Ger J Exerc Sport Res
https://doi.org/10.1007/s12662-023-00922-6
Received: 8 June 2023
Accepted: 8 November 2023

© The Author(s) 2023

Luis Heuel · Ann-Kathrin Otto · Bettina Wollesen
Institute of Human Movement Science, University of Hamburg, Hamburg, Germany

Physical exercise and ergonomic workplace interventions for nursing personnel—effects on physical and mental health: a systematic review

Introduction

The COVID-19 pandemic highlighted the relevance of the nursing profession in our society. During this time, the physical and psychological work challenges of nurses in different settings (hospital, outpatient, and geriatric) increased drastically, including reduced contact time between nurses and geriatric patients (Kramer et al., 2021; Rutten, Backhaus, Hamers, & Verbeek, 2022). Furthermore, the risk of infection was significantly higher in nurses than in other populations (Alshamrani, El-Saed, Al Zunitan, Almulhem, & Almohrij, 2021). Increasing work-related demands are linked to discontent with working conditions as well as increased risks for musculoskeletal disorders, high stress levels, low job satisfaction, and the desire to leave the profession (van der Heijden, Brown Mahoney, & Xu, 2019; Wollesen et al., 2019).

Nurse-specific stressors are manifold, including high workload, emotion suppression, time pressure, work disruptions, multiple responsibilities, shift work, heavy lifting and carrying, and unfavorable postures for prolonged periods (Rohwer, Mojtahedzadeh, Harth, & Mache, 2021). These stressors are typically linked to physical and psychological health problems (McVicar, 2003; Ruotsalainen, Verbeek, Mariné, & Serra, 2016). For instance, the risk of back pain is drastically higher in nurses than in other healthcare professions such as physiotherapists (Çınar-Medeni, Elbasan, & Duzgun, 2017; Dawson et al., 2007; Vinstrup, Jakobsen, & Andersen, 2020). Moreover, musculoskeletal diseases, sleep and concentration disorders, and dysfunctional behaviors (lack of exercise, drug and alcohol consumption) are frequently observed in nurses (Rohwer et al., 2021). To minimize perceived demands and job turnover, workplace health promotion programs (WHPPs) including physical exercise are necessary and should be implemented in nursing settings as an integral part of nursing facilities (Mojtahedzadeh et al., 2021).

To improve the work ability of nurses, resources such as health knowledge, stress management skills, health-promoting lifting and carrying behavior, as well as physical fitness should be increased (Converso et al., 2017). One method for resource enhancement is the implementation of WHPPs with a focus on exercising and/or ergonomics that initiate work behavior without inducing musculoskeletal discomfort and that reduce stress perceptions (Kreis, 2003; Wollesen, Menzel, Lex, & Mattes, 2016).

The goals of WHPPs are to reduce back pain via ergonomics-based interventions (Carta et al., 2010; Karahan & Bayraktar, 2013; Kindblom-Rising, Wahlström, Nilsson-Wikmar, & Buer, 2011; Ratzon, Bar-Niv, & Froom, 2016), "back school" programs (Jaromi et al., 2018), strength training (Cooper, Tate, & Yassi, 1998), or multicomponent interventions (Otto & Wollesen, 2022). The underlying mechanisms of these interventions are to reduce physical stress at the workplace (e.g., transfer situations) by improving movement quality (Carta et al., 2010; Ratzon et al., 2016), lifting techniques, and strength (Jaromi et al., 2018). A few studies demonstrated a reduction in back pain (Carta et al., 2010; Kindblom-Rising et al., 2011), while other studies found no effect (Karahan & Bayraktar, 2013; Ratzon et al., 2016). In a more recent study, Otto and Wollesen (2022) investigated the effects of a multicomponent program in a geriatric nursing setting, combining ergonomics training including exercises for body perception and learning of different lifting techniques and strength training.

In addition, WHPPs aim to improve work ability psychologically via reduced stress (Bischoff, Otto, Hold, & Wollesen, 2019; Fang & Li, 2015; Mohebbi, Dehkordi, Sharif, & Banitalebi, 2019) or enhanced quality of life (QoL; Becker, Angerer, & Muller, 2017). For example, yoga reduces self-reported sleep disturbances and work stress experienced by hospital nurses (Fang & Li, 2015). Similarly, a controlled clinical study investigated the effect of an aerobic exercise program and found reduced stress levels (Mohebbi

Trial registration number: CRD42021239665
Date of registration: 05/04/2021

Data transparency
The data that support the findings of this study as well as the review protocol are available on request from the corresponding author LH.

Published online: 13 December 2023

et al., 2019). Generally, exercising may decrease perceived stress by shifting the psychological stress threshold, by reinforcing personal (e.g., self-efficacy) and social resources (e.g., social support), and by decreasing psychological and physical stress reactivity (stress buffer effect; Gerber & Pühse, 2009; Bischoff et al., 2019).

Beside exercise and training interventions, the World Health Organization (WHO) as well as national guidelines promote the combination of physical activity during daily live (e.g., to go for a walk or to work in the garden) with physical training to overcome sedentary behavior (Wackerhage et al., 2021; Rütten & Pfeifer, 2017). Therefore, WHPPs also include interventions to increase physical activities (Malik, Blake, & Suggs, 2014).

However, oftentimes WHPPs lack the application of training principles to induce discrete training effects. For instance, FITT principles (frequency, intensity, time, type of exercise; Swain, Brawner, & American College of Sports Medicine, 2014) should be integrated to ensure high-quality, effective interventions. Moreover, it has been shown that the training specificity, individualization, and overload are evidence-based training aspects that have to be integrated into the training methodology (Hecksteden, Faude, Meyer, & Donath, 2018). Within the actual practice of WHPPs, it remains unclear whether a more exercise scientific approach might increase the effectiveness of exercise interventions regarding the work ability of nurses. In particular, the intensity and time components of the FITT principle tend to be missing in exercise-based study reports (Billinger, Boyne, Coughenour, Dunning, & Mattlage, 2015). Moreover, aspects of individualization, progression, and control of the training load might be beneficial for gaining positive effects (Holzgreve, Schulte, Germann, & Wanke, 2022).

In regard to individualization, health promotion should be conducted in a setting-specific vs. one-size-fits-all manner (Schwarzer, 2008; Wollesen et al., 2016). As work demands differ between settings, the interventions should be adapted to the requirements of the specific setting (elderly care, outpatient care, or hospital). As demonstrated in the study by Otto and colleagues (2019), the highest strain on the musculoskeletal system was reported for nurses in elderly care compared to hospital care and outpatient care. Also, stressors in an outpatient setting include long driving times and high emotional involvement with patients, while this is less problematic in hospital settings (Vander Elst et al., 2016).

Accordingly, the focus of this systematic review is to address the literature gaps concerning the identification of effective exercise-related WHPP intervention types that enhance work ability in the nursing setting. Moreover, a specific aim is to give an overview of the implementation of FITT and training control principles (individualization aspects, progression, and variety) within the identified interventions in different nursing settings in order to gain more insights of the effect of training mechanisms on health-related outcomes. This will help practitioners and occupational health promotion experts to identify and conduct effective, setting-specific measures. Accordingly, the research questions of the current study include the following:

- Which exercising and ergonomic intervention types in different nursing settings (hospital, geriatric, outpatient) can be identified?
- What are the effects regarding physical and psychological health on nurses?
- Which specific training principles and tailoring aspects can be identified to enhance the effectiveness of the interventions?

Methods

This systematic review was registered at the international prospective register of systematic reviews (PROSPERO; registration ID: CRD42021239665). Further, the review adhered to the guidelines of the Preferred Reporting Items for Systematic Reviews (PRISMA; Page et al., 2021).

Eligibility criteria

Following the PICOS scheme, interventions that tested nurses and nurse aides in different settings (hospital, outpatient, and geriatric) were eligible (P). Studies that included other health personnel (e.g., physicians, janitors, technical or office staff) were excluded due to differing work demands. Interventions qualified for synthesis if at least one component of the intervention was based on exercise or ergonomic work behavior (I). As this review mainly aimed to analyze the composition of the interventions, all potential control conditions were analyzed and reported in the results tables (C). Furthermore, outcomes that may impact nurses' work ability were synthesized, including individual, social–cognitive, and organizational characteristics such as stress perception, pain, (QoL), physical activity, self-efficacy, ergonomic abilities, work demands, work satisfaction, sickness absence (O). The review included peer-reviewed intervention studies published in English or German since 1990. These included randomized controlled trials (RCTs), controlled quasi-experimental interventions, single-group pre–post studies, and pilot studies (S).

Search strategy and study retrieval

In November 2022 the final database search was conducted in the databases Medline, PsycInfo, and CINAHL with search words comprising MeSH terms "hospital nurses," "outpatient nurses," "elderly care nurses," "physical activity," "ergonomics," "stress," "pain," "absenteeism," and respective synonyms thereof (cf. Appendix B for complete search strategy). AKO imported the retrieved studies to the software Citavi 6. After deletion of duplicates, authors LH and AKO independently screened titles and abstracts of remaining studies with regard to the inclusion criteria. In a second screening cycle, LH and AKO reviewed the remaining full texts for eligibility. Disagreements for inclusion were resolved by discussion and, if necessary, via consultation with BW (supervising researcher).

Data extraction and risk-of-bias assessment

Extraction of the study data was performed by LH and AKO. Relevant criteria pertained to (1) participant description, (2) study design, (3) study aims, (4) intervention type, (5) intervention duration, (6) studied outcomes, (7) training principles, and (8) results.

Authors LH and AKO independently assessed the methodological quality of the included studies. The assessment was based on the "Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields" (Kmet, Cook, & Lee, 2004). Assessed studies are rated with respect to 14 criteria and each criterion is awarded an individual score of 0 (*not fulfilled*), 1 (*partially fulfilled*), or 2 (*fulfilled*) for a potential total score of 28. Accordingly, the assessed studies receive a percentage-based quality score. Quality scoring was adapted from recent studies (Curry, Patterson, Greenley, Pearson, & Forbes, 2021) such that a score of $<70\%$ was rated as "poor," 70–84% was considered "moderate," and $\geq 85\%$ was "high" quality. Through discussion, LH and AKO resolved disagreements in quality scoring for perfect agreement. For one study to avoid bias, the quality assessment was performed by consulting a colleague in the research team (acknowledged in the Disclosures and declarations section).

Data synthesis

The data synthesis includes a description of general characteristics (quality assessment, participants, study design, intervention type, intervention duration, and outcome parameters), as well as an outcome-specific synthesis. Thus, we analyzed separately interventions with physical outcomes, psychological outcomes, and self-managed interventions aiming at increasing physical activity. Assignment of intervention type was made through analysis of the study report and, if necessary, via discussion.

A meta-analytic approach was not feasible due to the high heterogeneity in the measured outcomes and intervention types.

Abstract

Ger J Exerc Sport Res https://doi.org/10.1007/s12662-023-00922-6
© The Author(s) 2023

L. Heuel · A.-K. Otto · B. Wollesen

Physical exercise and ergonomic workplace interventions for nursing personnel—effects on physical and mental health: a systematic review

Abstract

Background. Improving the work ability of nurses is highly important for ensuring a functioning healthcare system, which can be achieved via exercising and enhancing ergonomic work behaviors of the nurses. The objective of this systematic review was to synthesize work ability-enhancing exercise and ergonomic workplace health promotion interventions in different nursing settings and their effects on work ability.

Methods. Intervention studies incorporating at least one component of physical exercise or ergonomic work behavior for nurses were eligible for inclusion. Three electronic databases (Medline, PsycInfo, CINAHL) were searched for studies published until October 2022. The methodological quality of interventions was assessed. Due to intervention and outcome heterogeneity, narrative synthesis was conducted.

Results. The search identified a total of 37 studies. Sample size ranged from 14 to 316 ($N = 3487$). Overall quality was moderate ($M = 0.76$). Programs comprised aerobic exercising, "back school," ergonomics, increasing physical activity, multicomponent programs, physiotherapy, and yoga. Positive effects on work ability (e.g., reduced back pain or stress levels) were reported in 34 studies. However, if follow-up analyses were included, the effects typically diminished. Common training principles and training control mechanisms were applied in studies.

Discussion. The review indicates the efficacy of exercise-based health promotion for increasing nurses' work ability. However, results are limited by the lack of long-term improvements and scarcity of application of training principles. Therefore, setting-specific interventions, respecting work demands and training principles, are recommended.

Keywords
Workplace health promotion · Work ability · Outpatient care · Geriatric care · Hospital nursing staff

Results

A total number of 37 studies were eligible for this review (cf. **Fig. 1** for search flow).

Reasons for exclusion included wrong study design ($n = 29$), no separate analysis of exercising components ($n = 4$), and inclusion of non-nursing subjects ($n = 21$).

Assessment of methodological quality

The overall quality of included studies was moderate ($M = 0.76$, $\min = 0.43$, $\max = 0.92$). The assessment identified 11 studies with low quality, 19 studies with moderate quality, and seven studies with high quality (cf. **Table 1**).

Description of included studies

Sample sizes of studies ranged from 14 (Martins & Marziale, 2012) to 316 (Hartvigsen et al., 2005) nurses (overall $N = 3487$). The general intervention types were aerobic exercising ($n = 1$), back school ($n = 3$), ergonomics ($n = 6$), increasing physical activity ($n = 3$), multicomponent ergonomics ($n = 6$), multicomponent exercising ($n = 12$), multicomponent ergonomics and exercising ($n = 1$), physiotherapy ($n = 2$), and yoga ($n = 3$).

Concerning settings, 29 studies were based in hospitals, one study intervened with outpatient nurses, three studies were conducted with geriatric-care nurses, and four studies included nurses from different settings. Most studies involved female nurses (79–100%) or no sex distribution was found in the study report. Further, the mean age of the treated nurses was 38.82 years ($\min = 25.3$, $\max = 51.28$). Three studies (Karahan & Bayraktar, 2013; Martins & Marziale, 2012; C.-J. Zou et al., 2021) did not report mean sample age (cf. **Table 2**).

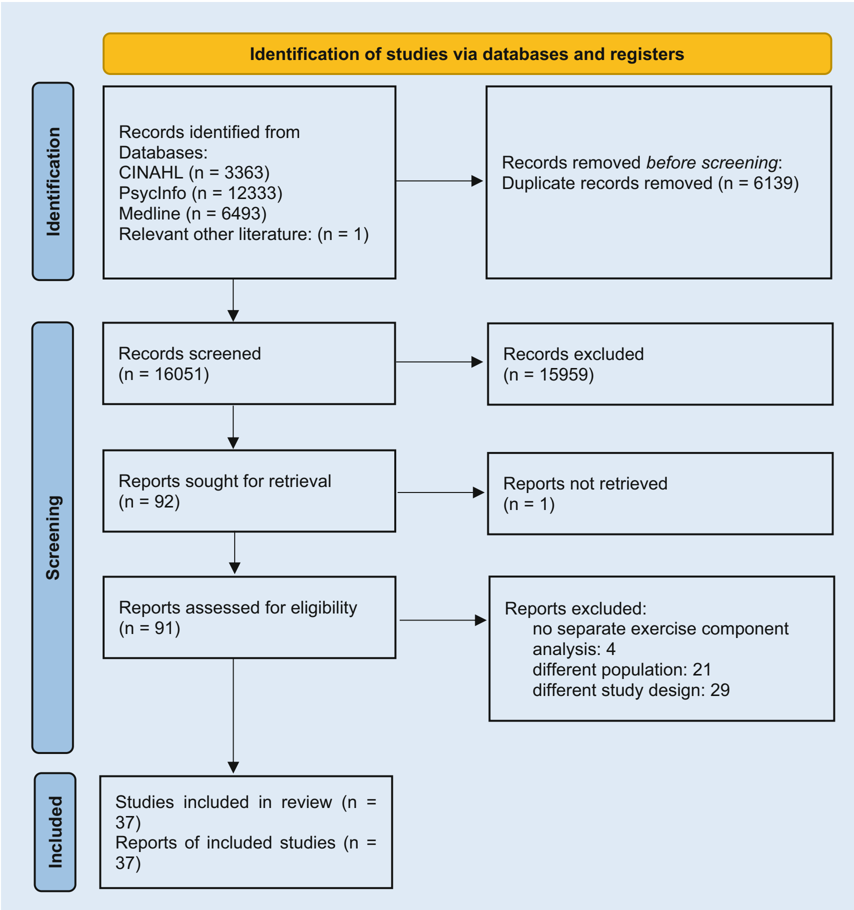

Fig. 1 ▲ Prisma diagram

Synthesis of evidence for different intervention outcomes

Table 3 shows synthesized results of the included studies according to primary intervention outcomes. Within outcome categories, intervention types are differentiated. Various studies tested more than one primary outcome. Moreover, the frequency and duration of interventions are presented in **Table 3**. Additionally, **Table 4** shows significant effects. In the case of no significant effects, "no" is reported in the table.

Intervention effects of studies with primarily physical outcomes

A total number of 28 studies aimed to improve physical outcomes (aerobic exercising $n=1$, back school $n=3$, ergonomics $n=6$, increasing physical activity $n=3$, multicomponent ergonomics $n=5$, multicomponent exercising $n=7$, multicomponent exercising and ergonomics $n=1$, physiotherapy $n=2$; cf. **Table 3**).

Aerobic exercising. In a quasi-experimental study, Yuan et al. (2009) used treadmill exercise training for hospital nurses. The intervention group reduced their BMI and increased their strength, flexibility, and cardiopulmonary functioning.

Back school. One combined intervention (Alexandre et al., 2001) consisting of education about work-related back pain accompanied by strength and flexibility exercises for hospital nurses that was compared to a single 45-minute (min) exercise class led to reduced cervical back pain.

The studies by Jaromi et al. (2012, 2018) used the same back school training curriculum (Spine Care for Nurses ergonomic training, muscle strengthening and stretching) compared to a passive control group for hospital nurses. In both studies, participants were strongly encouraged to carry out the learned exercises at home for five times per week. The interventions reduced back pain and improved ergonomic lifting behavior.

Ergonomics. Best (1997) intervened with a specific ergonomic method for 32 hours (h) (manutention). The intervention improved the lifting technique of the participating geriatric nurses.

Carta et al. (2010) tested a single-group multimodal ergonomic, combining a 2-h educative lesson with 3 h of practical training. At the 6-month follow-up, back pain and patient handling knowledge as well as patient handling techniques improved significantly.

Feldstein et al. (1993) examined multicomponent ergonomic intervention (education: body mechanics, transfer techniques, identification of environmental hazards, and the importance of daily stretching) combined with practical training for hospital nurses. The intervention group improved in various patient transfer variables and reduced back pain while the inactive control group did not.

One intervention with outpatient nurses (Hartvigsen et al., 2005) included education and advice from a physiotherapist regarding ergonomic work behavior (lifting techniques, body mechanics). Further, nurses participated in four group-counselling sessions to deepen the learned transfer techniques and body mechanics. They found no effects on lower back pain (LBP).

Karahan and Bayraktar (2013) conducted a single-group multimodal ergonomic intervention with a 2-h educational part and a 2-h practical part (body mechanics, causes and reinforcing factors for back pain, back anatomy, lifting devices, and back protecting exercises). At the 3-month follow-up, knowledge about work-related back pain increased significantly. Moreover, patient handling tasks improved significantly. The change was maintained at the 3-month follow-up.

The multimodal ergonomic intervention by Kindblom-Rising et al. (2011) for hospital nurses examined two half-day patient transfer courses with a 2-

Table 1 Quality scores of included studies in alphabetical order

Study	Quality criteria														Quality score
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Akyurek et al. (2020)	2	2	2	2	2	n/a	n/a	2	0	2	2	2	2	2	0.917
Alexander et al. (2015)	2	1	2	2	1	n/a	n/a	1	1	2	2	2	2	2	0.833
Alexandre et al. (2001)	2	2	2	1	1	0	n/a	1	1	2	1	0	2	1	0.615
Bauer et al. (2019)	2	2	2	1	2	2	n/a	2	1	2	2	1	1	2	0.846
Becker et al. (2017)	2	2	2	2	2	2	n/a	1	1	2	2	2	2	2	0.923
Best (1997)	2	1	2	1	1	0	0	1	1	1	0	0	1	1	0.429
Brox and Froystein (2005)	1	2	1	2	1	2	n/a	1	2	2	1	0	2	2	0.731
Carta et al. (2010)	2	1	1	2	n/a	n/a	n/a	1	1	2	2	2	2	2	0.818
Chen et al. (2014)	2	2	2	2	2	0	n/a	2	2	2	2	2	2	1	0.885
Chen et al. (2016)	2	2	2	2	2	0	n/a	2	2	1	2	2	2	0	0.808
Cooper et al. (1998)	2	2	1	2	n/a	0	n/a	1	1	1	1	1	1	1	0.583
Das Gecim and Esin (2021)	2	2	2	2	2	n/a	n/a	2	2	2	2	2	2	1	0.885
Ehegartner et al. (2021)	2	2	2	2	2	n/a	n/a	1	2	2	2	1	2	1	0.808
Ewert et al. (2009)	2	2	2	2	2	0	n/a	1	1	2	2	2	2	1	0.808
Fang and Li (2015)	2	2	2	2	2	0	n/a	2	1	1	2	2	2	2	0.846
Feldstein et al. (1993)	2	2	1	1	0	2	n/a	1	1	2	2	1	2	1	0.692
Hartvigsen et al. (2005)	2	1	1	2	0	0	0	1	2	2	2	1	1	1	0.571
Jalalvandi et al. (2022)	2	2	2	2	2	n/a	n/a	1	2	2	2	2	2	2	0.885
Jaromi et al. (2012)	2	2	2	2	2	2	n/a	1	1	2	2	0	2	1	0.808
Jaromi et al. (2018)	2	2	2	2	2	2	n/a	1	1	2	2	2	2	1	0.885
Karahan and Bayraktar (2013)	2	2	1	0	n/a	n/a	n/a	1	2	2	0	0	2	1	0.591
Kindblom-Rising et al. (2011)	2	2	2	2	0	0	0	2	1	2	0	0	2	1	0.571
Lavoie-Tremblay (2014)	2	2	1	2	n/a	n/a	n/a	2	1	2	2	0	2	2	0.818
Mandal et al. (2021)	2	2	2	2	2	0	n/a	1	1	2	2	0	2	1	0.731
Martins and Marziale (2012)	2	2	2	2	1	2	n/a	1	0	1	0	0	2	1	0.615
Matsugaki et al. (2017)	2	2	2	2	2	0	n/a	1	0	2	2	2	2	1	0.769
Mohebbi et al. (2019)	2	1	2	2	2	0	n/a	2	1	1	2	0	1	0	0.615
Moreira et al. (2021)	2	2	2	2	1	2	n/a	1	2	2	2	1	2	1	0.846
Mueller et al. (2001)	2	2	2	1	2	2	n/a	1	1	2	1	0	2	1	0.731
Otto and Wollesen (2022)	2	2	2	2	2	2	n/a	2	1	2	1	2	1	1	0.846
Ratzon et al. (2016)	2	2	2	2	2	1	n/a	1	1	2	2	0	2	1	0.769
Tucker et al. (2011)	2	2	2	2	n/a	0	n/a	1	1	2	2	2	2	1	0.792
Tucker et al. (2016)	2	2	2	2	1	n/a	n/a	1	1	2	2	2	2	2	0.875
Warming et al. (2008)	2	2	2	2	2	0	n/a	1	1	2	2	2	2	2	0.846
Yang et al. (2021)	2	2	2	2	2	n/a	0	1	1	2	2	2	2	2	0.786
Yuan et al. (2009)	1	2	1	1	1	0	n/a	1	1	2	2	2	2	2	0.692
Zou et al. (2021)	2	1	1	1	0	0	n/a	1	2	2	2	2	1	1	0.615

0 criterion not fulfilled, *1* criterion partially fulfilled, *2* criterion fulfilled. Quality criteria: *1* Question/objective described, *2* Study design evident and appropriate, *3* Method of subject/comparison group selection described or source of information/input variables described, *4* Subject characteristics described, *5* If interventional, random allocation described, *6* If interventional, blinding of investigators reported, *7* If interventional, blinding of subjects reported, *8* Outcome and exposure measures well defined and robust to measurement/misclassification bias? Means of assessment reported, *9* Sample size appropriate, *10* Analytic methods described/justified and appropriate, *11* Estimate of variance reported for main results, *12* Controlled for confounding, *13* Results reported in detail, *14* Conclusion supported by results, *n/a* not applicable

Table 2 Study table

Eligible study, author and year	Participants *n*, sex, age (M ± SD)	Study design	Study aims	Intervention	Outcome measurements
Akyurek et al. (2020)	Hospital nurses IG: *n* = 15, female, 33.53 ± 13.67 years CG: *n* = 15, female, 41.47 ± 9.39 years	RCT	To investigate the effects of a workplace health promotion program in terms of pain, fatigue, stress, coping skills, and professional quality of life on nurses	IG: PMR, posture exercises, breathing exercises, and ergonomic suggestions CG: no intervention	VAS-pain/fatigue/stress Brief COPE Compassion satisfaction, burnout, secondary traumatic stress (Pro-QoL)
Alexander et al. (2015)	Hospital nurses *n* = 40, 39 female, 46.38 ± 10.23 years	Pilot-level RCT	To examine the efficacy of yoga to improve self-care and reduce burnout among nurses	IG: supervised yoga intervention CG: no intervention	HPLP II FMI MBI
Alexandre, de Moraes, Correa Filho, and Jorge (2001)	Hospital nursing aides with back pain IG: *n* = 27, female, 36.9 ± 8.0 years CG: *n* = 29, female, 37.5 ± 6.1 years	RCT	To evaluate whether an intervention program reduced the frequency and intensity of back pain	IG: back school CG: single-session educational Back school	VAS-pain NQ for lumbar, thoracic, cervical spine
Bauer et al. (2019)	Hospital nurses with subacute LBP IG: *n* = 42, female, 45.7 ± 7.8 years CG: *n* = 41, female, 46.7 ± 7.7 years	RCT	To investigate the impact of neuromuscular exercise (NME) on the variability of lumbar movement patterns during a work-related repetitive lifting task	IG: NME (strength, balance, endurance, coordination) + encouragement for independent home training CG: no intervention	Sensor-based lumbar movement variability with inertial measurement unit (IMU)
Becker et al. (2017)	Hospital nurses with MSC in shoulder, back, or neck IG: *n* = 34, 85.29% female, 44.41 ± 9.89 years CG: *n* = 34, 88.24% female, 43.09 ± 10.75 years	RCT	To determine whether a coaching intervention that was focused on enabling better strategies for coping with work stressors is superior to physiotherapy alone in the reduction of MSC	IG: individualized physiotherapy + group-based psychoeducation CG: individualized physiotherapy	Mobility and strength examination with Spallek and Cyriax assessment Pain (NQ, VAS-pain, MPI) WAI Work-related psychological well-being (Irritations scale, MBI)
Best (1997)	Geriatric nurses IG: *n* = 18; n. a., 41 ± n. a. years CG: *n* = 37; n. a., 38 ± n. a. years	Quasi-RCT	To evaluate the outcomes of training in the Manutention method of manual handling of patients	IG: ergonomic intervention (in-house orientation & comprehensive training course in Manutention manual handling) CG: in-house orientation training	Lifting quality (OWAS scale) Back pain Injury rates
Brox and Froystein (2005)	Geriatric nurses IG: *n* = 63, 97% female, 42.5 ± 36.9 years CG: *n* = 56, 96% female, 42.5 ± 39.6 years	RCT	To evaluate the effectiveness of aerobic group exercise on aerobic fitness, health-related quality of life and sickness absence	IG: aerobic exercise model (cardiovascular, strength, flexibility) CG: no intervention	Aerobic fitness (UKK walking test) Health-related QoL (COOP/WONCA charts) number of sick days self-developed questionnaire assessing leisure-time physical activity, subjective health complaints and job satisfaction
Carta et al. (2010)	Hospital nurses and health-care assistants, *n* = 140, 83% women, 38 ± n. a. years	Single-group pre/post analysis	To educate nursing staff on patient handling techniques to prevent LBP	Multimodal ergonomic intervention (didactical and practical)	Patient handling technique observation Self-developed LBP knowledge test Self-developed LBP equipment use questionnaire Back pain

Table 2 (Continued)

Eligible study, author and year	Participants *n*, sex, age (M ± SD)	Study design	Study aims	Intervention	Outcome measurements
Chen et al. (2014)	Hospital nurses IG: *n* = 64, n. a., 30.67 ± 4.45 years CG: *n* = 63, n. a., 37.7 ± 8.88 years	RCT	To examine the effectiveness of a stretching exercise program on LBP and exercise self-efficacy among Taiwan nurses	IG: Stretching exercise program (back pain exercise, core muscle training, and relaxation exercises) CG: no intervention	VAS-pain EXSE Program satisfaction
Chen et al. (2016)	Hospital nurses IG: *n* = 50, female, 33.29 ± 2.92 years CG: *n* = 49, female, 33.59 ± 6.96 years	Experimental study with a pre/post intervention	To evaluate the effectiveness of a releasing exercise program (REP) on anxiety and exercise self-efficacy	IG: releasing exercise program (strength, stretching, mediation) CG: no intervention	CVBAI VAS-anxiety EXSE
Cooper et al. (1998)	Back-injured hospital nurses IG: *n* = 40, n. a., 31.1 ± 8.1 years CG: *n* = 118, n. a., 34.4 years ± 8.5	Nonequivalent controlled pre/post intervention	To compare components of LBP disability of intervention participants receiving an individualized rehabilitation program with those who did not	IG: individualized work-hardening program (physiotherapy and occupational therapy, rehabilitation program + work-hardening program if necessary) CG: advised to seek care from their regular caregivers	Back pain/injury (OSW)
Das Gecim and Esin (2021)	Hospital nurses IG: *n* = 30, female, 46.5 ± 4.1 years CG: *n* = 30, female, 47.5 ± 3.3 years	Parallel RCT	To test the hypothesis that attitude–social influence– self-efficacy self-management would affect work ability and QOL for nurses aged 45 years and over	IG: Self-management program (health training, yoga training and individual nutrition Counselling) CG: no intervention	WAI SF-12 BMI Waist and hip circumference
Ehegartner et al. (2021)	Nurses from different settings IG: *n* = 57, 54 female, 47.8 ± 9.4 years CG: *n* = 68, 61 female, 45.8 ± 11 years	Waitlist RCT	To assess the efficacy of a need-tailored activity and education-based prevention program for nurses in terms of stress, work ability, recovery ability, well-being and health-related quality of life	IG: 5-day prevention program including back school, aerobic exercises and active, and passive relaxation and psychoeducation about stress and work demands and2 refresher days including CG: waitlist	Stress (PSQ, PSS) WAI QoL (SF-12, WHO-5)
Ewert et al. (2009)	Hospital and geriatric nurses with at least one episode of back pain IG: *n* = 92, 84 female, 37.9 ± 11.6 years CG: *n* = 91, 85 female, 41.1 ± 10.8 years	Parallel-group RCT	To examine whether a multimodal, secondary prevention program is superior to a unimodal program and to explore the change in psychosocial and physical process variables	IG: strength, stretching, aerobic, relaxation exercises & segmental stabilization, ergonomic and cognitive-behavioral (pain, stress, PMR, communication) educational sessions CG: strength, stretching, aerobic and relaxation exercises	Primary variables: MPI SF-36 Secondary variables: FABQ CSQ CESDS-D BQ GPSE JDI DHS MSI BST PILE

Table 2 (Continued)

Eligible study, author and year	Participants *n*, sex, age (M ± SD)	Study design	Study aims	Intervention	Outcome measurements
Fang and Li (2015)	Female hospital nurses IG: $n = 54$, female, 35.13 ± 10.98 years CG: $n = 51$, female, 36.05 ± 9.91 years	RCT	To evaluate the quality of sleep and work pressure in Chinese nurses after yoga intervention	IG: Yoga CG: no intervention	C-PSQI QMWS
Feldstein et al. (1993)	Hospital nurses, nurses' aides, and orderlies $n = 55$ (IG = 30, CG = 25), 79% women, 42 ± n. a. years	Pilot intervention	To pilot test the multidimensional program "Back Attack" to prevent back injuries among nurses, nurses' aides and orderlies	IG: multimodal ergonomic intervention (didactical, and practical) CG: not specified	Back Pain Questionnaire (self-developed) Back Injury Prevention Project (BIPP) Transfer Evaluation Flexibility test 4 standard tests of proprioception: walking a straight line, knee band, balancing on the right (left) foot with closed eyes for 5 s
Hartvigsen et al. (2005)	Outpatient nurses and nurse aides IG: $n = 171$, female, 44.6 years (min–max 21–64) CG: $n = 145$, female, 44.4 years (min–max 21–64)	Prospective controlled study	To evaluate the effectiveness of an intensive educational and low-tech ergonomic intervention program aimed at reducing LBP	IG: multimodal ergonomic intervention (didactical, practical, and group counselling) CG: single-time workshop in lifting technique	NQ SF-36
Jalalvandi et al. (2022)	Operating room nurses with non-specific LBP Back exercise group: $n = 22$, 16 female, 37.86 ± 6.74 years TENS group: $n = 22$, 14 female, 36.05 ± 5.11 years	Parallel group RCT	To determine and compare the effects of exercise and TENS on chronic LBP of the operating room nurses (and nurse aides) of an Iranian Hospital	Back exercise group: Strength and stretching exercises for back and pelvis muscles TENS group: received transcutaneous electrical nerve stimulation for lower back	MPQ OSW
Jaromi et al. (2018)	Hospital nurses with low back pain IG: $n = 67$, 62 female, 41.7 ± 3.54 years CG: $n = 70$, 66 female, 41.1 ± 3.80 years	RCT	To evaluate whether an intervention program (Spine Care for Nurses) would result in a reduction of chronic nonspecific LBP and an improvement in the execution of proper patient lifting techniques compared to a control group	IG: back school CG: brief written lifestyle guidance	Lifting technique quality (Zebris WinSpine Triple Lumbar biomechanical motion analysis) VAS-pain for LBP
Jaromi et al. (2012)	Hospital nurses with LBP IG: $n = 56$, 82.1% women, 32.3 ± 8.15 years CG: $n = 55$, 85.5% women, 31.5 ± 8.25 years	RCT	To measure the effectiveness of a spine training program (back school) in nurses who have been living with chronic LBP	IG: back school CG: passive physiotherapy	Lifting technique quality of vertical and horizontal patient lifting (Zebris WinSpine Triple Lumbar biomechanical motion analysis) VAS-pain for non-specific back pain
Karahan and Bayraktar (2013)	Hospital nurses $n = 60$, n. a., n. a.	One-group pre/post intervention	To investigate the effectiveness of an ergonomic intervention to prevent LBP in nurses	Multimodal ergonomic intervention (didactical, and practical)	LBP knowledge test Lifting mechanics (all self-developed)

Table 2 (Continued)

Eligible study, author and year	Participants *n*, sex, age (M ± SD)	Study design	Study aims	Intervention	Outcome measurements
Kindblom-Rising et al. (2011)	Hospital nurses IG: $n = 99$, n. a., 48 ± n. a. years CG: $n = 77$, n. a., 44.6 ± n. a. years	Controlled pre/post intervention	To evaluate changes after two half-day patient transfer course regarding nursing staff's movement and body awareness, attitudes reported, behavior, strain, disorder and sick leave	IG: multimodal ergonomic intervention (didactical, and practical) CG: no intervention	Single, self-developed questionnaire comprising movement and body awareness, attitude to work, behavior in patient transfer, physical disorders, sick leave, and strain (ÖSC)
Lavoie-Tremblay et al. (2014)	Hospital nurses $n_{postintervention} = 51$, 47 female, 47.86 years ± 8.91	One-group pre/post intervention	To describe the impact of a pedometer-based activity program	Pedometer challenge	Number of steps taken per day Physical health indicators (weight; waist circumference; height; total cholesterol, HDL cholesterol, LDL cholesterol, and triglyceride levels; fasting glucose; systolic and diastolic blood pressure) MFI ISI PSS-10 IPAQ
Mandal et al. (2021)	Hospital nurses IG: $n = 58$, 50 female, 35 ± 7.9 years CG: $n = 52$, 30 female, 32.5 ± 6.8 years	RCT	To study the efficacy of structured yoga and also to assess the sustainability of this yoga program among this nursing staff	IG: yoga CG: no intervention	PSS ProQoL Cortisol Blood pressure
Martins and Marziale (2012)	Hospital nurses with rotator cuff disorder $n = 16$, 14 female, 87.6% older than 40	RCT	To compare a physiotherapy program consisting of stretching exercises, strengthening, proprioception, and cryotherapy with a control physical therapy program consisting of stretching exercises, strengthening, and cryotherapy in nurses suffering from rotator cuff disorders	IG: strengthening and stretching exercises and cryotherapy + proprioceptive exercises CG: strengthening and stretching exercises and cryotherapy	WORC Work stress (OSI) VNS-pain
Matsugaki et al. (2017)	Hospital nurses IG (supervised exercise group): $n = 15$, female, 25.3 ± 3.4 years CG (voluntary exercise group): $n = 14$, female, 24.7 ± 3.7 years	RCT	To evaluate the effectiveness of workplace exercise supervised by a physiotherapist on physical fitness, anthropometric data, biochemical data, and mental health status among nurses conducting shift work	IG: aerobic and strength exercises and physiotherapist advice CG: aerobic and strength exercises	Physiological measures: BMI Physiological measures (body fat, muscle mass, and basal metabolic rate, blood pressure, VO_{2max}, various blood samples) knee extensor strength (dynamometer) Self-rated measures: BDI-II POMS VAS-self-efficacy for continuing exercise
Mohebbi et al. (2019)	Hospital nurses $n = 57$, all female, 33 years ± 2.7	RCT	To examine the effect of aerobic exercise on the amount of stress of nurses	IG: aerobic stretching exercises CG: no intervention	Stress (HSE)

Table 2 (Continued)

Eligible study, author and year	Participants *n*, sex, age (M ± SD)	Study design	Study aims	Intervention	Outcome measurements
Moreira et al. (2021)	Hospital nursing assistants IG: $n=46$, 41 female, 37.53 ± 9.93 years CG: $n=44$, 41 female, 32.11 ± 7.57 years	RCT	To investigate the effectiveness of a therapeutic exercise program designed to nursing assistants aiming at increasing trunk extensor and trunk flexor muscles strength, back and leg flexibility, and promoting low back symptoms control compared to a reference group	IG: therapeutic exercising program for spine stabilization CG: no intervention	Peak force of trunk extensors and flexor evaluation Back and leg flexibility using the Wells flexometer Pressure pain threshold measurement for low back symptoms
Muller, Schwesig, Leuchte, and Riede (2001)	Hospital nurses with LBP during last year $n=104$, 89% female, 35.1 (min–max 19.8–58.8) years	RCT	To evaluate whether a coordinative training regimen improves not only coordination, but also back pain and quality of life	IG1: coordinative exercising and preventive education IG2: coordinative exercising CG1: preventive education CG2: no intervention	Body surface electromyography and posturography WHOQOL-BREF Self-developed questionnaire regarding back pain
Otto and Wollesen (2022)	Geriatric nurses IG: $n=22$, female, 41 ± 10.5 years CG: 20, 17 female, 44 ± 10.7 years	RCT	To investigate whether an intervention program combining ergonomics training with strength and resistance training tailored to the target group improves lifting behavior, strength endurance, LBP, and functional impairment caused by back pain	IG: multicomponent ergonomics and strength training CG: no intervention	PILE BST VAS-pain OSW
Ratzon et al. (2016)	Hospital nurses with musculoskeletal pain IG: $n=14$, female, 51.28 ± 7.55 years CG: $n=17$, female, 47.7 ± 10.38 years	RCT	To determine whether a comprehensive and personalized ergonomic intervention can reduce the biomechanical workload and introduce personalized exercise to reduce associated musculoskeletal complaints	IG: multimodal ergonomic intervention (didactical & physiotherapeutic exercising) CG: received instruction sheets that included explanations about the principles of proper work performance and when and how to perform exercises during the work shift	REBA NQ KJCQ
Tucker et al. (2011)	Hospital nurses who were mothers of young children $n=58$ (IG: $n=30$, CG: $n=28$), female, 35 ± 6.91 years	Quasi-experimental non-randomized pilot intervention	To develop and test an innovative 10-week worksite physical activity intervention integrated into the workflow of nurses who are mothers	IG: environmental facilitation of PA during working time CG: no intervention	Measurement of fat mass Step tracker (wearable) BMI
Tucker et al. (2016)	Nurses of different settings IG_{early}: $n=28$, female, 43 ± 12.4 years $IG_{delayed}$: $n=14$, n. a., 42.2 ± 12.0 years	Repeated-measures crossover design	To explore the feasibility, preliminary effects, and barriers and facilitators of integrating a 6-month worksite non-exercise activity thermogenesis (NEAT) + physical activity intervention, with personalized health coaching via text messaging, into the workflow of nursing staff	Environmental facilitation of physical activity during working time, and individualized coaching Both groups received the intervention. IG_{early} received individualized coaching for first three months, $IG_{delayed}$ received individualized coaching for last three months	Fat mass using x-ray absorptiometry PA (Sensewear monitor with three-axis accelerometer, heat flux sensor, galvanic skin response sensor, skin temperature sensor, near-body ambient temperature sensor, and an optional heart rate sensor)ak WLQ

Table 2 (Continued)

Eligible study, author and year	Participants *n*, sex, age (M ± SD)	Study design	Study aims	Intervention	Outcome measurements
Warming et al. (2008)	Hospital nurses $n = 181$, n. a., 34.8 ± n. a. years	Cluster-RCT	To evaluate the effect of a transfer technique education program (TT) alone or in combination with physical fitness training (TTPT)	IG_{TTPT}: multimodal ergonomic intervention (didactical and aerobic and strength exercising) IG_{TT}: ergonomic intervention (didactical) CG: no intervention	NQ modified version of the Low Back Pain Rating Scale Self-developed questions regarding Knowledge of transfer technique Physical test (submaximal bicycle test) with Borg RPE scale
Yang et al. (2021)	ICU nurses IG: $n = 89$, 70 female, 28.83 ± 4.25 years CG: $n = 101$, 83 female, 28.86 ± 4.13 years	Cluster-controlled trial	To evaluate the effectiveness of a multidimensional intervention program in reducing WRMD symptoms among ICU nurses in China	IG: multidimensional ergonomic intervention (improvement of risk perception, providing safe work environment, health behavior training) CG: two lectures on work-related musculoskeletal disease and safe work environment	NQ Chinese version of the Risk Perception of Musculoskeletal Injury Nursing Physical Factors Evaluation Questionnaire (self-developed) Hospital Safety Climate Questionnaire
Yuan et al. (2009)	Hospital nurses IG: $n = 45$, n. a., 35 ± n. a. years CG: $n = 41$, n. a., 31 ± n. a. years	Quasi-experimental intervention	To assess the effects of an exercise intervention on nurses' health-related physical fitness	IG: treadmill exercising CG: no intervention	Cardiopulmonary function BMI grip strength back strength abdominal strength flexibility (sit-and-reach)
Zou et al. (2021)	Hospital nurses with non-specific LBP (NSLBP) IG: $n = 20$, female, 26 to 40 years CG: $n = 20$, 19 female, 23 to 43 years	Self-selected controlled trial	To investigate the effect of core stability training on NSLBP in nurses	IG: health education + core stability training CG: health education	Surface electromyography of spine Pain NRS LBP (JOA questionnaire)

BDI-II Beck Depression Inventory–Second Edition, *Borg RPE scale* Borg Rating of Perceived Exertion Scale, *BQ* Basler's Questionnaire, *Brief COPE* Coping Orientation to Problems Experienced, *BST* Biering-Sorensen Test, *CESDS-D* German version of the Center for Epidemiologic Studies Depression Scale, *CSQ* Coping Strategies Questionnaire, *CVBAI* Chinese Version of the Beck Anxiety Inventory, *DHS* Daily Hassles Scale, *EXSE* Exercise Self-efficacy scale, *FABQ* Fear Avoidance Beliefs Questionnaire, *FMI* Freiburg Mindfulness Inventory, *GPSE* General Perceived Self-Efficacy Scale, *HPLP II* Health Promoting Lifestyle Profile II, *HSE* Health and Safety Executive, *IPAQ* International Physical Activity Questionnaire, *ISI* Insomnia Severity Index, *JDI* Job-Description-Index, *JOA* Japanese Orthopaedic Association, *KJCQ* Karasek's Job Content Questionnaire, *LBP* lower back pain, *MBI* Maslach Burnout Inventory, *MFI* multidimensional fatigue inventory, *MPI* Multidimensional Pain Inventory, *MSI* Muscle Strength Index, *MPQ* McGill Pain Questionnaire, *MSC* musculoskeletal complaints, *n. a.* not applicable, *NQ* Nordic Questionnaire, *NRS* Numeric Rating Scale, *OSI* Occupational Stress Indicator, *OSW* Oswestry Low Back Pain and Disability questionnaire, *ÖSC* Örebro screening questionnaire for strain, disorders and sick leave, *OWAS* Ovako Working Assessment System, *PILE* Progressive Isoinertial Lifting Evaluation Test, *PMR* progressive muscle relaxation, *POMS* Profile of Mood States, *Pro-Qol* Professional Quality of Life Scale, *PSQ* Perceived Stress Questionnaire, *PSQI* Pittsburgh Sleep Quality Index, *PSS-10* Perceived Stress Scale, *QMWS* Questionnaire on Medical Worker's Stress, *REBA* Rapid Entire Body Assessment, *SF-36* Short-Form 36 Health Survey, *TENS* transcutaneous electric nerve stimulation, *VAS* visual analog scale, *VNS* Visual Numeric Scale, *WAI* Work Ability Index, *WHOQOL-BREF* World Health Organization Quality of Life, *WLQ* Work Limitation Questionnaire, *WORC* Western Ontario Rotator Cuff Index

Table 3 Results by main intervention type in alphabetical order

Author (year)	Description of contents	Frequency and duration	Intensity	Individual-ization/need-tailoring	Training principles and control mechanisms (number and description)	Effects on examined outcomes
Aerobic exercise						
Yuan et al. (2009)	IG: stair stepper exercising CG: no intervention	At least 3 × a week for 20–30 min until heart rate reached 70–85% of the maximum heart rate of 220-age for 3 months (≥ 12 h)	Light	No	Intensity control: participants exercised on the stair-stepper 20–30 min until the heart rate reached 70–85% of the maximum heart rate of 220-age	Positive effects on BMI, grip strength, flexibility, abdominal and back muscles, and cardiopulmonary functions
Back school (specific exercising and education)						
Alexandre et al. (2001)	IG: back school CG: single-session educational back school	Exercising: 45 min 2 ×/week, for 4 months (25.5 h) Education: six 1-h modules, twice a week for 4 months (ambiguous report) CG: single 45-min class	n. r.	Yes (specific to back pain)	/	Reduced cervical and lumbar pain No effects on thoracic pain
Jaromi et al. (2018)	IG: back school CG: brief written lifestyle guidance	IG: twice a week for 12 weeks in 60-min sessions (24 h) CG: no frequency/duration denoted	n. r.	Yes (specific to back pain)	/	Improved lifting technique and reduced LBP intensity in IG vs. CG
Jaromi et al. (2012)	IG: back school CG: passive physiotherapy	IG: 50 min/week for 6 weeks (5 h) CG: 1 session/week for 6 weeks (no frequency/duration denoted)	n. r.	Yes (specific to back pain)	/	Reduced nonspecific back pain intensity in both groups at postmeasurement, reduced pain intensity and improved body posture in IG vs. CG at 6-month and 12-month FU home exercises and therapies were carried out 4.2 days per week on average by the study group
Ergonomics						
Best (1997)	IG: ergonomic intervention (in-house orientation and comprehensive training course in manutention manual handling) CG: inactive	IG: total time 32 h (frequency and session duration not denoted)	n. r.	No	/	Lifting quality improved in IG vs. CG No decrease of injury rates and back pain at 9-month FU
Carta et al. (2010)	Multimodal ergonomic intervention (didactical, and practical)	2 h education lesson, 3 h practical training session (5 h; session interval not precisely denoted)	n. r.	No	/	Improvement in LBP test scores and handling techniques at 6-month FU No statistical effect on LBP and use of equipment reported
Feldstein et al. (1993)	IG: multimodal ergonomic intervention (didactical, and practical) CG: not specified	2 h didactical part and 8 h practical part (10 h; session interval not precisely denoted)	n. r.	No	/	Improved patient transfer techniques in IG vs. CG No effects on flexibility, proprioception, and back pain

Table 3 (Continued)

Author (year)	Description of contents	Frequency and duration	Intensity	Individualization/need-tailoring	Training principles and control mechanisms (number and description)	Effects on examined outcomes
Hartvigsen et al. (2005)	IG: multimodal ergonomic intervention (didactical, practical, and group counselling) CG: single-time workshop in lifting technique	IG: ergonomic advice for at least 1 h/week for 2 years and 2 h group counselling sessions four times in 7 months (112 h; session interval not precisely denoted) CG: workshop (3 h)	n. r.	No	/	No effects on pain and general health
Karahan and Bayraktar (2013)	Multimodal ergonomic intervention (didactical, and practical)	2 h theoretical content, 2 h practical application (4 h; session interval not precisely denoted)	n. r.	No	/	LBP knowledge and lifting mechanics improved at 3-month FU
Kindblom-Rising et al. (2011)	IG: multimodal ergonomic intervention (didactical, and practical) CG: no intervention	2 half-day workshops with 2 weeks interval (frequency and duration not denoted)	n. r.	No	/	IG improved movement awareness, transfer behavior, reduction in sick leave, and physical disorders after 1 year No improvement in attitude to work and strain in IG vs. CG
Increasing physical activity						
Lavoie-Tremblay et al. (2014)	Pedometer challenge	8-week challenge during work time	n. r.	No	/	Sitting time per weekday reduced from baseline to 6-month FU No other variables improved from baseline to FU stress increased at FU
Tucker et al. (2011)	IG: environmental facilitation of PA during working time CG: no intervention	10-week intervention during working hours	n. r.	Yes	/	Desirable decrease in BMI and less body fat in IG vs. CG No increased physical activity (steps taken/day)
Tucker et al. (2016)	Environmental facilitation of physical activity during working time, and individualized coaching Both groups received the intervention. IG_{early} received individualized coaching for first 3 months, $IG_{delayed}$ received individualized coaching for last 3 months	6-month intervention during working hours	Light	Yes	/	Positive effect on PA (PA increase, sedentary time decrease, energy expenditure, steps per day) No effect on total lean mass, fat mass, WLQ
Multicomponent ergonomics						
Akyurek et al. (2020)	IG: PMR, posture exercises, breathing exercises, and ergonomic suggestions CG: no intervention	2×/week for 5 weeks: Breathing exercises 5 min PMR 20 min Posture exercises 10 min Ergonomic suggestions not specified (ca. 7 h)	n. r.	No	/	At 12-month FU, IG had lower subjective stress, better coping strategies and compassion satisfaction, less burnout compared to CG No effects on pain, fatigue, and secondary traumatic stress

Table 3 (Continued)

Author (year)	Description of contents	Frequency and duration	Intensity	Individualization/need-tailoring	Training principles and control mechanisms (number and description)	Effects on examined outcomes
Cooper et al. (1998)	IG: individualized work-hardening program (physiotherapy and occupational therapy, rehabilitation program + work-hardening program if necessary) CG: regular advice from usual caregivers	Not denoted	n. r.	Yes	/	Decrease in back pain/injury (OSW scores) in IG at postintervention
Ewert et al. (2009)	IG: strength, stretching, aerobic, relaxation exercises and segmental stabilization, ergonomic and cognitive-behavioral (pain, stress, PMR, communication) educational sessions CG: strength, stretching, aerobic and relaxation exercises	IG: 17 group sessions of 1.75 h and one individual session of 45 min (30.5 h) CG: 11 1-h sessions, (11 h) Both groups exercised for 4 weeks with the opportunity to continue the supervised program for an additional 10 weeks, if desired (ambiguous report)	n. r	Yes	Intensity control: warm-up aimed to increase the HR to at least 130 bpm (method not specified)	No effects for MPI and SF-36 scores at 12-month FU No significance values reported for secondary variables
Otto and Wollesen (2022)	IG: multicomponent ergonomics and strength training CG: no intervention	Ergonomics: weekly for 20–30 min for 10 weeks Strength training: weekly for 45–60 min for 12 weeks (17 h)	Moderate	Yes	Intensity control: based on participants' perceived exhaustion (BORG scale), they could take individual breaks or perform a lighter exercise, simplified by trainers Progressive overload	Improvement in lifting performance, and reduced back pain in IG vs. CG no effects on BST and OSW
Ratzon et al. (2016)	IG: multimodal ergonomic intervention (didactical and physiotherapeutic exercising) CG: received instruction sheets that included explanations about the principles of proper work performance and when and how to perform exercises during the work shift	IG: weekly 45-min group meetings for three weeks (2.25 h) + one individualized job analysis coaching (no duration denoted)	Individual	Yes	/	REBA: improvements in detrimental body posture scores after the intervention ($p < 0.001$) No improvements in the scores on Karasek's job content questionnaire No reduction of musculoskeletal pain
Warming et al. (2008)	IG_{TTPT}: multimodal ergonomic intervention (didactical and aerobic and strength exercising) IG_{TT}: ergonomic intervention (didactical) CG: no intervention	IG_{TTPT}: 2 1-h sessions/week for 8 weeks (16 h) + introduction to lifting aids (no duration denoted) IG_{TT}: introduction to lifting aids	n. r.	Yes	Intensity control: Heart rate sensor monitored and a level of 70–90% of the participant's aerobic capacity (VO_{2max}) was considered sufficient for increasing aerobic fitness	No difference in LBP, pain level, knowledge of transfer technique, disability or sick leave and no improvement in bicycle test between IGs and CG at 12-month FU

Table 3 (Continued)

Author (year)	Description of contents	Frequency and duration	Intensity	Individualization/needtailoring	Training principles and control mechanisms (number and description)	Effects on examined outcomes
Yang et al. (2021)	IG: multidimensional ergonomic intervention (improvement of risk perception, providing safe work environment, health behavior training) CG: two lectures on work-related musculoskeletal disease and safe work environment	Total duration: 8 weeks IG: *improvement of risk perception* (WRMD lecture [40 min]), WRMD awareness month where brochures were distributed with WRMD knowledge competition), *providing safe work environment* (40-min lectures [no number denoted]), adjustment of work environment), *health behavior education* (ergonomic lecture [40 min]), health behavior guidance (no duration denoted), health behavior reinforcement training (weekly for 4 weeks, no duration denoted) CG: *improvement of risk perception* (WRMD lecture [40 min]), *providing safe work environment* (lectures on safe work environment [multiple, 40 min each, no number denoted]) total intervention time not specified	n. r.	Yes	/	At 6-month FU, IG showed improvements in NQ, risk perception of WRMDs, application of health behaviors, and perceptions of a safe work environment compared to CG
Multicomponent exercising						
Bauer et al. (2019)	IG: Neuromuscular exercising (strength, balance, endurance, coordination) + encouragement for independent home training CG: no intervention	1 h supervised training sessions 2/week for 6 months (48 h)	n. r.	Yes (specific to back pain)	Progressive overload	Lumbar movement variability improved at postintervention (no significance values reported) Effects were not maintained at 12-month FU
Brox and Froystein (2005)	IG: aerobic exercise model (cardiovascular, strength, flexibility) CG: no intervention	IG: weekly 1-h exercise classes for 6 months (26 h)	Light	No	/	No improvements in aerobic fitness, health-related quality of life mean sickness absence increased in both groups Increased self-reported PA in IG vs. CG No improvements in the frequency of headache, neck, shoulder or back pain
Chen et al. (2014)	IG: Stretching exercise program (back pain exercise, core muscle training, and relaxation exercises) CG: no intervention	50 min, 3 ×/week for 6 months (65 h)	n. r.	No	/	Lower VASP scores and higher self-efficacy scores in IG vs. CG 78% of IG reported high level of satisfaction with the program
Chen et al. (2016)	IG: releasing exercise program (strength, stretching, mediation) CG: no intervention	50-min sessions 3 times a week for 24 weeks (65 h)	n. r.	No	/	Reduced anxiety and improved self-efficacy in IG vs. CG

Table 3 (Continued)

Author (year)	Description of contents	Frequency and duration	Intensity	Individualization/need-tailoring	Training principles and control mechanisms (number and description)	Effects on examined outcomes
Das Gecim and Esin (2021)	IG: Self-management program (health training, yoga training and individual nutrition counselling) CG: no intervention	Health training weekly for 4 weeks (no session length and topics denoted) Yoga twice/week for 60 min for 4 weeks (+ nurses received DVD and were encouraged and prompted via phone or text message to practice at home for 8 following weeks) Individual nutrition Counselling for 4 weeks based on a daily nutrition form filled in by the nurses	n. r.	No (yoga) yes (nutrition)	/	Work ability improved at 3-month FU in IG vs. CG No changes in QoL, BMI, or waist and hip circumference
Ehegartner et al. (2021)	IG: 5-day prevention program including back school, aerobic exercises and active, and passive relaxation and psychoeducation about stress and work demands and 2 refresher days including CG: waitlist	5-day prevention program contained: Psychoeducation about "stress and work demands" (5 × 120 min) Back school (2 × 60 min) Aerobic exercises (2 × 60 min) Active relaxation (Qigong, PMR; 4 × 60 min) and passive relaxation (heat therapy, massages; 2 × 50 min) (19.75 h)	n. r.	Yes (needs assessment)	/	Stress (PSQ, PSS) decreased for IG at 9-month FU, and health-related QoL (WHO-5) improved vs. CG No effects at 9-month FU for work ability, QoL (SF-12)
Jalalvandi et al. (2022)	Back exercise group: Strength and stretching exercises for back and pelvis muscles TENS group: received transcutaneous electrical nerve stimulation for lower back	Both groups: 3 ×/week for 15 min for 6 weeks (4.5 h)	n. r.	Yes (specific for LBP)	Intensity control: Trio 300 dual-channel TENS device from ITO. Co was used. The electrodes of the device were placed in the lower back region. A frequency of 100 Hz, duration of 0.2 ms and an intensity that increased as the participants felt a comfortable prickling sensation (about 15 mA) was applied	Pain and disability decreased in both groups with higher effects the TENS group for both variables
Martins and Marziale (2012)	IG: strengthening and stretching exercises and cryotherapy + proprioceptive exercises CG: strengthening and stretching exercises and cryotherapy	IG and CG: 2 sessions/week for 6 weeks (no duration denoted)	n. r.	Yes (specific to shoulder pain)	Progressive overload: progressive increase in resistance during strengthening exercises at every three sessions	VNSP: reduction of pain in IG and CG WORC: all domains improved in IG but no difference between groups No differences found within and between groups for work stress (OSI) IG was not superior to CG
Matsugaki et al. (2017)	IG: aerobic and strength exercises and physiotherapist advice CG: non-supervised aerobic and strength exercises	IG and CG: 2 sessions/week for 12 weeks (no duration denoted)	± 10 bpm of participants' target HR	Yes	Intensity control: determined by the heart rate reserve (target HR [HR] = (HR max – HR rest) × 0.6 + HR rest). HR max was calculated by 220 subtracted by age	Improvements were found for VO_{2max}, knee extensor torque, LDL-C, and dROM in IG vs. CG Depressive symptoms decreased No effects were found for body fat, muscle mass, and basal metabolic rate, blood pressure, other blood samples, mood and exercise self-efficacy

Table 3 (Continued)

Author (year)	Description of contents	Frequency and duration	Intensity	Individualization/need-tailoring	Training principles and control mechanisms (number and description)	Effects on examined outcomes
Mohebbi et al. (2019)	IG: aerobic stretching exercises CG: no intervention	3 1-h sessions per week for 8 weeks (24 h)	Moderate	No	Intensity control: During each session, five Polar pulse meters, as chest belt, were used randomly to observe the exercise severity for individuals. Target was moderate severity equal to 60–70% of the maximum HR	No effects on stress after 2-month FU
Muller et al. (2001)	IG_1: coordinative exercising and preventive education IG_2: coordinative exercising CG_1: preventive education CG_2: no intervention	$IG_{1,2}$: 30-min weekly sessions 1–2 times/week for 36 weeks (18–36 h) CG_1: n. s.	n. r.	Yes (specific to back pain)	/	Active groups improved trunk muscle coordination and WHOQOL-BREF while passive groups showed no changes No difference between baseline and 3-month FU for posturography and back pain
Zou et al. (2021)	IG: health education + core stability training CG: health education	Health education: not reported Core stability training: 5 ×/week for 45 min for 4 weeks (15 h)	n. r.	Yes (specific for LBP)	/	Reduced LBP (JOA) in IG vs. CG Improved erector spine and multifidus muscle strength in IG vs. CG
Physiotherapy						
Becker et al. (2017)	IG: individualized physiotherapy + group-based psychoeducation CG: individualized physiotherapy	IG: 10 weekly individual physiotherapy sessions (45 min) + seven problem-related psychoeducational group sessions (90 min) (18 h) CG: weekly individual physiotherapy sessions (45 min) for 10 weeks (7.5 h)	Individual	Yes	Progressive overload	Reduction of pain level in everyday movements at 3-month FU Subjective work ability and work-related psychological well-being improved No effects on muscle strength, mobility/restrictions of everyday activities/reduction or impairments due to pain
Moreira et al. (2021)	IG: therapeutic exercising program for spine stabilization CG: no intervention	2 ×/week for 30 min for 12 weeks (12 h)	n. r.	No	/	Strength improvements and low back pain reduction were found for trunk flexor muscles at postintervention in IG vs. CG no significant differences for back extensor strength and back and leg flexibility

Table 3 (Continued)

Author (year)	Description of contents	Frequency and duration	Intensity	Individualization/need-tailoring	Training principles and control mechanisms (number and description)	Effects on examined outcomes
Yoga						
Alexander et al. (2015)	IG: Yoga CG: no intervention	8 weeks (no frequency/duration denoted)	n. r.	No	Variety: Additional exercises, breathing practices, and meditations were added to expose participants to a wider range of movements	Improvement in IG vs. CG for health-promoting behaviors (HPLP II), burnout symptoms, nonsignificant improvements for mindfulness
Fang and Li (2015)	IG: Yoga CG: no intervention	More than twice per week for 50–60 min for 6 months (~> 43 h; not stated precisely)	n. r.	No	/	Improvement in sleep in IG vs. CG and reduced work-related stress
Mandal et al. (2021)	IG: Yoga CG: no intervention	2 ×/week for 50 min for 12 weeks (20 h)	n. r.	No	/	Reduced stress in IG vs. CG no effects on ProQoL and biochemical parameters

BST Biering–Sorensen Test, ***BMI*** body mass index, ***CI*** confidence interval, ***CVBAI*** Chinese Version of the Beck Anxiety Inventory, ***dROM*** reactive oxygen metabolites, ***EXSE*** Exercise Self-efficacy scale, ***FMI*** Freiburg Mindfulness Inventory, ***HSE*** Health and Safety Executive, ***HPLP II*** Health Promoting Lifestyle Profile II, ***HR*** heart rate, ***LBP*** lower back pain, ***LDL-C*** low-density lipoprotein cholesterol, ***MBI-DP*** Maslach Burnout Inventory-Depersonalization, ***MBI-EE*** Maslach Burnout Inventory-Emotional Exhaustion, ***MBI-PA*** Maslach Burnout Inventory-Personal Accomplishment, ***MPI*** Multidimensional Pain Inventory, ***SF-36*** Short-Form 36 Health Survey, ***OSI*** Occupational Stress Indicator, ***OSW*** Oswestry Low Back Pain and Disability questionnaire, ***PMR*** progressive muscle relaxation, ***ProQoL*** Professional Quality of Life, ***PSQI*** Pittsburgh Sleep Quality Index, ***PSS*** Perceived Stress Scale, ***REBA*** Rapid Entire Body Assessment, ***ROM*** range of motion, ***RR*** risk ratio, ***TENS*** transcutaneous electric nerve stimulation, ***VASA*** Visual Analog Scale for Anxiety, ***VASP*** VAS-pain, ***VNSP*** Visual Numeric Scale for pain, ***WHOQOL-BREF*** World Health Organization Quality of Life, ***WLQ*** Work Limitation Questionnaire, ***WORC*** Western Ontario Rotator Cuff Index, ***WRMD*** work-related musculoskeletal disorder, ***IG*** intervention group, ***CG*** control group, ***FU*** follow-up, ***n. s.*** not specified, ***n. r.*** not reported

week interval involving role playing and transfer exercises. At the 12-month follow-up, items on a self-developed questionnaire regarding physical complaints, movement awareness, and patient instructions during transfers improved in the intervention group, whereas in the inactive control group the number of sick leave days decreased.

Multicomponent ergonomics. An RCT including hospital nurses with musculoskeletal complaints investigated a program including individual-specific job analysis (Ratzon et al., 2016). In addition, nurses performed segmental stabilization exercises. The intervention group exhibited less detrimental body postures at the end of the intervention compared to a passive control group.

Cooper et al. (1998) used a controlled individualized physiotherapy ergonomic intervention for hospital nurses with diagnosed back injuries. Moreover, a work-hardening program was instituted if sickness absence exceeded four working days after participation in the physiotherapy program. They found a significant reduction in back pain in the intervention compared with the control group.

In the RCT by Ewert et al. (2009) nurses from different settings with back pain received either a multicomponent exercise intervention combined with ergonomic and stabilization education or an active control intervention. Both intervention programs exhibited significant improvements in pain and QoL, but effects were not maintained at the 12-month follow-up.

In the study by Warming et al. (2008), hospital nurses either received a multicomponent ergonomic intervention (primary intervention), including patient transfer education as well as exercising components, or patient transfer education (secondary intervention), or no intervention. The patient transfer education was based on using transfer aids, the support of the patient, and ergonomic movement. The exercise regimen included aerobic and strength training. At the 12-month follow-up, the primary intervention group improved in one back pain dimension (disability)

Table 4 Results by main intervention type in alphabetical order

Author (year)	Training type	Strength/ flexibility	BMI/ body fat	Fitness	Pain/Dis-comfort	Posture/ working technique	Work ability	Stress	QoL	Increased PA	Number of training control principles
Aerobic exercise											
Yuan et al. (2009)	IG: stair stepper exercising (≥ 12 h) CG: no intervention	↑	↓	↑	–	–	–	–	–	–	1
Back school (specific exercising and education)											
Alexandre et al. (2001)	IG: back school (25.5 h) CG: single-session educational back school	–	–	–	(↓)	–	–	–	–	–	1
Jaromi et al. (2018)	IG: back school (24 h) CG: brief written lifestyle guidance	–	–	–	↓	↑	–	–	–	–	1
Jaromi et al. (2012)	IG: back school (5 h) CG: passive physiotherapy	–	–	–	↓	↑	–	–	–	–	1
Ergonomics											
Best (1997)	IG: ergonomic intervention (in-house orientation and comprehensive training course in Manutention manual handling, 32 h) CG: inactive	–	–	–	No	↑	No	–	–	–	0
Carta et al. (2010)	Multimodal ergonomic intervention (didactical and practical [5 h])	–	–	–	–	↑	–	–	–	–	0
Feldstein et al. (1993)	IG: multimodal ergonomic intervention (didactical, and practical 10 h) CG: not specified	No	–	–	No	↑	–	–	–	–	0
Hartvigsen et al. (2005)	IG: multimodal ergonomic intervention (didactical, practical, and group counselling 112 h) CG: single-time workshop in lifting technique	–	–	–	No	–	–	–	No	–	0
Karahan and Bayraktar (2013)	Multimodal ergonomic intervention (didactical, and practical 4 h)	–	–	–	–	↑	–	–	–	–	0
Kindblom-Rising et al. (2011)	IG: multimodal ergonomic intervention (didactical, and practical 2 workshops duration not specified) CG: no intervention	–	–	–	↓	↑	↑	–	–	–	–
Increasing physical activity											
Lavoie-Tremblay et al. (2014)	Pedometer challenge (8 weeks)	–	–	–	–	–	–	↑	–	↑	0
Tucker et al. (2011)	IG: environmental facilitation of PA during working time (10 weeks) CG: no intervention	–	↓	–	–	–	–	–	–	No	1
Tucker et al. (2016)	Environmental facilitation of physical activity during working time, and individualized coaching (6 months) IG_{early} individualized coaching for first 3 months $IG_{delayed}$ individualized coaching for last 3 months	–	No	–	–	–	No	–	No	↑	2

Table 4 (Continued)

Author (year)	Training type	Strength/ flexibility	BMI/ body fat	Fitness	Pain/Dis-comfort	Posture/ working technique	Work ability	Stress	QoL	Increased PA	Number of training control principles
Multicomponent ergonomics											
Akyurek et al. (2020)	IG: PMR, posture + breathing exercises, ergonomics (6 h) CG: no intervention	–	–	–	No	–	–	↓	–	–	0
Cooper et al. (1998)	IG: individualized work-hardening program (physiotherapy and occupational therapy) CG: regular advice from usual caregivers	–	–	–	↓	–	↑	–	–	–	1
Ewert et al. (2009)	IG: strength, stretching, aerobic, relaxation exercises and segmental stabilization, ergonomic and cognitive-behavioral education (pain, stress, communication) 30.5 h CG: strength, stretching, aerobic and relaxation exercises, 11 h	–	–	–	No	–	–	–	↑	–	2
Otto and Wollesen (2022)	IG: multicomponent ergonomics + strength training (12–17 h) CG: no intervention	No	–	–	↓	↑	No	–	–	–	4
Ratzon et al. (2016)	IG: multimodal ergonomics (didactical and physiotherapeutic exercising 2.25 h) CG: education about principles of proper work performance and when and how to perform exercises during the work shift	–	–	–	No	↑	No	–	–	–	2
Warming et al. (2008)	IG_{TTPT}: multimodal ergonomic intervention (didactical and aerobic and strength exercising; 16 h) IG_{TT}: ergonomic intervention (didactical) CG: no intervention	–	–	No	No	No	No	–	–	–	2
Yang et al. (2021)	IG: multimodal ergonomic intervention (risk perception, safe work environment, health behavior) 8 weeks, no overall volume denoted CG: two lectures on work-related musculoskeletal disease and safe work environment	–	–	–	↓	–	↑	–	–	–	1
Multicomponent exercising											
Bauer et al. (2019)	IG: neuromuscular exercising (strength, balance, endurance, coordination) + encouragement for independent home training (48 h) CG: no intervention	–	–	–	–	No	–	–	–	–	2
Brox and Froystein (2005)	IG: aerobic exercise (cardiovascular, strength, flexibility 26 h) CG: no intervention	–	–	No	No	–	↓	–	No	↑	1
Chen et al. (2014)	IG: stretching exercise program (back pain exercise, core muscle training, and relaxation exercises; 65 h) CG: no intervention	–	–	–	↓	–	–	–	–	–	0
Chen et al. (2016)	IG: releasing exercise program (strength, stretching, mediation) (65 h) CG: no intervention	–	–	–	↓	–	–	–	–	–	0

Table 4 (Continued)

Author (year)	Training type	Strength/ flexibility	BMI/ body fat	Fitness	Pain/Dis-comfort	Posture/ working technique	Work ability	Stress	QoL	Increased PA	Number of training control principles
Das Gecim and Esin (2021)	IG: self-management program (health training, yoga + individual nutrition counselling) 4 + 8 weeks no volume accessible CG: no intervention	–	No	–	–	–	↑	–	No	–	1
Ehegartner et al. (2021)	IG: 5-day prevention program including back school, aerobic exercises, active, and passive relaxation, psychoeducation about stress and work demands and 2 refresher days including (19.75 h) CG: waitlist	–	–	–	–	–	No	↓	(↑)	–	1
Jalalvandi et al. (2022)	Back exercise group: strength + stretching exercises for back and pelvis muscles TENS group: received transcutaneous electrical nerve stimulation for lower back (4.5 h)	–	–	–	↓	–	–	–	–	–	2
Martins and Marziale (2012)	IG: strengthening + stretching and cryotherapy + proprioceptive exercises (6 weeks volume not accessible) CG: strengthening and stretching exercises and cryotherapy	↑	–	–	↓	–	–	No	–	–	2
Matsugaki et al. (2017)	IG: aerobic + strength exercises and physiotherapist advice (12 weeks volume not accessible) CG: non-supervised aerobic and strength exercises	↑	No	↑	–	–	–	↓	–	–	3
Mohebbi et al. (2019)	IG: aerobic stretching exercises (24 h) CG: no intervention	–	–	–	–	–	–	No	–	–	2
Muller et al. (2001)	IG_1: coordinative exercising and preventive education IG_2: coordinative exercising (18–36 h) CG_1: preventive education CG_2: no intervention	↑	–	–	No	No	–	–	↑	–	1
Zou et al. (2021)	IG: health education + core stability training (15 h) CG: health education	↑	–	–	↓	–	–	–	–	–	1
Physiotherapy											
Becker et al. (2017)	IG: individualized physiotherapy + group-based psychoeducation (18 h) CG: individualized physiotherapy (7.5 h)	No	–	–	↓	–	↑	–	↑	–	3
Moreira et al. (2021)	IG: therapeutic exercising program for spine stabilization (12 h) CG: no intervention	(↑)	–	–	↓	–	–	–	–	–	0
Yoga											
Alexander et al. (2015)	IG: yoga (8 weeks no volume reported) CG: no intervention	–	–	–	–	–	–	(↓)	–	–	1
Fang and Li (2015)	IG: yoga (~> 43 h; not stated precisely) CG: no intervention	–	–	–	–	–	–	↓	–	–	0
Mandal et al. (2021)	IG: yoga (20 h) CG: no intervention	–	–	–	–	–	–	↓	No	–	0

Work ability includes reduced sickness/injury rates, ↑, ↓ outcome was assessed and changed to the desired direction, ***no*** outcome was assessed and did not change in the desired direction compared with the secondary intervention group.

The study by Yang et al. (2021) evaluated the effects of an 8-week multidimensional ergonomic intervention to reduce work-related musculoskeletal disorders (WRMD) in hospital nurses. The participants received education, health behavior training, and work environment adjustments, whereas the control group only received two lectures on WRMDs and safe work environments. No group effects were found, merely a within-group improvement in WRMDs, risk perception, and health behaviors.

In a cross-over RCT by Otto and Wollesen (2022), geriatric nurses received a multimodal ergonomic and strength training. The intervention group received ergonomics training once per week for 20–30 min over the course of 10 weeks. Subsequently, the intervention group exercised for 12 weeks once per week for 45–60 min. The need-tailored approach yielded improvements in lifting performance and in subjective back pain.

Multicomponent exercising. In one RCT, hospital nurses with back pain received an intervention incorporating coordination exercises and preventive education (Muller et al., 2001). Coordinative exercises were executed inside a space curl (36 sessions, 30 min each, one to two times per week). Preventive education was based on back-friendly patient transfers. The intervention group was compared with one active control group (received only coordination training), one passive control group (received only preventive education), and one inactive control group. Positive intervention effects (trunk muscle coordination, LBP frequency, and QoL) diminished after the 12-month follow-up.

Martins and Marziale (2012) compared a program for hospital nurses with rotator cuff disorder comprising strengthening and stretching exercises, shoulder proprioception, and cryotherapy with an active control group. At postintervention, pain and rotator cuff disorder-related QoL improved in both groups.

Bauer et al. (2019) conducted an RCT with hospital nurses suffering from LBP. Participants in the intervention group performed specific neuromuscular exercises to restore functioning of lumbar back muscles. The authors reported improvements in the intervention group compared to the control groups lumbar movement variability immediately after the intervention but did not provide data on statistical significance.

In one parallel-group RCT, the research group tested the effects of back exercises (strengthening and stretching) vs. transcutaneous electrical nerve stimulation (TENS) for hospital nurses with nonspecific LBP (Jalalvandi et al., 2022). At postintervention, both groups exhibited reduced pain and disability; however, the TENS group outperformed the exercise group.

Zou et al. (2021) investigated the effects of core stability training on back pain in hospital nurses. The self-selected nurses exercised five times per week for 45 min, for a total of 4 weeks. Subjective pain decreased in intervention group compared to the control group.

In the RCT of Brox and Froystein (2005), geriatric nurses received aerobic exercises, muscle strengthening, and stretching, in weekly meetings for 6 months. Only self-reported physical activity increased compared to an inactive control group.

The research group of Matsugaki et al. (2017) performed an RCT in different nursing settings where female nurses were randomized to either a multicomponent exercise (resistance and aerobic training) group with or without physiotherapist advice. Both groups exercised two times per week for 12 weeks. Compared to the active control group, knee muscle strength, oxidative stress, and low-density lipoprotein cholesterol significantly improved in the intervention group.

Physiotherapy. In the study by Becker et al. (2017), injured hospital nurses received individualized physiotherapy to restore general physical capacity and psychological group sessions to improve well-being. An active control group only received the physiotherapeutic component of the intervention. At the 3-month follow-up, the intervention group had reduced pain levels, physical demands, and burnout symptoms, while work-related psychological well-being improved compared to the control group.

Moreira et al. (2021) examined hospital nurses receiving therapeutic exercises for spine stabilization. The intervention group showed significant improvements in strength in trunk flexor muscles compared to the inactive control condition.

Intervention effects in studies aiming to increase physical activity

One single-group study with hospital nurses used a pedometer challenge (Web-based step tracker; Lavoie-Tremblay et al., 2014). The steps per day were recorded for a duration of 8 weeks, with the goal of 10,000 daily steps. At the 6-month follow-up, participating nurses reduced their sitting time and had less insomnia.

In a non-randomized controlled pilot study, hospital nurses who were mothers participated in a 10-week intervention that aimed at facilitating physical activity during working hours (Tucker et al., 2011). Facilitation was achieved by providing different options in the working environment for being physically active. At the end of the study, intervention group participants had reduced body fat, healthier BMI, and less percent fat mass; however, steps per day did not increase significantly.

Similarly, Tucker et al. (2016) researched a program in different nursing settings with comparable content as an earlier study by Tucker et al. (2011). During work time, the workplace of the nurses was adjusted in a way that physical activity was facilitated. Additionally, participants received individualized mobile coaching messages to increase intervention adherence and success. The single-group study lasted for 6 months, and significantly increased moderate physical activity with increased steps per day while sedentary behavior decreased.

Intervention effects of studies with primarily psychological outcomes

A total of nine interventions aiming to improve psychological outcomes were identified (multicomponent ergonomics $n=1$, multicomponent exercising $n=5$, yoga $n=3$).

Multicomponent ergonomics. Akyurek and colleagues (2020) investigated the effects of a WHPP for hospital nurses including progressive muscle relaxation, posture exercises, and ergonomic education. Progressive muscle relaxation and posture exercise were trained for 30 min per session, whereas no specific duration for the ergonomic suggestions was reported. At the 12-month follow-up, the intervention group had lower subjective stress and burnout as well as better coping strategies and compassion satisfaction than the inactive control group.

Multicomponent exercising. Two RCTs applied a similar stretching training (including back pain, core muscle, and relaxation exercises) for hospital nurses and investigated the effects on exercise self-efficacy, pain (Chen et al., 2014), and anxiety (Chen et al., 2016). The interventions were successful in improving exercise self-efficacy, pain, and anxiety, compared to an inactive control group.

The RCT by Mohebbi et al. (2019) investigated effects of an aerobic training regimen on hospital nurses' stress perceptions compared to an inactive control group. Positive effects on occupational stress levels were not maintained at the 2-month follow-up.

In the RCT by Ehegartner et al. (2021), nurses from different settings received a 5-day need-tailored practical and educational prevention program with contents being back school (2 × 60 min), aerobic exercises (2 × 60 min), active (4 × 60 min) and passive (2 × 50 min) relaxation, and cognitive-behavioral lectures on stress and work demands (5 × 120 min). At the 9-month follow-up, stress and health-related well-being improved subjectively between groups.

Das Gecim and Esin (2021) studied the effects of a self-management program including general health education, yoga, and individualized nutrition counselling in an RCT for hospital nurses. The nurses were also encouraged to continue exercises at home. At the 3-month follow-up, the intervention group showed improved work ability compared with the control group.

Yoga. In Alexander and colleagues' (2015) pilot study, hospital nurses either received an 8-week yoga intervention or no intervention (total duration and frequency not reported). Participants in the yoga group significantly improved in terms of self-care and burnout symptoms.

In another study, yoga compared to an inactive control group was found to improve sleep quality and work stress in hospital nurses (Fang & Li, 2015).

Moreover, in an RCT including hospital nurses (Mandal et al., 2021), the nurses practiced yoga for a total of 12 weeks. The analysis identified intervention effects for perceived stress in the intervention vs. control group.

Applied training principles

Frequency and duration. Concerning training frequencies of training sessions and total duration, in the aerobic intervention, nurses exercised for 20–30 min three times per week for a total of 12 h.

The duration of three back school studies ranged from 5 to 25.5 h and was delivered twice per week for 45–60 min (Alexandre et al., 2001; Jaromi et al., 2018) or in weekly 50-min sessions (Jaromi et al., 2012).

There was a wide range of duration in the six ergonomic studies, lasting between 4 and 112 h. Session frequencies and intervals were typically reported ambiguously. Two studies (Best, 1997; Kindblom-Rising et al., 2011) reported insufficient information.

Multicomponent ergonomic interventions addressing primarily physical outcomes ($n=6$) were conducted between 2.25 and 30.5 h, typically in weekly (Otto & Wollesen, 2022; Ratzon et al., 2016) or twice-weekly (Warming et al., 2008) sessions lasting 45–60 min. However, three studies lacked important information regarding frequency and duration (Cooper et al., 1998; Ewert et al., 2009; Yang et al., 2021). One multicomponent ergonomic intervention that addressed psychological outcomes was conducted twice per week for about 40 min over 5 weeks; however, detailed information regarding ergonomic training is missing (Akyurek et al., 2020).

Multicomponent exercise studies for improved physical outcomes ($n=7$) had a wide range of total duration with 4.5–48 h. Jalalvandi et al. (2022) applied a regimen with three sessions per week with a short duration of only 15 min and participants in the intervention by C.-J. Zou et al. (2021) exercised for 45 min five times per week. Other studies typically had weekly training duration of 1 (Brox & Froystein, 2005; Muller et al., 2001) to 2 h (Bauer et al., 2019). Two studies (Martins & Marziale, 2012; Matsugaki et al., 2017) failed to report session durations. In exercise studies aiming to improve psychological outcomes, total duration was between 19.75 and 65 h. While three studies (Chen et al., 2014; Chen et al., 2016; Mohebbi et al., 2019) involved exercise three times per week for 50- to 60-min sessions, Ehegartner et al. (2021) delivered a 5-day intensive prevention program for a total of 19.75 h. Lastly, Das Gecim and Esin (2021) did not provide information regarding session length and session content for a 4-week intervention.

Physiotherapeutic interventions had a total duration of 12–18 h. While nurses in the study by Moreira et al. (2021) exercised twice weekly for 30 min over 12 weeks, those in the study by Becker et al. (2017) trained weekly for 45 min over 10 weeks.

In yoga studies, session duration was typically 50 min in twice-weekly sessions over 3 (Mandal et al., 2021; 20 h) to 6 months (Fang & Li, 2015; 43 h). Alexander et al. (2015) did not provide sufficient information regarding frequency and duration.

Control mechanisms. In total, 11 studies explicitly stated and applied training control mechanisms. Intensity control was used in seven studies (Ewert et al., 2009; Jalalvandi et al., 2022; Matsugaki et al., 2017; Mohebbi et al., 2019; Otto & Wollesen, 2022; Warming et al., 2008; Yuan et al., 2009), four studies pertained to progressive overload (Bauer et al., 2019; Becker et al., 2017; Martins & Marziale, 2012; Otto & Wollesen, 2022), and one study offered training variety (Alexander et al., 2015).

Further, eight studies reported the intensity of the trainings, of which three were light (Brox & Froystein, 2005; Tucker et al., 2016; Yuan et al., 2009) two were moderate (Mohebbi et al., 2019; Otto & Wollesen, 2022) and three had individualized intensity (Becker et al., 2017; Matsugaki et al., 2017; Ratzon et al., 2016).

Lastly, 19 studies were tailored to the needs of the target group or were individualized. Of those, seven were specific to back pain or LBP (Alexandre et al., 2001; Bauer et al., 2019; Jalalvandi et al., 2022; Jaromi et al., 2018; Jaromi et al., 2012; Muller et al., 2001; C.-J. Zou et al., 2021), one study was specific to shoulder pain (Martins & Marziale, 2012), and 11 studies applied a need-tailored or individualized training regimen (Becker et al., 2017; Cooper et al., 1998; Ehegartner et al., 2021; Ewert et al., 2009; Matsugaki et al., 2017; Otto & Wollesen, 2022; Ratzon et al., 2016; Tucker et al., 2016; Tucker et al., 2011; Warming et al., 2008; Yang et al., 2021).

Discussion

The overall aim of this systematic review was to illuminate the evidence regarding the efficacy of different exercise and ergonomic intervention types on the work ability of nurses. Furthermore, we included a qualitative analysis of training methods and content with respect to the FITT principles (Swain et al., 2014) and parameters of training control (e.g., RPE, progression, or variety).

In this review, nine types of exercise-based interventions in nursing settings were identified. These intervention types included aerobic exercising ($n = 1$), back school ($n = 3$), ergonomics ($n = 6$), increasing physical activity ($n = 3$), multicomponent ergonomics ($n = 6$), multicomponent exercising ($n = 12$), combination of exercising and ergonomics ($n = 1$), physiotherapy ($n = 2$), and yoga ($n = 3$).

Effectiveness of intervention types addressing physical outcomes

Light aerobic exercise on a stair stepper (Yuan et al., 2009) improved BMI, grip strength, flexibility in a sit-and-reach rest, durability of abdominal and back muscles, and cardiopulmonary function compared to an inactive control group. This exercise was done with a volume of 720–1080 min in 3 months. The improvements in the BMI as well as in cardiopulmonary functioning could have been expected due to the type of exercise (Christle & Arena, 2020). The improvements in grip strength as well as abdominal and back muscles are unexpected with respect to aerobic exercise. However, if participants are exercising on a stair-stepper they might have balanced their body movement on the stepper with holding the handrails and might have grabbed the handle bars and squeezed them. This may induce a higher grip strength. Moreover, this leads to an upright body posture with muscle activity in the abdominal and back muscles (which are also involved in the stair-stepping movements). Interestingly, these improvements were reached with light intensities. It may be possible that the participants were untrained and therefore even the light intensities were able to offer positive effects on physical fitness (Bann et al., 2015). In addition, there is some evidence that grip strength could be a marker of overall body composition and fitness (Bohannon, 2019). However, these explanations are only speculative and are not supported by the study description. Moreover, the study quality was low and therefore these results should not be overestimated, especially as this was the only study using stair-stepping exercises identified in this review.

The back school programs were able to improve body posture and the quality of the lifting performance (Jaromi et al., 2012; Jaromi et al., 2018) and to reduce cervical back pain (Alexandre et al., 2001) and non-specific back pain (Jaromi et al., 2012; Jaromi et al., 2018). In the study by Jaromi et al. (2012), the intervention was not more effective than passive physiotherapy in reducing back pain directly after the intervention. However, the positive changes in the intervention group were maintained in the 6- and 12-month follow-ups. Together with the positive changes of the lifting techniques and accompanying improvements in body posture, the nurses might have changed their lifting behavior, which led to persistent reduction in back pain (Al Johani & Pascual Pascua, 2019). To gain these effects, a total duration of 5 in 6 weeks was reported.

Included ergonomic studies ($n = 6$) exhibited improvements in movement quality and pain perceptions. In contrast to the results of the back schools including education, only one ergonomic program succeeded in reducing physical disorders and the number of sick leave days (Kindblom-Rising et al., 2011). None of the programs showed positive effects on reducing back pain compared to the control groups. One might argue that the intervention duration of classic ergonomic workshops is insufficient to gain positive effects on lifting behaviors. However, the length of the identified programs had a duration between 4 h and 112 h. Moreover, reflecting the duration of the back schools, positive results were found for a duration of 5 h in total (Jaromi et al., 2012). Out of three studies that measured follow-ups, two studies (Carta et al., 2010; Karahan & Bayraktar, 2013) reported sustainable intervention effects for ergonomic working. However, low study quality may confound the study results (M = 0.61). Thus, more high-quality interventions are necessary to establish the effects of short-term ergonomic trainings.

In addition, classic ergonomic interventions favor a straight upper body for correct lifting and carrying. A straight upper body with a strong lordotic characteristic is often presented here (the lower back tends to hollow in order to keep the back straight, especially when bending forward) and the assumption of a "rounded back" (kyphotic characteristic) is used as a potentially harmful negative example. However, there is often the contradiction that participants describe the negative example as being more pleasant, and the frequency of observations of these negative examples in practice raises the question of whether the techniques known from classic back schools are actually effective. In a combination of in vivo data and simulation models, Khoddam-Khorasani et al. (2020) compared the compression forces between lordotic, kyphotic, and medium postures and came to the conclusion that the extreme "back-friendly" lordotic upper body posture generates significantly higher compression forces and higher muscular activities than the other two variants. On the basis of the results of the study, the authors advocate adopting a middle position that avoids extreme upper body postures in one direction or the other. Therefore, one might argue that the content and the composition of the ergonomic programs should be changed, e.g., with the expertise of sports science to gain sustainable effects.

One solution might be multicomponent ergonomic programs incorporating aspects of education, ergonomic practical training, as well as strength or resistance training. In multicomponent ergonomic studies (interventions that combined ergonomic intervention and another component, e.g., exercising, meditation), mixed results were obtained regarding work ability enhancement. This may be due to the fact that intervention components trigger different physiological and psychological mechanisms. These mechanisms are linked to specific adaptation processes that require different training types, frequencies, and durations to occur (e.g., Rivera-Brown & Frontera, 2012).

Overall, five out of seven interventions led to positive results on body postures and lifting performance (Otto & Wollesen, 2022, combining ergonomics, education and strength training; Ratzon et al., 2016 combining education and physiotherapeutic exercises). Moreover, low back pain and accompanying disabilities were reduced in three of the programs (Cooper et al., 1998; Otto & Wollesen, 2022; Warming et al., 2008). The three studies combined education and strength exercises, while Warning et al. (2008) also included additional aerobic exercises. Therefore, a combination of the three components of education, ergonomic behavior, and (strength) exercises seems to be most promising. The potential benefits of classic training interventions might be one reason why the extensive ergonomic and exercise intervention by Ewert et al. (2009) did not find superior improvements in the intervention group that received ergonomic training, segmental stabilization, and cognitive-behavioral education in addition to multicomponent exercises compared to physical exercises only. Potential reasons pertain to training content selection, operation on the same psychological mechanisms as the exercise components, and inclusion of motivated participants, who may already have a good basic understanding of ergonomic work behavior.

An intervention combining progressive muscle relaxation, posture exercises, and ergonomics (Akyurek et al., 2020) was not able to gain positive effects on pain and body posture. The program had only 10 min per session for body posture exercises and the amount of ergonomic training was not specified. Therefore, one might conclude that the composition of the training was not specific enough to trigger mechanism to reduce pain and to improve body posture.

Nine multicomponent exercise studies examined physical outcomes, with eight studies reporting positive effects. Decreased pain was found for five studies that used different combinations of strength and stretching training (cf. **Table 3**; Chen et al., 2016; Chen et al., 2014; Jalalvandi et al., 2022; Martins & Marziale, 2012; Zou et al., 2021). Interestingly, the combination of the physical training with additional therapy used in the intervention by Martins and Marziale (2012) did not add further benefits.

Also, improvements of strength and trunk muscle coordination were reported in three studies (Matsugaki et al., 2017; Muller et al., 2001; Zou et al., 2021). These effects might be explained by the exercise specificity (cf. **Table 3**). However, exercise and test specificity might be a potential problem with respect to the reported benefits of the interventions. For instance, the study by Muller et al. (2001) examined coordination training for nurses, and while they found an improvement of trunk muscle coordination, there were no posturography-related improvements. With no balance-specific training components, it cannot be expected to find improvements in posturographic outcomes.

The aspect of specificity is also addressed in physiotherapy. In the integrated studies of this review, physiotherapy seems to improve work ability by changing various physical and psychological parameters (mobility, strength, psychological well-being, pain perception; Becker et al., 2017; Moreira et al., 2021). One major advantage of physiotherapy is that it should be designed to tackle the specific complaints of clients. Nevertheless, the extensive requirements regarding financial, personnel, and time-related resources might hinder the feasibility of physiotherapeutic approaches (Kreis, 2003).

Effectiveness of intervention types addressing psychological outcomes

A total number of 10 studies addressed psychological outcomes such as stress and QoL (cf. **Tables 2 and 3**). In the eight programs with positive benefits on stress outcomes, three used a yoga intervention (Alexander et al., 2015; Fang & Li, 2015; Mandal et al., 2021). In line with previous literature (e.g., Bischoff et al., 2019; Otto & Wollesen, 2022), significant effects on stress perceptions in nursing personnel were observed after a total intervention time of 20 h (50-min sessions two times/week). Unfortunately, no yoga study included follow-up measurements, nor was the yoga intervention compared with other intervention types. Moreover, the study quality was only moderate.

One might argue that yoga has the potential to improve biochemical markers of stress (Riley & Park, 2015); however, Mandal et al. (2021) did not find improvements in biochemical outcomes after a 20-h yoga intervention.

One study examining multicomponent ergonomics including progressive muscle relaxation and breathing exercises assessed primarily psychological outcomes (Akyurek et al., 2020). Applying the curriculum twice per week for 5 weeks was linked to improved coping strategies as well as less perceived subjective stress and burnout symptoms. However, the lack of information concerning session duration is unfortunate and does not allow further conclusions to be drawn on adaptative mechanism.

Two studies evaluated the effect of a multicomponent exercising regimen on stress outcomes (Ehegartner et al., 2021; Mohebbi et al., 2021). The 5-day prevention program by Ehegartner et al. (2021; total duration of 19.75 h) led to short-term effects on stress reduction, but desirable effects diminished at the 9-month follow-up. Mohebbi et al. (2019) assessed a multicomponent aerobic training (24 h, three times/week for 1 h). Participants improved on stress-related outcomes: Unfortunately, no training-appropriate outcomes such as VO_{2max} were assessed to offer conclusions, e.g., with respect to the stress-buffering hypotheses (for an overview, cf. Bischoff et al., 2019).

It should be noted that one study that aimed to increase physical activity (Lavoie-Tremblay et al., 2014) was able to reduce sitting times but led to significant higher stress values in the intervention group. Whether this result was due to a higher effort that had to be managed next to the daily working tasks or whether this aspect refers to, e.g., the physical activity paradox (Janssen & Voelcker-Rehage, 2023) cannot be answered in this review. Moreover, a short-term intervention with the goal to increase general physical activity may not be sufficient to induce stress-buffering effects (Gerber, Kellmann, Hartmann, & Pühse, 2010).

Quality-of-life parameters were examined in three interventions: multicomponent training including several exercises, ergonomics, and cognitive-behavioral aspects (Ewert et al., 2009); self-management training including health behavior, yoga, and nutrition (Das Gecim and Esin, 2021); coordination exercises combined with preventive education (Muller et al., 2001). None of these interventions exhibited an effect on QoL from pre- to post-testing. Previous studies on health-related QoL showed that, e.g., compassion fatigue, burnout, and compassion satisfaction influence the physical and mental components of QoL in nurses (Ruiz-Fernández et al., 2020). These aspects were not specifically addressed in these interventions. This might be one explanation why the measurement of QoL as surrogate marker did not show positive effects. Moreover, it needs to be discussed whether a self-management intervention should be combined with supervised training, as supervision guarantees appropriate training and exercise execution (Ninot et al., 2011).

Effectiveness of intervention types addressing increasing physical activity

Finally, three studies examined a self-managed physical activity challenge in hospital nurses (Lavoie-Tremblay et al., 2014; Tucker et al., 2011; Tucker et al., 2016). The trials had effects on reduced sedentary and inactivity times as well as weight loss and BMI. However, the examined stress outcomes did not change in the desired direction. The interventions were based on a motivational, self-management and therefore non-supervised model. Also, the studies used a gamification approach where participants could compare themselves with their participating colleagues. It has been found that there are moderating effects for gamification elements for participants who do not meet the WHO criteria on health-promoting physical activity (Bischoff, Baumann, Meixner, Nixon, & Wollesen, 2021). Specifically, different personality types may have differential preferences for gamified health promotion (Ghaban & Hendley, 2019). Thus, need-tailored gamification aspects should be considered in future self-managed WHPPs.

Benefits of identified training principles and control of training load

Frequency and duration. A total of 15 studies failed to include relevant information pertaining to frequency, duration, or training session intervals (cf. **Table 3**). In particular ergonomic studies omitted details, leading to ambiguity regarding frequency, session duration, and session intervals. Studies with more exercise-related content were more often formulated clear specifications toward frequency and duration of trainings. For intervention studies that do not rely on a self-management model (e.g., mhealth interventions; Krebs, Prochaska, & Rossi, 2010), providing information on training principles should be the default to aid rigorous efficacy analyses.

Further, the high variability in training duration in the intervention types renders analysis difficult. However, it is noticeable that two sessions per week resulted predominantly in a reduction of back pain. This is in line with the findings of Wackerhage et al. (2021), who recommend a frequency of two training sessions per week.

Ergonomic studies with total duration of between 4 and 112 h exhibit poor reporting quality and highly heterogenous effectiveness. For instance, the most extensive intervention time (112 h; Hartvigsen et al., 2005) had no effects on pain and general health. However, the results showed improved lifting techniques with at least 4 h of intervention (Best, 1997; Carta et al., 2010; Feldstein et al., 1993; Karahan & Bayraktar, 2013; Kindblom-Rising et al., 2011). Thereby, the frequency of intervention units is often not specified. Further studies with high quality are needed to verify the effects (Otto et al., 2021).

Multicomponent ergonomic interventions were also highly variable concerning intervention duration, but there is a clear indication that intervention duration of 22 weeks (once a week) is associated with reduced back pain and improved working technique (Otto & Wollesen, 2022). This is linked to the finding that increased intervention effectiveness is associated with higher intervention duration (Greaves et al., 2011). Furthermore, long-term studies showed an average of 66 days for behavioral changes and 12–16 weeks for improvements in strength, reinforcing the study's findings (Prieske et al., 2019; Scherenberg et al., 2018).

Therapeutic approaches can have subjective psychological effects for nurses at a total duration of 18 h in ten weekly sessions; however, these changes were not associated with objective strength measures (Becker et al., 2017). However, the therapeutic exercises in the study by Moreira et al. (2021) were linked to strength increases at a total time of 12 h, delivered twice weekly within 12 weeks. This difference may be due to the healthy participants in their study (2021) who did not suffer from pain during the intervention.

Lastly, yoga can have psychological effects on sleep quality and stress perception with two 50-min training sessions per week within 12 weeks. This was also found in the review by Zou et al. (2018), who recommend at least 60 min of yoga practice weekly over 12–16 weeks for psychological health effects.

Training intensity. Concerning intensity, only eight studies explicitly mentioned training intensity (cf. **Table 3**). For light intensity ($n = 3$), results were mixed. It might not be sufficient to induce cardiovascular changes with light-intensity exercises, even with relatively high training load (Brox & Froystein, 2005). When moderate training intensities were applied ($n = 2$), effects on work ability improved. However, Mohebbi et al. (2019) did not analyze training specific outcomes but merely self-reported stress. This is unfortunate in training- and exercise-based studies that are likely to induce training-specific adaptations (e.g., Gibala, Little, MacDonald, & Hawley, 2012). Individual intensity studies ($n = 3$) were effective in reducing pain and improving body posture, strength, and vital parameters such as VO_{2max}. However, results were heterogeneous between studies, which may be due to very different total intervention volumes. Also, intensity is merely one of many aspects for training individualization and should be combined with further control mechanisms (Simpson et al., 2021).

Individualization and need-tailoring. Overall, 19 studies intervened with an individualized or need-tailored approach (cf. **Table 3**). Studies that aimed to improve region-specific pain levels (back or shoulder; $n = 9$) for injured nurses typically exhibited the desired results. However, maintaining work ability over long periods of time is a multifaceted endeavor and should consider both injured and non-injured nurses. Thus, need-tailoring and individualization procedures should incorporate multiple aspects of individuals, such as physical, psychological, and social circumstances (Bull et al., 2020). Additionally, the other studies with an individualized or need-tailored approach demonstrated predominantly positive effects with regard to their investigated outcomes ($n = 8$). This highlights the importance for individualized need-tailored interventions that consider nurses' needs, wishes, and barriers (Otto et al., 2021; van Hoof et al., 2018). This approach has been shown to promote sustainable and long-term behavioral modifications and increase the employees' motivation (Wollesen et al., 2016).

Training control. Training control mechanisms were mentioned by 11 studies and included intensity control ($n = 7$), progressive overload ($n = 4$), and variety ($n = 1$; cf. **Table 3**). Studies with intensity control typically exhibited positive results at postintervention for outcomes that were associated with training aspects that were controlled for intensity. Similarly, progressive overload was associated with outcome improvement for various pain-, strength-, and movement-related parameters at postintervention in strength-based studies. The results point to the added value of sport science-based training control procedures (Borresen & Lambert, 2009).

Training principles and controls should be described as a default in exercise-based studies so as to allow for more thorough and detailed assessment and increase intervention efficacy. Where detailed description of training principles is missing, heterogenous effects of similar exercise interventions ensue (Herold, Müller, Gronwald, & Müller, 2019).

Strengths and limitations

This systematic review is the first in-depth analysis of exercise-based WHPP intervention types in different nursing settings. Additionally, the study shed light on the usage of relevant training principles in WHPPs. To our knowledge, the analysis of FITT and training control principles is unique in a WHPP setting and should become a standard procedure for WHPP and other health promotion reviews in order to establish common ground for the evaluation of intervention quality. Furthermore, we identified a large gap in the health promotion literature in the geriatric and outpatient setting. Additionally, this review could identify specific shortcomings of WHPPs in nurses. For instance, a lack of follow-up measurements and missing information pertaining to relevant training principles prevent the analysis of long-term adaptations to exercise regimens.

One limitation of the study pertains to the fact that our search strategy may not have detected all appropriate studies within the scope of our research aims. After checking the literature lists of related reviews (Bischoff et al., 2019; Otto et al., 2021), we believe that we identified the majority of relevant studies. However, we included all identified study types and did not focus on RCTs specifically. This might influence the evidence gained from the results due to missing control groups. Furthermore, with respect to theories of work ability, work performance, or work capacity, the results of this review might be limited. Future reviews should include additional outcomes regarding psychosomatic symptoms, work ability, and occupational health models. Also, the heterogeneity of outcomes was rather large. Comparisons between studies and a meta-analytical approach are therefore not feasible. Future studies may aim for the assessment of more homogeneous outcomes and rely on validated, often-used questionnaires rather than self-developed scales to allow for meta-analytic analyses in the future. Finally, while we contacted researchers for full texts of retrieved studies, we did not contact authors who failed to report full result details such as missing significance values.

Conclusion and recommendations

The review showed that intervention types such as back school, multicomponent ergonomics and training interventions, as well as yoga positively impact work ability via psychological and physical mechanisms.

Regarding evidence-based training principles, this review showed for the nursing setting that training specificity leads to benefits in the evaluated outcomes. In line with the previous literature, this was shown for improving ergonomic behavior in back schools and some of the ergonomic interventions, reducing back pain in combined interventions using in particular ergonomic and strength training and in reducing stress by yoga interventions. Moreover, regarding multicomponent training interventions including strength, endurance, and flexibility training, these interventions were as effective as physiotherapy. While the review clearly showed that different intervention types can lead to improvements in work ability at postintervention, only one study that included follow-ups found an improvement after 12 months postintervention, which relied heavily on the autonomy and self-responsibility of the participants. Accordingly, future studies should attempt to innovate workplace health promotion programs (WHPPs) in a way that allows for sustainable long-term work ability improvements. Also, integration of sport scientific expertise concerning training control mechanisms for enhanced health promotion program success is essential to achieve sustainable effects on the work ability of nurses and other target groups.

Moreover, this systematic review showed that WHPPs in nursing settings currently may not adhere to the setting approach sufficiently, as suggested by the lack of studies in two of the analyzed settings. To ensure a high work ability of the entire nursing work force, it is very important to conduct WHPPs in all nursing settings so as to avoid nursing crises in the future. To accomplish this, there is a need for more high-quality intervention studies such as randomized controlled trials that identify feasible exercise-based WHPPs in nursing settings conducted according to evidence-based training principles.

Corresponding address

Ann-Kathrin Otto
Institute of Human Movement Science, University of Hamburg
Turmweg 2, 20148 Hamburg, Germany
ann-kathrin.otto@uni-hamburg.de

Acknowledgements. We thank MF for supporting us with her expertise for the quality assessment of one study. We acknowledge financial support from the Open Access Publication Fund of Universität Hamburg.

Author Contribution. BW had the original idea for the article and supervised the writing. LH and AKO performed the literature search, applied eligibility criteria, and conducted quality scoring of included articles. LH performed the qualitative synthesis of included studies and drafted the manuscript. AKO and BW critically revised the work.

Funding. Open Access funding enabled and organized by Projekt DEAL.

Declarations

Conflict of interest. L. Heuel, A.-K. Otto and B. Wollesen declare that there is a conflict of interest due to Bettina Wollesen's position as Editor-in-Chief of the *German Journal of Exercise and Sport Research*.

For this article no studies with human participants or animals were performed by any of the authors. All studies mentioned were in accordance with the ethical standards indicated in each case.

Open Access. This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

Appendix

Appendix A. Excluded studies

Table 5 Excluded studies in alphabetical order with reason for exclusion

Study	Reason for exclusion
Anderson, R., Mammen, K., Paul, P., Pletch, A., & Pulia, K. (2017). Using Yoga Nidra to Improve Stress in Psychiatric Nurses in a Pilot Study. *Journal of Alternative & Complementary Medicine*, 23(6), 494–495	Included non-nursing participants/different population
Anyan, W., Faraklas, I., Morris, S., & Cochran, A. (2013). Overhead lift systems reduce back injuries among burn care providers. *Journal of Burn Care & Research*, 34(6), 586–590	
Cantarella, C., Stucchi, G., Menoni, O., Consonni, D., Cairoli, S., Manno, R., Tasso, M., Galinotti, L., & Battevi, N. (2020). MAPO method to assess the risk of patient manual handling in hospital wards: A validation study. *Human Factors*, 1141–1149	
Carter, P. A., Dyer, K. A., & Mikan, S. Q. (2013). Sleep Disturbance, Chronic Stress, and Depression in Hospice Nurses: Testing the Feasibility of an Intervention. *Clinical Journal of Oncology Nursing*, 17, E368–73	
Clayton, M. F., Iacob, E., Reblin, M., & Ellington, L. (2019). Hospice nurse identification of comfortable and difficult discussion topics: Associations among self-perceived communication effectiveness, nursing stress, life events, and burnout. *Patient Education and Counseling*, 102(10), 1793–1801	
Daynard, D., Yassi, A., Cooper, J. E., Tate, R., Norman, R., & Wells, R. (2001). Biomechanical analysis of peak and cumulative spinal loads during simulated patient-handling activities: A substudy of a randomized controlled trial to prevent lift and transfer injury of health care workers. *Applied Ergonomics*, 32(3), 199–214	
Doran, K., Resnick, B., Kim, N., Lynn, D., & McCormick, T. (2017). Applying the social ecological model and theory of self-efficacy in the Worksite Hart Health Improvement Project-PLUS. *Research & Theory for Nursing Practice*, 8–27	
Evanoff, B. A., Bohr, P. C., & Wolf, L. D. (1999). Effects of a participatory ergonomics team among hospital orderlies. American Journal of Industrial Medicine (35), 358–365	
Fillion, L., Duval, S., Dumont, S., Gagnon, P., Tremblay, I., Bairati, I., & Breitbart, W. S. (2009). Impact of a meaning-centered intervention on job satisfaction and on quality of life among palliative care nurses. *Psycho-Oncology*, 18(12), 1300–1310	
Freitas, A. R., Carneseca, E. C., Paiva, C. E., & Sakamoto Ribeiro Paiva, B. (2014). Impact of a physical activity program on the anxiety, depression, occupational stress and burnout syndrome of nursing professionals. *Revista Latino-Americana De Enfermagem (RLAE)*, 22(2), 332–336	
Kalicinska, M., Chylinska, J., & Wilczek-Rozyczka, E. (2012). Professional burnout and social support in the workplace among hospice nurses and midwives in Poland. *International Journal of Nursing Practice*, 18(6), 595–603	
Kusma, B., Pietsch, A., Riepenhof, H., Haß, S., Kuhn, D., Fischer, K., & Nienhaus, A. (2019). The Back College for nurses—an evaluation of intermediate effects. *Journal of Occupational Medicine & Toxicology*, 14, 19	
Lennefer, T., Lopper, E., Wiedemann, A. U., Hess, U., & Hoppe, A. (2020). Improving employees' work-related well-being and physical health through a technology-based physical activity intervention: A randomized intervention-control group study. *Journal of Occupational Health Psychology*, 143–158	
Levy, J. A., & Gordon, A. K. (1987). Stress and burnout in the social world of hospice. *Hospice Journal*, 3(2–3), 29–51	
Lim, H. J., Black, T. R., Shah, S. M., Sarker, S., & Metcalfe, J. (2011). Evaluating repeated patient handling injuries following the implementation of a multi-factor ergonomic intervention program among health care workers. *Journal of Safety Research*, 42(3), 185–191	
Lok, N., & Bademli, K. (2017). Pilot testing of the "First You Should Get Stronger" program among caregivers of older adults with dementia. *Archives of Gerontology and Geriatrics*, 68, 84–89	
Rasmussen, C. D. N., Holtermann, A., Bay, H., Sogaard, K., & Birk Jorgensen, M. (2015). A multifaceted workplace intervention for low back pain in nurses' aides: A pragmatic stepped wedge cluster randomised controlled trial. *Pain*, 156(9), 1786–1794	
Rasmussen, C. D. N., Holtermann, A., Jorgensen, M. B., Orberg, A., Mortensen, O. S., & Sogaard, K. (2016). A multi-faceted workplace intervention targeting low back pain was effective for physical work demands and maladaptive pain behaviours, but not for work ability and sickness absence: Stepped wedge cluster randomised trial. *Scandinavian Journal of Public Health*, 44(6), 560–570	
Richman, J. M., & Rosenfeld, L. B. (1987). Stress reduction for hospice workers: A support group model. *Hospice Journal*, 3(2–3), 205–221	
Risor, B. W., Casper, S. D., Andersen, L. L., & Sorensen, J. (2017). A multi-component patient-handling intervention improves attitudes and behaviors for safe patient handling and reduces aggression experienced by nursing staff: A controlled before-after study. *Applied Ergonomics*, 74–82	
Wasner, M., Longaker, C., Fegg, M. J., & Borasio, G. D. (2005). Effects of spiritual care training for palliative care professionals. *Palliative Medicine*, 19(2), 99–104	

Table 5 (Continued)

Study	Reason for exclusion
Bazarko, D., Cate, R. A., Azocar, F., & Kreitzer, M. J. (2013). The impact of an innovative mindfulness-based stress reduction program on the health and well-being of nurses employed in a corporate setting. *Journal of Workplace Behavioral Health*, 107–133	Wrong study design
Bost, N., & Wallis, M. (2006). The effectiveness of a 15 minute weekly massage in reducing physical and psychological stress in nurses. *The Australian Journal of Advanced Nursing: A Quarterly Publication of the Royal Australian Nursing Federation,* 23(4), 28–33	
Botha, E., Gwin, T., & Purpora, C. (2015). The effectiveness of mindfulness based programs in reducing stress experienced by nurses in adult hospital settings: A systematic review of quantitative evidence protocol. *JBI Database of Systematic Reviews and Implementation Reports*, 13(10), 21–29	
Budarick, A. R., Lad, U., & Fischer, S. L. (2020). Can the use of turn-assist surfaces reduce the physical burden on caregivers when performing patient turning? *Human Factors*, 77–92	
Diaz-Rodriguez, L., Arroyo-Morales, M., Cantarero-Villanueva, I., Fernandez-Lao, C., Polley, M., & Fernandez-De-Las-Penas, C. (2011). The application of Reiki in nurses diagnosed with burnout syndrome has beneficial effects on concentration of salivary IgA and blood pressure. *Revista Latino Americana De Enfermagem*, 19(5), 1132–1138	
Engkvist, I.-L. (2006). Evaluation of an intervention comprising a no lifting policy in Australian hospitals. *Applied Ergonomics*, 37(2), 141–148	
Eren, N. B., & Oztunc, G. (2017). The effects of aromatherapy on the stress and anxiety levels of nurses working in intensive care units. *International Journal of Caring Sciences*, 10(3), 1615–1623	
Guthrie, P. F., Westphal, L., Dahlman, B., Berg, M., Behnam, K., & Ferrell, D. (2004). A patient lifting intervention for preventing the work-related injuries of nurses. *IOS Press*, (22), 79–88	
Hrabe, D. P., Melnyk, B. M., Buck, J., & Sinnott, L. T. (2017). Effects of the Nurse Athlete Program on the Healthy Lifestyle Behaviors, Physical Health, and Mental Well-being of New Graduate Nurses. *Nursing Administration Quarterly*, 41(4), 353–359	
Hunter, L. (2016). Making time and space: The impact of mindfulness training on nursing and midwifery practice. A critical interpretative synthesis. Journal of Clinical Nursing, 918–929	
Isaksson, Ro, KE, Gude, T., Tyssen, R., & Aasland, O. G. (2010). A self-referral preventive intervention for burnout among Norwegian nurses: One-year follow-up study. *Patient Education & Counseling*, 78(2), 191–197	
Jensen, H. I., Markvart, J., Holst, R., Thomsen, T. D., Larsen, J. W., Eg, D. M., & Nielsen, L. S. (2016). Shift work and quality of sleep: Effect of working in designed dynamic light. *International Archives of Occupational & Environmental Health*, 89(1), 49–61	
Jukic, T., Ihan, A., Šter, M. P., Strojnik, V., Stubljar, D., Starc, A., & Petek-Šter, M. (2020). Adherence of Female Health Care Workers to the Use a Web-Based Tool for Improving and Modifying Lifestyle: Prospective Target Group Pilot Study. *Journal of Medical Internet Research*, 22(8)	
Kurebayashi, L. F., & da, Silva, MJ (2015). Chinese auriculotherapy to improve quality of life of nursing team. *Revista Brasileira De Enfermagem*, 68(1), 109–15, 117–23	
Kutash, M., Short, M., Shea, J., & Martinez, M. (2009). The Lift Team's Importance to a Successful Safe Patient Handling Program. The Journal of Nursing Administration, 39(4), 170–175	
Lehmann, A. I., Brauchli, R., Jenny, G. J., Fullemann, D., & Bauer, G. F. (2020). Baseline psychosocial and affective context characteristics predict outcome expectancy as a process appraisal of an organizational health intervention. *International Journal of Stress Management*, 1–11	
Li, J., Wolf, L., & Evanoff, B. (2004). Use of mechanical patient lifts decreased musculoskeletal symptoms and injuries among health care workers. Injury Prevention: *Journal of the International Society for Child and Adolescent Injury Prevention*, 10(4), 212–216	
Lomas, T., Medina, J. C., Ivtzan, I., Rupprecht, S., & Eiroa-Orosa, F. J. (2019). A systematic review and meta-analysis of the impact of mindfulness-based interventions on the well-being of healthcare professionals. Mindfulness, 1193–1216	
Maatouk, I., Muller, A., Angerer, P., Schmook, R., Nikendei, C., Herbst, K., Gantner, M., Herzog, W., & Gundel, H. (2018). Healthy ageing at work—Efficacy of group interventions on the mental health of nurses aged 45 and older: Results of a randomised, controlled trial. *PLoS ONE*, 13(1), e0191000	
McDonald, G., Jackson, D., Wilkes, L., & Vickers, M. H. (2013). Personal resilience in nurses and midwives: Effects of a work-based educational intervention. Contemporary Nurse: *A Journal for the Australian Nursing Profession*, 45(1), 134–143	
Rasmussen, C. D. N., Holtermann, A., Mortensen, O. S., Sogaard, K., & Jorgensen, M. B. (2013). Prevention of low back pain and its consequences among nurses' aides in elderly care: A stepped-wedge multi-faceted cluster-randomized controlled trial. *BMC Public Health*, 13, 1088	
Saavedra, J., Murvartian, L., & Vallecillo, N. (2020). Health and burnout of home health care assistants: Impact of a training intervention. *Anales De Psicologia*, 30–38	
Sampson, M., Melnyk, B. M., & Hoying, J. (2020). The MINDBODYSTRONG Intervention for New Nurse Residents: 6-Month Effects on Mental Health Outcomes, Healthy Lifestyle Behaviors, and Job Satisfaction. *Worldviews on Evidence Based Nursing*, 17(1), 16–23	
Springer, P. J., Lind, B. K., Kratt, J., Baker, E., & Clavelle, J. T. (2009). Preventing Employee Injury. *AAOHN Journal* (57), 143–148	
Steinberg, B. A., Klatt, M., & Duchemin, A. M. (2016). Feasibility of a Mindfulness-Based Intervention for Surgical Intensive Care Unit Personnel. *American Journal of Critical Care*, 26(1), 10–18	

Table 5 (Continued)	
Study	**Reason for exclusion**
Stevens, M. L., Boyle, E., Hartvigsen, J., Mansell, G., Sogaard, K., Jorgensen, M. B., Holtermann, A., & Rasmussen, C. D. N. (2019). Mechanisms for reducing low back pain: A mediation analysis of a multifaceted intervention in workers in elderly care. *International Archives of Occupational and Environmental Health*, 92(1), 49–58	Wrong study design
Terry, V. R., Graham, C. J., Rogers, C., Craigie, M., Hegney, D. G., Rees, C. S., & Small, C. (2020). Building resilience among rural and remote nurses in Queensland, Australia. Collegian, 27(3), 265–270	
Turan, N. (2021). An investigation of the effects of an anger management psychoeducation programme on psychological resilience and affect of intensive care nurses. *Intensive & Critical Care Nursing*, 62, N.PAG-N.PAG	
Zadvinskis, I. M., & Salsbury, S. L. (2010). Effects of a multifaceted minimal-lift environment for nursing staff: Pilot results. Western Journal of Nursing Research, 32(1), 47–63	
Marshall, L., Villeneuve, J., & Grenier, S. (2018). Effectiveness of a multifactorial ergonomic intervention and exercise conditioning kinesiology program for subsequent work related musculoskeletal disorder prevention. *Work (Reading, Mass.)*, 61(1), 81–89	No separate exercise component analysis
Soler-Font, M., Ramada, J. M., van Zon, Sander K R, Almansa, J., Bultmann, U., & Serra, C. (2019). Multifaceted intervention for the prevention and management of musculoskeletal pain in nursing staff: Results of a cluster randomized controlled trial. *PLoS ONE*, 14(11), e0225198	
Speroni, K. G., Williams, D. A., Seibert, D. J., Gibbons, M. G., & Earley, C. (2013). Helping nurses care for self, family, and patients through the nurses living fit intervention. *Nursing Administration Quarterly*, 37(4), 286–294	
Tveito, T. H., & Eriksen, H. R. (2009). Integrated health programme: A workplace randomized controlled trial. *Journal of Advanced Nursing*, 65(1), 110–119	
Oka, H., Nomura, T., Asada, F., Takano, K., Nitta, Y., Uchima, Y., Sato, T., Kawase, M., Sawada, S., Sakamoto, K., Yasue, M., Arima, S., Katsuhira, J., Kawamata, K., Fujii, T., Tanaka, S., Konishi, H., Okazaki, H., Miyoshi, K., … Matsudaira, K. (2019). The effect of the 'One Stretch' exercise on the improvement of low back pain in Japanese nurses: A large-scale, randomized, controlled trial. *Modern Rheumatology*, 29(5), 861–866	Retrieval of full-text not possible

Appendix B. Search strategy

"registered nurses" or "nursing staff" or "nurses" or "hospital nurses" or "health care nurses" or "nursing auxiliary" or "nursing aides" or "care assistant" or "nursing workers" or "attendant nurses" or "medic nurses" or "home care nurses" or "ambulant nurses" or "outpatient nurses" or "nursing person" or "nursing personnel" or "assistant nursing staff" or "geriatric nurses" or "gerontological nurses" or "elderly care nurses" or "aged care nurses" or "community health nurs*"

and "ergonomics" or "training" or "coordinative training" or "workplace health promotion" or "health promotion" or "prevention" or "primary prevention" or "occupational health promotion" or "exercise" or "intervention" or "physical activity" or "sports" or "work$ health promot$" or "work$ improv$" or "promot$ health" or "improv$ work$ health" or "health develop$" or "health work$ environment" or "training"

"musculoskeletal disease$" or "back pain" or "pain" or "injuries" or "physiological stress" or "physical health" or "incapacity of work" or "sick days" or "sick leave days" or "sickness" or "absenteeism" or "presenteeism" or "sick leaves" or "well-being" or "burden" or "health status" or "job satisfaction" or "turn over" "stress" or "mental illness" or "depression" or "burnout" or "job exposure" or "strain" or "anxiety" or "tension" or "mental disorder" or "derangement" or "mental disease" or "mental sickness" or "mental wellbeing" or "psychological load" or "mental load" or "mental strain" or "emotional instability" or "nervous"

Searches were conducted on CINAHL, Medline, and PsycInfo.

References

Akyurek, G., Avci, N., & Ekici, G. (2020). The effects of "Workplace Health Promotion Program" in nurses: A randomized controlled trial and one-year follow-up. *Health Care for Women International*, 16 (1), 16-20. https://doi.org/10.1080/07399332.2020.1800013.

Al Johani, W. A., & Pascual Pascua, G. (2019). Impacts of manual handling training and lifting devices on risks of back pain among nurses: an integrative literature review. *Nurse Media Journal of Nursing*, 9(2), 2010-2030. https://doi.org/10.14710/nmjn.v9i2.26435.

Alexander, G. K., Rollins, K., Walker, D., Wong, L., & Pennings, J. (2015). Yoga for self-care and burnout prevention among nurses. *Workplace Health & Safety*, *63*(10), 462–470. https://doi.org/10.1177/2165079915596102.

Alexandre, N. M., de Moraes, M. A., Correa Filho, H. R., & Jorge, S. A. (2001). Evaluation of a program to reduce back pain in nursing personnel. *Revista De Saude Publica*, *35*(4), 356–361. https://doi.org/10.1590/s0034-89102001000400004.

Alshamrani, M. M., El-Saed, A., Al Zunitan, M., Almulhem, R., & Almohrij, S. (2021). Risk of COVID-19 morbidity and mortality among healthcare workers working in a large tertiary care hospital. *International Journal of Infectious Diseases*, *109*, 238–243. https://doi.org/10.1016/j.ijid.2021.07.009.

Bann, D., Hire, D., Manini, T., Cooper, R., Botoseneanu, A., McDermott, M. M., Pahor, M., Glynn, N. W., Fielding, R., & King, A. C. (2015). Light Intensity physical activity and sedentary behavior in relation to body mass index and grip strength in older adults: cross-sectional findings from the Lifestyle Interventions and Independence for Elders (LIFE) study. *PloS One*, *10*(2), e116058. https://doi.org/10.1371/journal.pone.0116058.

Bauer, C. M., Kankaanpaa, M. J., Meichtry, A., Rissanen, S. M., & Suni, J. H. (2019). Efficacy of six months neuromuscular exercise on lumbar movement variability—A randomized controlled trial. *Journal of Electromyography and Kinesiology : Official Journal of the International Society of Electrophysiological Kinesiology*, *48*, 84–93. https://doi.org/10.1016/j.jelekin.2019.06.008.

Becker, A., Angerer, P., & Muller, A. (2017). The prevention of musculoskeletal complaints: A randomized controlled trial on additional effects of a work-related psychosocial coaching intervention compared to physiotherapy alone. *International Archives of Occupational and Environmental Health*, *90*(4), 357–371. https://doi.org/10.1007/s00420-017-1202-6.

Best, M. (1997). An evaluation of manutention training in preventing back strain and resultant injuries in nurses. *Safety Science*, *25*(1–3), 207–222. https://doi.org/10.1016/S0925-7535(97)00003-9.

Billinger, S. A., Boyne, P., Coughenour, E., Dunning, K., & Mattlage, A. (2015). Does aerobic exercise and the FITT principle fit into stroke recovery? *Current

Neurology and Neuroscience Reports, *15*(2), 519. https://doi.org/10.1007/s11910-014-0519-8.
Bischoff, L. L., Otto, A.-K., Hold, C., & Wollesen, B. (2019). The effect of physical activity interventions on occupational stress for health personnel: A systematic review. *International Journal of Nursing Studies*, *97*, 94–104. https://doi.org/10.1016/j.ijnurstu.2019.06.002.
Bischoff, L. L., Baumann, H., Meixner, C., Nixon, P., & Wollesen, B. (2021). App-tailoring requirements to increase stress management competencies within families: cross-sectional survey study. *Journal of Medical Internet Research*, *23*(7), e26376. https://doi.org/10.2196/26376.
Bohannon, R. W. (2019). Grip strength: an indispensable biomarker for older adults. *Clinical Interventions in Aging*, 97, 94-104. https://doi.org/10.2147/CIA.S.
Borresen, J., & Lambert, M. I. (2009). The quantification of training load, the training response and the effect on performance. *Sports Medicine (Auckland, N.Z.)*, *39*, 779–795. https://doi.org/10.2165/11317780-000000000-00000.
Brox, J. I., & Froystein, O. (2005). Health-related quality of life and sickness absence in community nursing home employees: Randomized controlled trial of physical exercise. *Occupational Medicine (Oxford, England)*, *55*(7), 558–563. https://doi.org/10.1093/occmed/kqi153.
Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.-P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., & Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, *54*(24), 1451–1462. https://doi.org/10.1136/bjsports-2020-102955.
Carta, A., Parmigiani, F., Roversi, A., Rossato, R., Milini, C., Parrinello, G., Apostoli, P., Alessio, L., & Porru, S. (2010). Training in safer and healthier patient handling techniques. *British Journal of Nursing (Mark Allen Publishing)*, *19*(9), 576–582. https://doi.org/10.12968/bjon.2010.19.9.48057.
Chen, H. M., Wang, H.-H., Chen, C.-H., & Hu, H.-M. (2014). Effectiveness of a stretching exercise program on low back pain and exercise self-efficacy among nurses in Taiwan: A randomized clinical trial. *Pain Management Nursing : Official Journal of the American Society of Pain Management Nurses*, *15*(1), 283–291. https://doi.org/10.1016/j.pmn.2012.10.003.
Chen, H. M., Wang, H. H., & Chiu, M. H. (2016). Effectiveness of a releasing exercise program on anxiety and self-efficacy among nurses. *Western Journal of Nursing Research*, *38*(2), 169–182. https://doi.org/10.1177/0193945914555405.
Christle, J. W., & Arena, R. (2020). Cardiopulmonary exercise testing and prescription of exercise. In *Textbook of sports and exercise cardiology* (pp. 897–912). https://doi.org/10.1007/978-3-030-35374-2_43.
Çınar-Medeni, Ö., Elbasan, B., & Duzgun, I. (2017). Low back pain prevalence in healthcare professionals and identification of factors affecting low back pain. *Journal of Back and Musculoskeletal Rehabilitation*, *30*(3), 451–459. https://doi.org/10.3233/BMR-160571.
Converso, D., Sottimano, I., Guidetti, G., Loera, B., Cortini, M., & Viotti, S. (2017). Aging and work ability: the moderating role of job and personal resources. *Frontiers in Psychology*, *8*, 2262. https://doi.org/10.3389/fpsyg.2017.02262.
Cooper, J. E., Tate, R. B., & Yassi, A. (1998). Components of initial and residual disability after back injury in nurses. *Spine*, *23*(19), 2118–2122. https://doi.org/10.1097/00007632-199810010-00016.
Curry, J., Patterson, M., Greenley, S., Pearson, M., & Forbes, C. C. (2021). Feasibility, acceptability, and efficacy of online supportive care for individuals living with and beyond lung cancer: A systematic review. *Supportive Care in Cancer : Official Journal of the Multinational Association of Supportive Care in Cancer*, *29*(11), 6995–7011. https://doi.org/10.1007/s00520-021-06274-x.
Das Gecim, G. Y., & Esin, M. N. (2021). A self-management programme for work ability and quality of life in nurses aged 45 years and over: A randomized controlled trial. *International Journal of Nursing Practice*. https://doi.org/10.1111/ijn.12963.
Dawson, A. P., McLennan, S. N., Schiller, S. D., Jull, G. A., Hodges, P. W., & Stewart, S. (2007). Interventions to prevent back pain and back injury in nurses: a systematic review. *Occupational and Environmental Medicine*, *64*(10), 642–650.
Ehegartner, V., Kirschneck, M., Wilhelm, E. M., Frisch, D., Schuh, A., & Kus, S. (2021). PFLEGEprevent—A randomized controlled intervention study on the effectiveness of a prevention program on caregiver workload. *Gesundheitswesen (Bundesverband der Arzte des Offentlichen Gesundheitsdienstes (Germany))*, *83*(5), 374–383. https://doi.org/10.1055/a-1160-5624.
Ewert, T., Limm, H., Wessels, T., Rackwitz, B., von Garnier, K., Freumuth, R., & Stucki, G. (2009). The comparative effectiveness of a multimodal program versus exercise alone for the secondary prevention of chronic low back pain and disability. *PM & R: The Journal of Injury, Function, and Rehabilitation*, *1*(9), 798–808. https://doi.org/10.1016/j.pmrj.2009.07.006.
Fang, R., & Li, X. (2015). A regular yoga intervention for staff nurse sleep quality and work stress: A randomised controlled trial. *Journal of Clinical Nursing*, *24*(23–24), 3374–3379. https://doi.org/10.1111/jocn.12983.
Feldstein, A., Valanis, B., Vollmer, W., Stevens, N. & Overton, C. (1993). The Back Injury Prevention Project pilot study. Assessing the effectiveness of back attack, an injury prevention program among nurses, aides, and orderlies. *Journal of occupational medicine: official publication of the Industrial Medical Association*, *35*(2), 114–120.
Gerber, M., & Pühse, U. (2009). Review article: Do exercise and fitness protect against stress-induced health complaints? A review of the literature. *Scandinavian Journal of Public Health*, *37*(8), 801–819. https://doi.org/10.1177/1403494809350522.
Gerber, M., Kellmann, M., Hartmann, T., & Pühse, U. (2010). Do exercise and fitness buffer against stress among Swiss police and emergency response service officers? *Psychology of Sport and Exercise*, *11*(4), 286–294. https://doi.org/10.1016/j.psychsport.2010.02.004.
Ghaban, W., & Hendley, R. (2019). How different personalities benefit from gamification. *Interacting with Computers*, *31*(2), 138–153. https://doi.org/10.1093/iwc/iwz009.
Gibala, M. J., Little, J. P., MacDonald, M. J., & Hawley, J. A. (2012). Physiological adaptations to low-volume, high-intensity interval training in health and disease. *The Journal of Physiology*, *590*(5), 1077–1084. https://doi.org/10.1113/jphysiol.2011.224725.
Greaves, C. J., Sheppard, K. E., Abraham, C., Hardeman, W., Roden, M., Evans, P. H., & Schwarz, P. (2011). Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health*, *11*(1), 1–12. https://doi.org/10.1186/1471-2458-11-119.
Hartvigsen, J., Lauritzen, S., Lings, S., & Lauritzen, T. (2005). Intensive education combined with low tech ergonomic intervention does not prevent low back pain in nurses. *Occupational and Environmental Medicine*, *62*(1), 13–17. https://doi.org/10.1136/oem.2003.010843.
Hecksteden, A., Faude, O., Meyer, T., & Donath, L. (2018). How to construct, conduct and analyze an exercise training study? *Frontiers in Physiology*, *9*, 1007. https://doi.org/10.3389/fphys.2018.01007.
Heijden, B. van der, Brown Mahoney, C., & Xu, Y. (2019). Impact of job demands and resources on nurses' burnout and occupational turnover intention towards an Age-moderated mediation model for the nursing profession. *International Journal of Environmental Research and Public Health*, *16*(11), 2011. https://doi.org/10.3390/ijerph16112011.
Herold, F., Müller, P., Gronwald, T., & Müller, N. G. (2019). Dose-response matters!—A perspective on the exercise prescription in exercise-cognition research. *Frontiers in Psychology*, *10*, 2338. https://doi.org/10.3389/fpsyg.2019.02338.
Holzgreve, F., Schulte, L., Germann, U., & Wanke, E. M. (2022). Krafttraining als Verhaltensprāventionsmaßnahme bei berufsbedingten muskuloskeletalen Beschwerden. *Zentralblatt Für Arbeitsmedizin, Arbeitsschutz Und Ergonomie*, *72*(5), 236–240. https://doi.org/10.1007/s40664-022-00476-8.
Hoof, W. van, O'Sullivan, K., O'Keeffe, M., Verschueren, S., O'Sullivan, P., & Dankaerts, W. (2018). The efficacy of interventions for low back pain in nurses: A systematic review. *International Journal of Nursing Studies*, 77, 222–231. https://doi.org/10.1016/j.ijnurstu.2017.10.015.
Jalalvandi, F., Ghasemi, R., Mirzaei, M., & Shamsi, M. (2022). Effects of back exercises versus transcutaneous electric nerve stimulation on relief of pain and disability in operating room nurses with chronic non-specific LBP: A randomized clinical trial. *BMC Musculoskeletal Disorders*, *23*(1), 291. https://doi.org/10.1186/s12891-022-05227-7.
Janssen, T. I., & Voelcker-Rehage, C. (2023). Leisure-time physical activity, occupational physical activity and the physical activity paradox in healthcare workers: A systematic overview of the literature. *International Journal of Nursing Studies*, 141, 1-14. https://doi.org/10.1016/j.ijnurstu.2023.104470.
Jaromi, M., Nemeth, A., Kranicz, J., Laczko, T., & Betlehem, J. (2012). Treatment and ergonomics training of work-related lower back pain and body posture problems for nurses. *Journal of Clinical Nursing*, *21*(11–12), 1776–1784. https://doi.org/10.1111/j.1365-2702.2012.04089.x.
Jaromi, M., Kukla, A., Szilagyi, B., Simon-Ugron, A., Bobaly, V. K., Makai, A., Linek, P., Acs, P., & Leidecker, E. (2018). Back School programme for nurses has reduced low back pain levels: A randomised controlled trial. *Journal of Clinical Nursing*, *27*(5–6), e895–e902. https://doi.org/10.1111/jocn.13981.

Karahan, A., & Bayraktar, N. (2013). Effectiveness of an education program to prevent nurses' low back pain: An interventional study in Turkey. *Workplace Health & Safety*, *61*(2), 73–78. https://doi.org/10.1177/216507991306100205.
Khoddam-Khorasani, P., Arjmand, N., & Shirazi-Adl, A. (2020). Effect of changes in the lumbar posture in lifting on trunk muscle and spinal loads: A combined in vivo, musculoskeletal, and finite element model study. *Journal of Biomechanics*, *104*, 109728. https://doi.org/10.1016/j.jbiomech.2020.109728.
Kindblom-Rising, K., Wahlström, R., Nilsson-Wikmar, L., & Buer, N. (2011). Nursing staff's movement awareness, attitudes and reported behaviour in patient transfer before and after an educational intervention. *Applied Ergonomics*, *42*(3), 455–463. https://doi.org/10.1016/j.apergo.2010.09.003.
Kmet, L. M., Cook, L. S., & Lee, R. C. (2004). *Standard quality assessment criteria for evaluating primary research papers from a variety of fields.*
Kramer, V., Papazova, I., Thoma, A., Kunz, M., Falkai, P., Schneider-Axmann, T., Hierundar, A., Wagner, E., & Hasan, A. (2021). Subjective burden and perspectives of German healthcare workers during the COVID-19 pandemic. *European Archives of Psychiatry and Clinical Neuroscience*, *271*(2), 271–281. https://doi.org/10.1007/s00406-020-01183-2.
Krebs, P., Prochaska, J. O., & Rossi, J. S. (2010). A meta-analysis of computer-tailored interventions for health behavior change. *Preventive Medicine*, *51*(3–4), 214–221. https://doi.org/10.1016/j.ypmed.2010.06.004.
Kreis, J. (2003). Gesundheitlicher und ökonomischer Nutzen betrieblicher Gesundheitsförderung und Prävention: Zusammenstellung der wissenschaftlichen Evidenz. https://www.dguv.de/medien/inhalt/praevention/praev_lohnt_sich/wirtschaftlichkeit/wirtschaftlichkeit_volkswirtschaft/iga-rep-03.pdf
Lavoie-Tremblay, M., Sounan, C., Trudel, J.G., Lavigne, G.L., Martin, K. & Lowensteyn, I. (2014). Impact of a Pedometer Program on Nurses Working in a Health-Promoting Hospital. *The Health Care Manager*, *33*(2), 172–180. https://doi.org/10.1097/HCM.0000000000000010.
Malik, S. H., Blake, H., & Suggs, L. S. (2014). A systematic review of workplace health promotion interventions for increasing physical activity. *British Journal of Health Psychology*, *19*(1), 149–180. https://doi.org/10.1111/bjhp.12052.
Mandal, S., Misra, P., Sharma, G., Sagar, R., Kant, S., Dwivedi, S. N., Lakshmy, R., & Goswami, K. (2021). Effect of structured yoga program on stress and professional quality of life among nursing staff in a tertiary care hospital of Delhi—A small scale phase-II trial. *Journal of Evidence Based Integrative Medicine*. https://doi.org/10.1177/2515690X21991998.
Martins, L. V., & Marziale, M. H. P. (2012). Assessment of proprioceptive exercises in the treatment of rotator cuff disorders in nursing professionals: a randomized controlled clinical trial. *Brazilian Journal of Physical Therapy*, *16*(6), 502–509. https://doi.org/10.1590/S1413-35552012005000057.
Matsugaki, R., Kuhara, S., Saeki, S., Jiang, Y., Michishita, R., Ohta, M., & Yamato, H. (2017). Effectiveness of workplace exercise supervised by a physical therapist among nurses conducting shift work: A randomized controlled trial. *Journal of Occupational Health*, *59*(4), 327–335. https://doi.org/10.1539/joh.16-0125-OA.
McVicar, A. (2003). Workplace stress in nursing: a literature review. *Journal of Advanced Nursing*, *44*(6), 633–642. https://doi.org/10.1046/j.0309-2402.2003.02853.x.
Mohebbi, Z., Dehkordi, S. F., Sharif, F., & Banitalebi, E. (2019). The effect of aerobic exercise on occupational stress of female nurses: a controlled clinical trial. *Investigacion Y Educacion En Enfermeria*. https://doi.org/10.17533/udea.iee.v37n2e05.
Mojtahedzadeh, N., Neumann, F. A., Augustin, M., Zyriax, B.-C., Harth, V., & Mache, S. (2021). Das Gesundheitsverhalten von Pflegekräften – Aktueller Forschungsstand, Potenziale und mögliche Herausforderungen. *Prävention Und Gesundheitsförderung*, *16*(1), 16–20. https://doi.org/10.1007/s11553-020-00792-y.
Moreira, R. F. C., Moriguchi, C. S., Carnaz, L., Foltran, F. A., Silva Luciana, C. C. B., & Coury Helenice, J. C. G. (2021). Effects of a workplace exercise program on physical capacity and lower back symptoms in hospital nursing assistants: A randomized controlled trial. *International Archives of Occupational and Environmental Health*, *94*(2), 275–284. https://doi.org/10.1007/s00420-020-01572-z.
Mueller, K., Schwesig, R., Leuchte, S., & Riede, D. (2001). Coordinative treatment and quality of life—a randomised trial of nurses with back pain. *Gesundheitswesen (Bundesverband der Arzte des Offentlichen Gesundheitsdienstes (Germany))*, *63*(10), 609–618. https://doi.org/10.1055/s-2001-17872.
Ninot, G., Moullec, G., Picot, M. C., Jaussent, A., Hayot, M., Desplan, M., Brun, J.-F., Mercier, J., & Prefaut, C. (2011). Cost-saving effect of supervised exercise associated to COPD self-management education program. *Respiratory Medicine*, *105*(3), 377–385. https://doi.org/10.1016/j.rmed.2010.10.002.
Otto, A.-K., & Wollesen, B. (2022). Multicomponent exercises to prevent and reduce back pain in elderly care nurses: A randomized controlled trial. *BMC Sports Science, Medicine & Rehabilitation*, *14*(1), 114. https://doi.org/10.1186/s13102-022-00508-z.
Otto, A.-K., Bischoff, L.L. & Wollesen, B. (2019). Work-Related Burdens and Requirements for Health Promotion Programs for Nursing Staff in Different Care Settings: A Cross-Sectional Study. *International Journal of Environmental Research and Public Health, 16*(19). https://doi.org/10.3390/ijerph16193586.
Otto, A.-K., Gutsch, C., Bischoff, L. L., & Wollesen, B. (2021). Interventions to promote physical and mental health of nurses in elderly care: A systematic review. *Preventive Medicine*, *148*, 106591. https://doi.org/10.1016/j.ypmed.2021.106591.
Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Systematic Reviews*, *10*(1), 89. https://doi.org/10.1186/s13643-021-01626-4.
Prieske, O., Dalager, T., Herz, M., Hortobagyi, T., Sjøgaard, G., Søgaard, K., & Granacher, U. (2019). Effects of physical exercise training in the workplace on physical fitness: a systematic review and meta-analysis. *Sports Medicine (Auckland, N.Z.)*, *49*, 1903–1921. https://doi.org/10.1007/s40279-019-01179-6.
Ratzon, N. Z., Bar-Niv, N. A., & Froom, P. (2016). The effect of a structured personalized ergonomic intervention program for hospital nurses with reported musculoskeletal pain: An assigned randomized control trial. *Work (Reading, Mass.)*, *54*(2), 367–377. https://doi.org/10.3233/WOR-162340.
Riley, K. E., & Park, C. L. (2015). How does yoga reduce stress? A systematic review of mechanisms of change and guide to future inquiry. *Health psychology review*, *9*(3), 379–396.
Rivera-Brown, A. M., & Frontera, W. R. (2012). Principles of exercise physiology: responses to acute exercise and long-term adaptations to training. *PM & R: The Journal of Injury, Function, and Rehabilitation*, *4*(11), 797–804. https://doi.org/10.1016/j.pmrj.2012.10.007.
Rohwer, E., Mojtahedzadeh, N., Harth, V., & Mache, S. (2021). Stressoren, Stresserleben und Stressfolgen von Pflegekräften im ambulanten und stationären Setting in Deutschland. *Zentralblatt Für Arbeitsmedizin, Arbeitsschutz Und Ergonomie*, *71*(1), 38–43. https://doi.org/10.1007/s40664-020-00404-8.
Ruiz-Fernández, M. D., Pérez-García, E., & Ortega-Galán, Á. M. (2020). Quality of life in nursing professionals: Burnout, fatigue, and compassion satisfaction. *International Journal of Environmental Research and Public Health*, *17*(4), 1253.
Ruotsalainen, J. H., Verbeek, J. H., Mariné, A., & Serra, C. (2016). Preventing occupational stress in healthcare workers. *Sao Paulo Medical Journal*, *134*(1), 92. https://doi.org/10.1590/1516-3180.20161341T1.
Rütten, A., & Pfeifer, K. (2017). *Nationale Empfehlungen für Bewegung und Bewegungsförderung*. Köln: Bundeszentrale für gesundheitliche Aufklärung.
Rutten, J. E. R., Backhaus, R., Hamers, J. P. H., & Verbeek, H. (2022). Working in a Dutch nursing home during the COVID-19 pandemic: Experiences and lessons learned. *Nursing Open*, *9*(6), 2710–2719. https://doi.org/10.1002/nop2.970.
Scherenberg, V., Pundt, J., Lohmann, H., & Opaschowski, H. W. (Eds.). (2018). *Digitale Gesundheitskommunikation: Zwischen Meinungsbildung und Manipulation*. APOLLON University Press.
Schwarzer, R. (2008). Modeling health behavior change: how to predict and modify the adoption and maintenance of health behaviors. *Applied Psychology*, *57*(1), 1–29. https://doi.org/10.1111/j.1464-0597.2007.00325.x.
Simpson, P., Holopainen, R., Schütze, R., O'Sullivan, P., Smith, A., Linton, S. J., Nicholas, M., & Kent, P. (2021). Training of physical therapists to deliver individualized biopsychosocial interventions to treat musculoskeletal pain conditions: a scoping review. *Physical Therapy*, *101*(10), pzab188. https://doi.org/10.1093/ptj/pzab188.
Swain, D. P., Brawner, C. A., & American College of Sports Medicine (2014). *ACSM's resource manual for guidelines for exercise testing and prescription*. Wolters Kluwer Health/Lippincott Williams & Wilkins.
Tucker, S., Lanningham-Foster, L., Murphy, J., Thompson, W., Weymiller, A., Lohse, C., & Levine, J. (2011). Effects of a worksite physical activity intervention for hospital nurses who are working mothers. *AAOHN Journal*, *59*(9), 377–386. https://doi.org/10.1177/216507991105900902.

Tucker, S., Farrington, M., Lanningham-Foster, L. M., Clark, M. K., Dawson, C., Quinn, G. J., Laffoon, T., & Perkhounkova, Y. (2016). Worksite physical activity intervention for ambulatory clinic nursing staff. *Workplace Health & Safety*, *64*(7), 313–325. https://doi.org/10.1177/2165079916633225.

Vander Elst, T., Cavents, C., Daneels, K., Johannik, K., Baillien, E., van den Broeck, A. & Godderis, L. (2016). Job demands–resources predicting burnout and work engagement among Belgian home health care nurses: A cross-sectional study. *Nursing Outlook*, *64*(6), 542–556. https://doi.org/10.1016/j.outlook.2016.06.004.

Vinstrup, J., Jakobsen, M. D., & Andersen, L. L. (2020). Perceived stress and low-back pain among healthcare workers: a multi-center prospective cohort study. *Frontiers in Public Health*, *8*, 297. https://doi.org/10.3389/fpubh.2020.00297.

Wackerhage, H., Sitzberger, C., Kreuzpointner, F., & Oberhoffer-Fritz, R. (2021). WHO-Leitlinien zu körperlicher Aktivität und sitzendem Verhalten. *Bayerisches Ärzteblatt*, *3*, 91–93.

Warming, S., Ebbehoj, N. E., Wiese, N., Larsen, L. H., Duckert, J., & Tonnesen, H. (2008). Little effect of transfer technique instruction and physical fitness training in reducing low back pain among nurses: A cluster randomised intervention study. *Ergonomics*, *51*(10), 1530–1548. https://doi.org/10.1080/00140130802238606.

Wollesen, B., Menzel, J., Lex, H., & Mattes, K. (2016). The BASE-program—A multidimensional approach for health promotion in companies. *Healthcare (Basel, Switzerland)*, *4*(4), 91. https://doi.org/10.3390/healthcare4040091.

Wollesen, B., Hagemann, D., Pabst, K., Schlüter, R., Bischoff, L. L., Otto, A.-K., Hold, C., & Fenger, A. (2019). Identifying individual stressors in geriatric nursing staff—A cross-sectional study. *International Journal of Environmental Research and Public Health*, *16*(19), 3587. https://doi.org/10.3390/ijerph16193587.

Yang, S., Li, L., Wang, L., Zeng, J., Yan, B., & Li, Y. (2021). Effectiveness of a multidimensional intervention program in improving occupational musculoskeletal disorders among intensive care unit nurses: a cluster-controlled trial with follow-up at 3 and 6 months. *BMC Nursing*, *20*(1), 1–14. https://doi.org/10.1186/s12912-021-00561-y.

Yuan, S.-C., Chou, M.-C., Hwu, L.-J., Chang, Y.-O., Hsu, W.-H., & Kuo, H.-W. (2009). An intervention program to promote health-related physical fitness in nurses. *Journal of Clinical Nursing (John Wiley & Sons, Inc.)*, *18*(10), 1404–1411. https://doi.org/10.1111/j.1365-2702.2008.02699.x.

Zou, C.-J., Li, J.-H., Wu, F.-C., Li, Y.-Z., Pan, H.-Y., & Wu, T. (2021). The effects of core stability training in nurses with nonspecific low back pain. *Medicine*, *100*(25), 1–5. https://doi.org/10.1097/MD.0000000000026357.

Zou, L., Sasaki, J. E., Wei, G.-X., Huang, T., Yeung, A. S., Neto, O. B., Chen, K. W., & Hui, S. S.-C. (2018). Effects of mind–body exercises (tai chi/yoga) on heart rate variability parameters and perceived stress: a systematic review with meta-analysis of randomized controlled trials. *Journal of Clinical Medicine*, *7*(11), 404. https://doi.org/10.3390/jcm7110404.

Publisher's Note. Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.