) (Otsuka et al., 2009). However, the term job strain includes not only physical but also psychological stress, which may also mediate cardiovascular health (Kristensen, 1996). Schilling et al. rated the cardiovascular risk in police officers using fitness level and occupational stress. They demonstrated that the highest risk occurred in the group with high occupational stress and low fitness levels (Schilling et al., 2019). Similarly, de Vries and Bakker reported that for their mixed occupational group, people with highly demanding jobs benefited from high leisure-time physical activity less than those with less demanding jobs and low burnout rates (de Vries and Bakker, 2021). Furthermore, nurses who were classified as more resilient revealed higher occupational physical activity levels than less resilient workers (Yu, 2020). These psychological variables suggest that any hypotheses about the paradox should also integrate psychological load.

To sum up, it seems necessary to objectively quantify not only physical, but also psychological load to comprehensively disentangle the physical activity paradox. The five studies related to the paradox did not assess psychological load. Furthermore, in addition to psychological stress, it should be acknowledged that other lifestyle factors, such as nutrition, are also known to influence cardiovascular health. Consequently, when considering the physical activity paradox, further lifestyle factors should also be controlled for. Finally, the results found in this review are influenced by subjective measurement methods that should be objectified for leisure-time and occupational physical activity, as well as cardiovascular health in the future. Whether the results related to the physical activity paradox are being determined by the physical activity level of the professions, psychological factors, or the overall lifestyle requires further analysis.

4.5. Strengths

This review focused on the characteristics of leisure-time and occupational physical activity and their relationship in healthcare workers as pink-collar workers. Pink-collar workers are underrepresented in studies reporting on the physical activity domains, in particular, in relation to the physical activity paradox. It should be noted that other reviews neither addressed leisure-time and occupational physical activity, nor have they researched specific occupations. This is a clear strength of the present review. Further, we reported the relationship between cardiovascular outcomes and leisure-time and occupational physical activity using the physical activity paradox characteristics. This quantification and standardization approach enables us to describe the context in more detail.

This review is the first to use exercise science characteristics (such as intensity and duration) and recommends reporting these when analyzing leisure-time and occupational physical activity and their effects. The definition of a "high occupational physical activity" (in other reviews) might depend on the sector and related professional activities and require standard reporting. Thus, a strength of this review is the quantification of physical activity by intensity using standard reporting and by considering components of the paradox (e.g., static posture during movement, recovery time). This is the first step towards standardization in reporting.

4.6. Limitations

The specification in the selection of the target group reduces the generalizability of this review, but also reveals the heterogeneity in the sector. The heterogeneity of the physical activity assessment tools and the age spans in the different studies have limited the expressive power of the results. Another limitation is the low body of evidence and that only observational studies could be integrated into this review. Furthermore, the weak quality of the available studies is a limitation that reduces the significance of this overview. In addition, when using exercise science quantifications of physical activity (such as intensity and duration), the reporting in the studies makes it difficult to generalize the physical activity levels to values per week and to compare them with the WHO recommendations for physical activity. First, it was difficult to properly assess the level of physical activity in the two domains. Second, relating leisure-time and occupational physical activity (assessed as daily values) to health outcomes (in this review, cardiovascular health) may be problematic as the physical activity values are not necessarily representative of a person's lifestyle. Third, the combination of subjective and objective data collection methods for the two domains of physical activity could explain the heterogeneity of the results and should be critically reconsidered in the future. A further limitation of this review is that two studies were integrated, that reported on a mixed population and the results of the healthcare workers were not reported separately. This might have confounded the overview. However, only female-dominated sectors were included and our findings are in line with the theory behind this review that suggests female-dominated professions are more closely equated within the framework of the paradox.

It is also notable that three studies in this study sample analyzed the effect of leisure-time and occupational physical activity on cardiovascular health based on the same study population, this may have also biased the overall findings. However, as there is currently a lack of research investigating the influence of physical activity level on the cardiovascular status in healthcare staff or specific occupational groups this review benefitted more from including the additional findings than it risked.

4.7. Future research directions

This review offers some preliminary ideas about how to analyze the effects of domain-specific physical activity using an exercise science approach. The primarily observational studies included in this review do have scientific merit, but should be supplemented in a more controlled setting. The following aspects should be considered in future studies.

As summarized by Coenen et al. objective methods for determining physical activity should be applied in future studies to assist with an accurate evaluation of the physical activity paradox (including body position, dynamics of movement, and recovery time) (Coenen et al., 2020). In particular, devices that can also distinguish between various activities, with different body positions and durations at a variety of activity levels as well as recovery time, should be used to quantify leisure-time and occupational physical activity in more detail (Chappel et al., 2017). Moreover, cardiovascular tools should be used in shorter intervals to clarify the effects of change in leisure-time and occupational physical activity. It would also be beneficial to supplement the traditional cardiovascular health measurements (such as blood pressure) with cardiovascular fitness measurements such as a step test protocol (Castro-Piñero et al., 2021; Bennett et al., 2016), a test of push-up capacity (Yang et al., 2019), or an incremental shuttle walk test carried out in the work domain (Marsico et al., 2021).

In addition, an independent evaluation of leisure-time and occupational physical activity is necessary to decode their associations and their separate health effects. Furthermore, it should be noted, that physical activity is a lifestyle component that can be influenced by other factors, such as dietary habits or stress. Controlling for such factors would be advantageous for understanding the relationship between leisure-time and occupational physical activity. Similarly, cultural effects or occupational structures in the respective countries may modify physical activity behavior in the two domains. Also, the reporting of leisure-time and occupational physical activity should correspond to a uniform line. Standardized reporting according to intensity and duration, e.g., based on the WHO recommendations, would be beneficial to make different studies comparable and to analyze the effects of the components of physical activity on health.

Even within the group of healthcare workers, there is high variability in leisure-time and occupational physical activity, due to shift patterns, working hours, family situations, and general health behavior, among others. Moreover, this pink-collar worker group shows heterogeneity in occupational tasks and shift systems. A division into groups with different professional requirements could avoid this heterogeneity. Based on the heterogenous occupational requirements within the health care sector, recommending physical activity, as "one size fits all", should be reconsidered and recommendations should integrate occupational physical activity profiles.

Considering all these factors might enable more tailored physical activity interventions and to derive recommendations that account for the specific characteristics of the different professional groups. From a practical point of view, these physical activity interventions could reduce the possible effects on cardiovascular health in the risk group.

5. Conclusions

In general, leisure-time physical activity of healthcare workers was classified as heterogeneous from sedentary to active leisure-time in moderate- to vigorous-intensity with shorter durations. Occupational physical activity could be classified as mostly light intensity with a long duration. Furthermore, we found a mostly negative relationship between leisure-time and occupational physical activity. However, these results are preliminary because of the low quality and number of studies. A clear statement based on the activity patterns in the two domains and cardiovascular health cannot yet be made due to the study types, methods, and low study density available. The mostly preliminary results of the studies included in this review support the physical activity paradox in relation to cardiovascular health in female-dominated occupational groups, but the findings need to be critically reconsidered. Controlled prospective studies are needed that assess leisure-time and occupational physical activity objectively and monitor cardiovascular health regularly in various occupations in order to verify or elicit the paradox. Particular consideration should be given to the differentiation of characteristics in the reporting of leisure-time and occupational physical activity including intensity, duration, and type of movement and their properties to disentangle their health effects.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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