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Effectiveness of occupational health and safety training: A systematic review with meta-analysis

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A systematic review with meta-analysis

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Abstract

Purpose – This meta-analysis aims to verify the efficacy of occupational health and safety (OHS) training in terms of knowledge, attitude and beliefs, behavior and health.

Design/methodology/approach – The authors included studies published in English (2007–2014) selected from ten databases. Eligibility criteria were studies concerned with the effectiveness of OHS training for primary prevention of workplace injury; and studies focused on examined outcome related to OHS.

Findings – The selected studies ($n = 28$) highlighted a strong support for the effectiveness of training on worker OHS attitudes and beliefs and, to a lesser extent, on worker's knowledge but only medium for behavior and small evidences for its effectiveness on health.

Research limitations/implications – Future research should more deeply investigate the efficacy on knowledge increase of trainings delivered by experts and researchers, applying different methods, in a small group; training delivered by peer and by researcher, applying different methods; and trained workers less than 29 years and more than 49 years old, considering that workers in these age groups are particularly vulnerable to fatalities.

Practical implications – Our study is a contribution for those they intend to grant effective training, in response to specific needs of OHS. The evidences presented could be considered a first step to identify the factors related to the efficacy of OHS training to plan adequate interventions.

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Social implications – The OHS training is effective on the basis of the extent interventions are carried out for each specific learning outcome.

Originality/value – This meta-analysis suggested that classroom training, although the most used and studied, does not ever revealed itself very effective: it was not significant for outcomes in terms of knowledge and showed a decreasing efficacy for attitudes and beliefs, behaviors and health. It seemed that there was a distinction between interventions on knowledge, attitudes and beliefs, as opposed to behavioral interventions and health.

Keywords Health, Effectiveness, Safety, Training evaluation, Training techniques, Safe behavior

Paper type Literature review

Introduction

The practices of health defense in work settings and the continuous improvement of occupational well-being do not depend merely on norms and processes. If we do not want to limit our interventions to the priority objective of injuries reduction, then we must go beyond the particular technical characteristics of a job: we must lay the groundwork so that the job conditions allow for real self-realization. This is an intrinsically multidisciplinary field, in which work psychology has long offered eminent and rich contributions, mainly oriented to the organizational, communicative and social competences of work processes (Reason, 2008). From this viewpoint, we are interested in investigating how occupational health and safety (OHS) training could effectively enhance worker's health dimensions that we define not as simple absence of disease but as global, bio-psycho-social well-being.

We started from a fundamental question advanced by many scholars and practitioners: "Does OHS training have any beneficial effect on workers (e.g. increase OHS knowledge, improve OHS attitudes, improve OHS behaviors, or protect health)?" (Robson *et al.*, 2012). If so, safety behavior is undoubtedly a potential training outcome and should be the object of continuous study. Moreover, other workers' psycho-social orientations may play a role because they could potentially influence workers' intention to act in a safe way: first of all, attitudes toward safe behavior along with the evaluation of its consequences (i.e. beliefs). Second, a worthwhile aspect is the actual knowledge of risks in the workplace. The question about the real effect of training programs on workers' behavior often remains unanswered. Evaluation of training effectiveness is crucial to deliver evidence-based interventions and to improve health conditions. In this sense, our meta-analysis includes studies carried out in the 2007-2014 timeframe, with the goal to complete and update the results already reached/achieved by Robson *et al.* (2012), who analyzed studies carried out until 2007, and to assess the effectiveness of OHS training based on the most recent evidence. We expect our review to contribute to the identification of a training model that could be really efficient in warranting health and safety in the workplace and whose predictions could be empirically verified in a number of work settings.

In 2009, over 2.8 million serious accidents and 3,806 fatal accidents occurred in EU-27, excluding Greece and North Ireland (Eurostat, 2009). For this reason, international agencies, supranational (e.g. European Union) and individual states began establishing strict guidelines and rules. The International Labour Organization (hereinafter ILO) has recently brought attention to the fact that:

> Many governments and employers' and workers' organizations are placing now greater emphasis on the prevention of occupational diseases. Even so, prevention is not receiving the priority warranted by the scale and severity of the occupational disease epidemic (ILO, 2013).

ILO emphasized that a good national OHS system is critical for the effective implementation of national policies and programs to strengthen the prevention of occupational diseases. It should include, for example, laws and regulations, as well as OHS information and training. Technical-engineering, ergonomic, medical and psychosocial studies have focused on the relationship between workers' characteristics and social context to eliminate as many dangers and risks from the workplace as possible and to reduce the number and severity of injuries.

Some residual risks, however, still hang on: they are usually managed by promoting worker's self-protection behaviors, such as the use of individual safety devices. When hazards cannot be removed, the next most desirable approach is to control them, so as to maximally prevent workers' exposure. Training is a tool intended to improve occupational health. Indeed, the training requirements in OSHA standards and training guidelines publication (Occupational Safety & Health Administration, 1998) states that "If ignorance of specific job hazards and of proper work practices is even partly to blame for this higher injury rate, then training will help to provide a solution". The actions and practices of workers, management, unions and safety specialists create, change and maintain many environmental conditions for safety work. For instance, highest management levels typically impose budget limits, whereas designers and decision makers may determine the layout of a workplace in the design of a production facility (Rosness *et al.*, 2012). However, workers' training is also an important mechanism that can affect decisions leading to healthy and safe workplaces.

The mere introduction of regulations by law has been shown not to be effective in reducing non-fatal and fatal injuries: additional strategies are needed to increase the compliance of employers and workers with the safety measures that are prescribed by law. For example, in most of developed countries, there are companies that choose to deliver additional training and/or to stress the importance of such interventions carried out by active and highly qualified instructors on top of the mandatory OHS training required by law. In these organizations, the employer makes it a priority for managers to be highly involved in safety and OHS trainings. Curcuruto *et al.* (2013) demonstrated a correlation between good management of relations within groups and psychological empowerment with health protection. Therefore, the positive effect of OHS training in improving behaviors is related to everyday habits. Furthermore, safe behaviors are linked to in-depth interventions and not only to knowledge extension (e.g. Burke *et al.*, 2006). There is indeed evidence that the effectiveness of training could depend on the integration of the organization as a whole and not only on occasional interventions. In these conditions, OHS training could probably be efficient in enhancing workers' health, not only in eliminating disease but also in promoting overall well-being (bio-psycho-social). Specific training in hazard identification, mentoring of supervisors and the introduction of a robust safety system (i.e. a system assessing the risk for employees and the subsequent safety measures for facilities, equipment, production, quality and working environment) could improve organizations' safety culture (Bahn, 2013).

Materials and methods

Our literature search was aimed at identifying available studies assessing OHS training of workers, i.e. all those individuals who perform a job or something equivalent to it (e.g. students in a lab) but do not have specific functions or delegated responsibilities for safety.

Data extraction was recoded and data were synthesized using meta-analytic methods. We selected experimental randomized controlled trial (RCT) and quasi-experimental studies, alike, for the purpose of expanding and updating our knowledge on the effectiveness of OHS training. For this reason, with regard to the studies' quality criteria (Rosenthal, 1995), and taking into account the difficulty to weigh the RCTs and non-RCT studies' quality, we introduced the research design as a potential moderator (RCT versus non-RCT). We differentiated between the two types of RCTs because RCTs are a peculiar type of scientific experiment, where participants are randomly allocated to one of the different conditions under study. RCTs are often considered the gold standard for clinical trials.

Literature search

A complete search of all relevant OHS training articles was conducted. We chose to consult the bibliographic databases that had access to the largest number of multi-disciplinary resources. First, we searched computer databases (PsycINFO, Google Scholar, Scopus, Scirus, TOXLINE, ERIC, Dissertation Abstracts Agricola, MEDLINE, PubMED, Web of Science) for OHS training articles with the following keywords: "training", "safety", "effectiveness", combined with the Boolean operator AND (title, abstract, key word, topic). We minimized the number of search terms so as to have a large pool from which to select the studies corresponding to our criteria. Queries were limited to studies published in English during 2007-2014. Studies published in languages other than English were excluded because of time and resource limitations. Then, the electronic search was supplemented by asking several external experts for relevant citations of published or in-press journal articles and by reviewing the reference lists of articles that passed this review's relevance assessment screening. At last, references lists of all manuscripts were examined and missing works collected. The search began in March 2013 and was updated in September 2014. To be included in this meta-analysis, OHS training studies needed to meet specific criteria: they had to evaluate the effectiveness of interventions for the workers' population and their results had to be supported by evidence-based data (we excluded studies without supporting evidence and/or which simply stated a further need for education/training on OHS training). Moreover, all studies compared intervention *vs* control groups and/or were longitudinal studies analyzing the learning outcome (knowledge, attitudes and beliefs, behaviors or health).

The lead author made a preliminary selection of the publications identified in the databases based on title and abstract. At a later stage, titles and abstracts previously selected were independently assessed and selected by two reviewers, who thereafter separately reviewed the full-text publications. If the training components could not be isolated, studies were excluded from the review. Every disagreement between the reviewers was resolved through discussion and third-party opinions if necessary.

Coding

Each research (all journal articles) was coded according to information on study design, study population, group characteristics at baseline and follow-up, outcome interventions, outcome co-interventions, outcome measurement, research methods, results, statistical analysis, characteristics of training interventions, publication year and country.

Several characteristics were identified and categorized. Their effects on outcomes were treated as moderators, namely, participants' socio-demographic characteristics (group gender and age), training factors (trainer's characteristics, training method, number of trainees, session duration, mandatory/not mandatory training) and study characteristics (measures of effectiveness, follow-up, RCTs/non-RCTs).

Because some of the studies had assessed intervention outcomes after a length of time had passed, we extracted the data relative to different time frames: baseline, first post-intervention assessment (W1) and second follow-up (W2). The outcomes were classified into one of four categories: knowledge; attitudes and beliefs; behaviors; health (death, injury, illness). When the authors used more specific measures referring to the same outcome, extracted data were reported from the most relevant instrument, as evaluated by the lead author, with priority given to non-self-report assessments. We adopted the same procedure when the authors reported subscales scores instead of a global score. When studies included more than one experimental plan, we chose the one reported to be the most effective. For studies that presented results concerning multiple outcomes, we processed each outcome separately through the Prometa 2.0 software©. Based on the data presented in each primary study, we calculated the intervention effect size for every specific OHS outcome.

Statistical analyses

Because the most common type of outcome data in the reviewed studies was continuous, we selected the standard mean difference as our metric. When results were expressed in a form other than continuous (e.g. binary data), they were transformed to Hedges's g using established methods through the Prometa 2.0 software©. Calculation of effect sizes (ESs) was based on means, standard deviations, difference in mean scores, P values and sample size of the groups. Data were statistically pooled by the standard meta-analysis approach, meaning that studies were weighted by the inverse of the sampling variance. Based on conventional standards, ESs of $g \leq 0.20$, from 0.21 to 0.50 and ≥ 0.80 may be considered small, medium and large, respectively (Cohen, 1988). However, we considered this reference values only as indicative, and their interpretation approach was not so restrictively uncritical, especially for all non-RCT studies, taking into account their methodological constraints and ecological value.

The Q statistic was used to assess heterogeneity among studies (a significant Q value indicated lack of homogeneity of findings among studies). Because we found significant heterogeneity for all the indexes, we assumed a random-effects model, so as to take into account both within and between studies variability (Huedo-Medina *et al.*, 2006). We also assessed the publication bias using Fail Safe N, with significance value based on Rosenthal's rule of thumb ($5k + 10 = \mathrm{N}$), where k is the number of interventions included in the meta-analysis. Fail Safe N indicates the number of non-significant or unpublished or missing studies that should be added to the meta-analysis to ensure that an overall statistically significant result becomes non-significant. If this number is large, i.e. if it would be necessary to add many studies to change a significant result, then we can be confident in the result obtained. In all confidence intervals (CIs), the confidence level was set at 95 per cent.

Comprehensive Prometa 2.0© software [ProMeta (Version 2) Computer software. Cesena, Italy: Internovi] was used for the statistical analyses. We will report the statistics in conformity to the Preferred Reported Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

Results

Initial queries identified a total of 3,846 citations from all databases and search methods. Comparison of the retrieved titles identified 654 studies that were duplicates, thus leaving 3,192 unique citations for relevance screening abstracts. After the second stage of evaluation, we selected 83 full texts, which were then read and evaluated. The result of this assessment was the exclusion of those texts that did not correspond to the indicated criteria and did not report the results needed to calculate ESs. At least 21 full publications (PRISMA flow diagram in Figure 1) were identified, for a total of 28 studies on OHS training (their core features are summarized in Table I).

Description of eligible studies

Out of 28 studies, 12 had used a random sampling, whereas seven even a control group (i.e. RCT). Ten studies had planned a comparison between a training group and a control group (seven of them were randomized). Studies were carried out in the USA (39.3 per cent), Italy (17.9 per cent), Denmark and Sweden (10.35 each), Brazil, India, Israel, Norway, Taiwan, The Netherlands (one study for each country). The sample sizes varied widely (range 8-2.375, median 94), clearly affecting the comparison of the studies' quality. The most common age groups were "30-39" and "40-49 years" (48 and 40

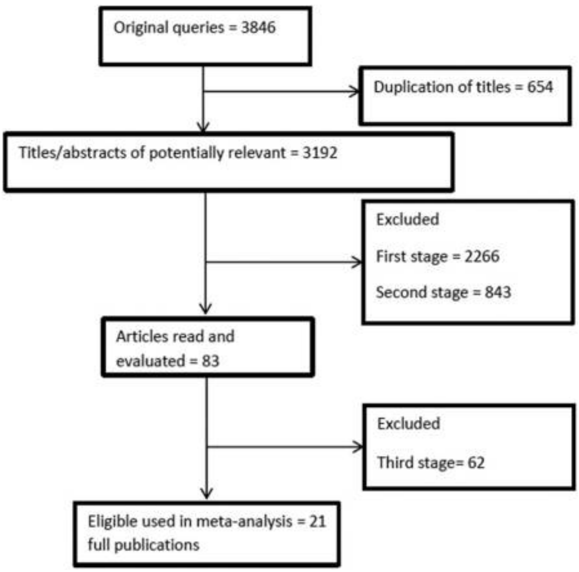

Figure 1.
PRISMA flour diagram

Table I. Summary of study characteristics

Authors	Hazard category[a]; training type	Intervention and randomization method	Occupation; workplace; country: N[b]	Outcomes[c] (follow-up)
(1) Bena *et al.* (2009)	a) S; classroom theory for *basic* module, active teaching	Training program developed from analysis of ongoing experiences and identification of the occupational accident risk determinants. No randomization	Workers at construction sites; high-speed railway line; Italy; $N_I = 2,375$	H (missing)
	b) S; classroom theory for *specific hazard* module, active teaching	As in a)	As in a); $N_I = 1,164$	H (missing)
(2) Cavazza *et al.* (2010)	S; training programs on workers' psychosocial orientation and behavior	Mandatory training program. No randomization (one control group)	Blue-collar; manufacturing; Italy; $N_I = 228$; $N_C = 117$	B (6 months)
(3) De Souza *et al.* (2012)	S; peer-led safety training	Training based on empowerment theory. No randomization	Latino day laborers; construction, gardening and cleaning service; USA; $N_I = 96$	K (0 m.)
(4) Holmes *et al.* (2008)	E; body mechanics education	Classroom theory with active teaching (video and fotonovela). No randomization	Fruit ware houseworkers; warehouse; USA; $N_I = 178$	B (0.5 m.)
(5) Holtermann *et al.* (2008)	E; electromyography biofeedback	Five sessions during computer activities for subjects using the computer mouse more than 50% (I_1) o less than 25% (I_2) of their work time. RCT (one control group)	Computer workers; insurance; Denmark; $N_{I1} = 64$, $N_{I2} = 49$, $N_C = 51$	B (0 m.)
(6) Ijzelemberg *et al.* (2007)	E; individualized education and training	Back pain prevention program. RCT (one control group)	Workers in physically demanding jobs; large companies; The Netherlands; $N_I = 258$, $N_C = 231$	H (0 m.)

(*continued*)

Table I.

Authors	Hazard category[a]; training type	Intervention and randomization method	Occupation; workplace; country: N[b]	Outcomes[c] (follow-up)
(7) Lesch (2008)	a) S; accident scenario training (warning symbol)	Presentation of warning symbols by a personal computer. No randomization	No information about occupation and workplace; USA; $N_I = 43$	K, A ($T_1 = 0$; $T_2 = 0,5$)
	b) S; verbal label training (warning symbol)	As in a)	As in a)	As in a)
(8) Levanon *et al.* (2012)	E; ergonomics interventions at the workplace	I_1: ergonomics intervention and biofeedback training. I_2: ergonomics intervention without biofeedback. RCT (one control group)	Computer workers; hi-tech workplaces; Israel; $N_{I1} = 22$, $N_{I2} = 20$, $N_C = 21$	B, H (1.5 m.)
(9) Pedersen *et al.* (2007)	E; physical training	Eighteen sessions during a nine-week period. No randomization (one control group)	Health care workers; geriatric ward; Denmark; $N_I = 18$, $N_C = 10$	B (12 m.)
(10) Pillastrini *et al.* (2007)	a) E; ergonomic intervention, informative brochure	Advice and supervision of a physical therapist for the ergonomic adjustment of own workstation. No randomization	Workers using video display terminals (VDT); town hall; Italy; $N_I = 99$	B, H (5 m.)
	b) E; informative brochure	Informative brochure. No randomization	Workers using video display terminals (VDT); town hall; Italy; 97	B, H (5 m.)
(11) Resnick and Sanchez (2009)	a) E; contextual training	Participant slide the patient to the head of the table and turn the patient onto his/her side. No randomization	Nurses; health care; USA; $N_I = 8$	B (0.25 m.)
	b) E; classroom training	Traditional classroom environment; 30 min of practice time after the lesson were allowed. No randomization	Nurses; health care; USA; $N_I = 8$	B (0.25 m.)

(*continued*)

Authors	Hazard category[a]; training type	Intervention and randomization method	Occupation; workplace; country: N[b]	Outcomes[c] (follow-up)
(12) Salvatore *et al.* (2009)	B; community-based participatory work site intervention	Field-based educational sessions, aimed to increase awareness of pesticide exposures and to promote safe behavior at/after work; trouble-shoot barriers to carrying out recommended behaviors. RCT (one control group)	Farm workers; farm; USA; $N_I = 74$, $N_C = 56$	B (2 m.)
(13) Sam *et al.* (2008)	B; educational program to promote pesticide safety	Structured individualized training program. No randomization	Pesticide handlers; farm; India; $N_I = 74$	K, A, B (0 m.)
(14) Santos *et al.* (2011)	E/Educational program for the prevention of work-related musculoskeletal disorders	I: six consecutive weekly training sessions of one hour duration at the worksite C: explanations and debates about important general health themes Randomized controlled trial	Clerical and production workers/steel trading company/Brazil I, $N = 43$; C, $N = 46$	H (6.5 m.)
(15) Sokas *et al.* (2009)	a) S; training fall safety session	Mandatory training program. No randomization	Construction workers; building trades; USA; $N_I = 92$	K (3 m.)
	b) S; training electrical safety session	Mandatory training program. No randomization	Construction workers; building trades; USA; $N_I = 83$	K (3 m.)
(16) Stave *et al.* (2007)	a) S; risk perception and perceived risk manageability	Open approach, barely structured and controlled. No randomization	Farm workers; farm; Sweden; $N_I = 30$	K, A, B, H (6 m.)
	b) S; risk perception and perceived risk manageability	Members were in addition given a diary, providing a structure for documenting incidents/accidents and analyzing the events upstream No randomization	Farm workers; farm; Sweden; $N_I = 28$	K, A, B, H (6 m.)
	c) S; risk perception and perceived risk manageability	Accident/incident diaries and information about the process leader. No randomization	Farm workers; farm; Sweden; $N_I = 26$	K, A, B, H (6 m.)

(*continued*)

Table I.

Table I.

Authors	Hazard category[a]; training type	Intervention and randomization method	Occupation; workplace; country: N[b]	Outcomes[c] (follow-up)
(17) Stephenson *et al.* (2011)	P; instruction and practice on hearing protection devices	Hearing loss prevention, using individualized and group training. No randomization	Carpenters; construction; USA; $N_I = 103$	A ($T_1 = 0$; $T_2 = 12$)
(18) Veiersted *et al.* (2008)	E; intervention group and later individual follow-up instructions	A pamphlet was given; later, every worker was contacted for individual demonstration and discussion of recommendations. RCT (one control group)	Hairdressers; salons of hairdressers; Norway; $N_I = 15$, $N_C = 15$	B (1.5 m.)
(19) Warming *et al.* (2008)	E; transfer technique instruction and physical fitness training	Hands-on (I_1) and hands-on plus supervised physical fitness training (I_2). RCT (one control group)	Nurses; health care; Denmark; $N_{I1} = 33$, $N_{I2} = 27$, $N_C = 51$	K, H (6 m.)
(20) Williams *et al.* (2010)	S; peer-led participatory health and safety training program	Classroom theory with active teaching. No randomization (one control group)	Construction workers; construction; USA; $N_I = 70$, $N_C = 313$	A, B, H (4 m.)
(21) Yang *et al.* (2007)	S; e-learning	Brochure addressing injuries No randomization	Nurses; health care; Taiwan; $N_I = 107$	H (4 m.)

Notes: [a]Hazard type: biological (B), chemical (C), ergonomic (E), physical (P), safety (S); [b]initial number of study participants: size of the study sample following exclusions on the basis of eligibility, initial inability to contact and initial refusal to participate; [c]outcome categories: knowledge (K); attitudes and beliefs (A); behaviors (B); health (H); EMG = electromyography per cent, respectively). Two studies included participants aged up to 29 years and one "$>$ 49 years" (in three researches, this information was missing). Research seemed to show a gender bias: male participation accounted for over 75 per cent in 13 out of 28 studies and from 51 to 75 per cent in three studies. Males represented a weak (26-50 per cent) or strong (less than 25 per cent) minority only in seven interventions, each one (two missing data). The majority of the studies did not report participants' education (57.1 per cent), ethnicity (71.4 per cent) or precarious employment rates (85.7 per cent). Overall, 12 interventions were mandatory training. In two studies, this information was missing and the remaining fourteen interventions included volunteering participation.

With regards to the training methods, it is possible to classify them as follows:

- *Classroom theory lessons with active teaching*: A lesson with exercise and discussion moderated by the teacher.
- *E-learning*: Use of technological tools in learning.
- *Ergonomic training*: Participants received instructions in proper body mechanics with demonstration and practice of safe behavior.
- *Hands-on practice*: Implementing a technique on the job, into contextual conditions.
- *Biofeedback*: Participants received an audiovisual signal when the EMG amplitude exceeded the target.
- *Resistance training*: The subjects were trained by a physical training instructor.
- *Hand-out of printed material*: Pamphlets that present health- and safety-related information.

Our analysis showed that the most common training methods were classroom theory lessons with active teaching (53.6 per cent of the studies), followed by e-learning (12 per cent), ergonomic training and hands-on practice (8 per cent), biofeedback, resistance training and hand-out of printed material (one study; three missing data).

It should be noted that the number and duration of the training sessions were usually modest: 57 per cent of the 26 interventions whose sessions' number could be assessed consisted of either one session only (13 studies) or two (two); eight interventions consisted of four to six sessions and only the remaining three training sessions featured more than ten sessions (11, 18 and 20, respectively). Moreover, 69.2 per cent of the sessions lasted 1 h or less, 15.4 per cent from 1 to 2 h, and 15.4 per cent lasted $\geq$ 2 h (two missing data). The most common type of trainer was either an expert (38.5 per cent) or a researcher (26.9 per cent), less frequently a peer (11.5 per cent) or a trade union representative (7.7 per cent). On the other hand, four studies (15.4 per cent) used a self-learning approach (two missing data).

Most of the 28 selected studies addressed accident (46.4 per cent) and ergonomic hazards (42.9 per cent); two addressed biological dangers and only one physical risk. None considered chemical exposure. The most frequently studied work sectors were construction (28 per cent), farming (24 per cent), health care (20 per cent), tertiary (16 per cent) and manufacturing (12 per cent). In three studies, this information was missing. The identified potential injuries concerned physical function (48 per cent), general health (2), back pain (16 per cent), contamination (pesticides: 8 per cent), hack and hearing (one study each). In three studies, this information was missing. In ten studies, the intervention was directed to one worker, whereas nine addressed small groups. Only one study took into account a large group composed of more than thirty-five trainees (eight missing data).

Twenty-five studies adopted only one follow-up appraisal, whereas Stephenson *et al.* (2011) planned two follow-ups and Lesch (2008) two follow-ups for each subgroup (younger versus older). The post intervention assessment was made immediately after the intervention in ten researches; ten studies planned a follow-up evaluation three months after the training, 11 from three to six months and two studies beyond six months (two missing data).

The 28 studies included in our meta-analysis enabled us to calculate the effect size of training efficacy on 44 different measures (Table I): the most common method for assessing effectiveness was through a questionnaire (65.9 per cent), followed by observation on job environment (13.6 per cent), practical test (9.1 per cent), physiological data of bodily functioning (6.8 per cent) and documentary database (4.5 per cent).

Effects of training on knowledge

As shown in Figure 2, the group of seven studies measuring workers' knowledge was heterogeneous ($Q = 156.06, p < 0.001$) and free from publication bias because the value of Fail Safe N ($N = 454$) was above the Rosenthal's rule of thumb ($5k + 10 = 45$). All studies coherently referred a positive training effect, with only one intervention not reaching statistical significance (Warming *et al.*, 2008). However, the outcome of this intervention was mainly in terms of health outcomes and only secondarily in terms of knowledge improvement. The overall combined ES g (1.03; CI $= 0.49 - 1.58$) was significant and far exceeded the evidence (Cohen, 1988) synthesis algorithm's criterion of large effect (0.80).

Effects of training on attitudes and beliefs

Even the eight studies including attitudes and beliefs as possible training outcomes were heterogeneous ($Q = 205.87, p < 0.001$) and did not suffer from publication bias ($N = 1540 >$ Rosenthal's rule of thumb $= 65$). We calculated 11 ESs (Figure 3) because three studies had planned two follow-up assessments (Lesch, 2008). All ESs were positive, indicating a more favorable attitude toward prevention behaviors after the training intervention; the overall combined g was strong and significant (1.26, CI $= 0.81 - 1.71$). The only training whose effect was not statistically significant was based on unstructured discussion group (Stave *et al.*, 2007), a procedure found to be less effective than a structured discussion group, with or without information.

	ES	95% CI	W	V	SE	Sig.
De Souza et al. 2012	0,26	0,05 , 0,46	14,73%	0,01	0,10	0,013
Lesch 2008a	2,16	1,76 , 2,56	13,91%	0,04	0,20	0,000
Lesch 2008b	1,76	1,40 , 2,12	14,12%	0,03	0,18	0,000
Sam et al. 2008	1,90	1,52 , 2,29	14,01%	0,04	0,19	0,000
Sokas et al. 2009a	0,46	0,25 , 0,67	14,70%	0,01	0,11	0,000
Sokas et al. 2009b	0,39	0,17 , 0,61	14,67%	0,01	0,11	0,001
Warming et al. 2008	0,39	−0,02 , 0,80	13,87%	0,04	0,21	0,059
Overall (random-effects model)	1,03	0,49 , 1,58	100,00%	0,08	0,28	0,000

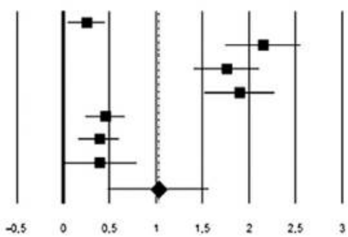

Figure 2.
Training on knowledge: heterogeneity and bias publication

Effects of training on behaviors

The 16 studies on training behavioral effects were less heterogeneous than the former sets ($Q = 97.58$, $p < 0.001$) and free from publication bias ($N = 730 >$ the Rosenthal's rule of thumb = 95). These studies enabled us to calculate 17 ESs (Figure 4), where one research (Levanon *et al.*, 2012) involved the comparison between two intervention groups and a single control group. All ESs showed that participating in OHS training induced workers to adopt a more safety-minded behavior, even though in three cases the effect did not reach statistical significance. However, the overall *g* for the behavioral outcome was less large, even if still significant, than that for knowledge and attitudes and may be defined as only moderate (0.61, CI = 0.40 − 0.83). The interventions that did not show a significant effect were accomplished through hand-out of a pamphlet to the participants (Pillastrini *et al.*, 2007), the use of pictograms (Sam *et al.*, 2008) and an unstructured group discussion (Stave *et al.*, 2007). On the other hand, the use of a booklet and pictograms was found to be effective in terms of improving knowledge, turning attitudes and beliefs into positive. However, these methods were not able to affect workers' safety behaviors. Furthermore, this confirmed that an unstructured discussion group is less effective than a structured discussion group.

	ES	95% CI	W	V	SE	Sig.
Lesch 2008a/W1	2,88	2,38 , 3,38	8,62%	0,06	0,25	0,000
Lesch 2008a/W2	1,82	1,47 , 2,18	9,09%	0,03	0,18	0,000
Lesch 2008b/W1	2,24	1,82 , 2,65	8,89%	0,05	0,21	0,000
Lesch 2008b/W2	1,54	1,23 , 1,86	9,19%	0,03	0,16	0,000
Sam et al. 2008/W1	1,37	1,06 , 1,69	9,20%	0,03	0,16	0,000
Stave et al. 2007a/W1	0,14	-0,21 , 0,49	9,10%	0,03	0,18	0,448
Stave et al. 2007b/W1	0,61	0,22 , 1,00	8,97%	0,04	0,20	0,002
Stave et al. 2007c/W1	0,42	0,03 , 0,81	8,99%	0,04	0,20	0,036
Stephenson et al. 2011/W1	1,78	1,47 , 2,09	9,21%	0,02	0,16	0,000
Stephenson et al. 2011/W2	0,85	0,62 , 1,07	9,41%	0,01	0,11	0,000
Williams et al. 2010/W1	0,35	0,09 , 0,61	9,33%	0,02	0,13	0,008
Overall (random-effects model)	1,26	0,81 , 1,71	100,00%	0,05	0,23	0,000

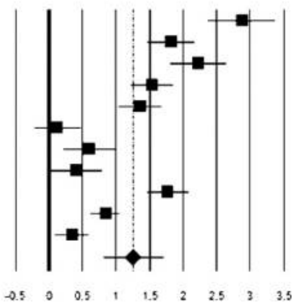

Figure 3.
Training on attitudes and beliefs: heterogeneity and bias publication

	ES	95% CI	W	V	SE	Sig.
Cavazza et al. 2010	0,30	0,07 , 0,52	7,98%	0,01	0,11	0,009
Holmes et al. 2008	0,74	0,58 , 0,91	8,31%	0,01	0,08	0,000
Holtermann et al. 2008	0,72	0,44 , 0,99	7,63%	0,02	0,14	0,000
Levanon et al. 2012/E-control	1,21	0,55 , 1,86	4,77%	0,11	0,33	0,000
Levanon et al. 2012/EWB-control	1,47	0,80 , 2,13	4,72%	0,11	0,34	0,000
Pedersen et al. 2007	1,15	0,09 , 2,21	2,74%	0,29	0,54	0,034
Pillastrini et al. 2007a	1,01	0,77 , 1,25	7,87%	0,02	0,12	0,000
Pillastrini et al. 2007b	0,07	-0,13 , 0,27	8,14%	0,01	0,10	0,492
Resnick et al. 2009a	1,10	0,28 , 1,92	3,80%	0,17	0,42	0,008
Resnick et al. 2009b	0,74	0,03 , 1,46	4,39%	0,13	0,37	0,042
Salvatore et al. 2009	1,50	0,51 , 2,50	2,99%	0,26	0,51	0,003
Sam et al. 2008	0,02	-0,21 , 0,24	7,97%	0,01	0,12	0,876
Stave et al. 2007a	0,08	-0,27 , 0,43	7,08%	0,03	0,18	0,649
Stave et al. 2007b	0,40	0,02 , 0,77	6,88%	0,04	0,19	0,038
Stave et al. 2007c	0,48	0,08 , 0,87	6,72%	0,04	0,20	0,018
Veiersted et al. 2008	4,67	0,67 , 8,68	0,27%	4,18	2,04	0,022
Williams et al. 2010	0,41	0,15 , 0,67	7,74%	0,02	0,13	0,002
Overall (random-effects model)	0,61	0,40 , 0,83	100,00%	0,01	0,11	0,000

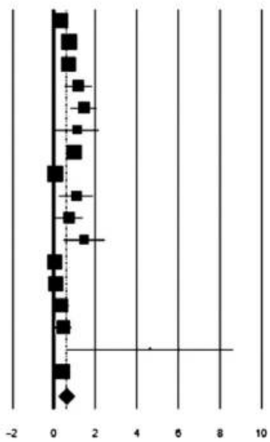

Figure 4.
Training on behaviors: heterogeneity and bias publication

Effects of training on health

From 13 studies, we calculated 15 effects ESs (Figure 5) because two studies (Levanon *et al.*, 2012; Warming *et al.*, 2008) compared two intervention groups with the same control group. The set of studies was heterogeneous ($Q = 40.38, p < 0.001$) and free from publication bias ($N = 227 >$ Rosenthal's rule of thumb = 85).

All the ESs were positive, suggesting that the training was successful in enhancing well-being. However, only nine ESs also corresponded to statistically significant pre-post training differences and, coherently, the overall *g* was definitely small (0.23, CI = 0.14 − 0.33), even if significant. Santos *et al.* (2011) described a classroom intervention on the dramatization of musculoskeletal disorders whose effects were equal to the outcomes of a dramatization on general health. Stave's (2007) unstructured group discussion did not result in improved health outcome, whereas the structured group discussion did. Williams *et al.* (2010) showed that a participatory peer training method for workers in the construction industry was not significant for improving health but was found effective for attitudes and behaviors. Moreover, booklets (Pillastrini *et al.*, 2007) did not prove to be effective, neither for health outcomes nor for behavioral changes. Finally, in the study of Warming *et al.* (2008) the subgroup that undertook simple hands-on practice, without physical exercise (TT group), did not induce significant effects. On the other hand, the intervention with additional exercise (TTPT group) was significant.

Consideration of the potential moderators

Socio-demographic characteristics

Gender. The gender difference did not modify the efficacy of training on knowledge, behavior and health, and it only affected the educational interventions aimed at improving attitudes and beliefs, whose ES significantly decreased ($p = 0.029$) as with the increasing of male participant percentage. The presence of women among the participants seemed to have facilitated the willingness to change attitudes and beliefs in a positive way.

Age. The set of 40 to 49-year-old participants showed that training efficacy was good for all indexes: knowledge ($g = 1.95$, CI = 1.56 − 2.33), attitudes and beliefs ($g = 1.24$, CI = 0.60 − 1.88), behaviors ($g = 0.45$, CI = 0.14 − 0.77) and health (but this ES was

	ES	95% CI	W	V	SE	Sig.
Bena et al. 2009a	0,05	0,01 , 0,09	18,44%	0,00	0,02	0,009
Bena et al. 2009b	0,09	0,03 , 0,14	17,80%	0,00	0,03	0,003
Ijzelenberg et al. 2007	0,50	0,05 , 0,95	3,51%	0,05	0,23	0,029
Levanon et al. 2012/E-control	0,81	0,18 , 1,43	1,98%	0,10	0,32	0,011
Levanon et al. 2012/EWB-control	0,75	0,15 , 1,36	2,08%	0,10	0,31	0,015
Pillastrini et al. 2007a	0,20	0,00 , 0,40	10,26%	0,01	0,10	0,049
Pillastrini et al. 2007b	0,07	−0,13 , 0,27	10,25%	0,01	0,10	0,499
Santos et al. 2011	0,53	−0,73 , 1,80	0,53%	0,41	0,64	0,407
Stave et al. 2007a	0,32	−0,04 , 0,67	4,99%	0,03	0,18	0,083
Stave et al. 2007b	0,17	−0,20 , 0,53	4,89%	0,03	0,19	0,367
Stave et al. 2007c	0,48	0,09 , 0,88	4,29%	0,04	0,20	0,016
Warming et al. 2008/TT-control	0,25	−0,19 , 0,68	3,68%	0,05	0,22	0,263
Warming et al. 2008/TTPT-control	0,57	0,10 , 1,04	3,24%	0,06	0,24	0,017
Williams et al. 2010	0,24	−0,02 , 0,50	7,69%	0,02	0,13	0,070
Yang et al. 2007	0,61	0,61 , 0,61	6,36%	0,02	0,15	0,000
Overall (random-effects model)	0,23	0,14 , 0,33	100,00%	0,00	0,05	0,000

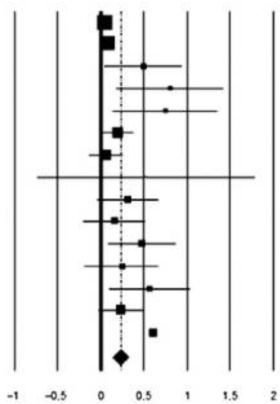

Figure 5.
Training on health: heterogeneity and bias publication

really low: $g = 0.21$, CI = 0.11 − 0.32). The 30 to 39-year-old workers mainly benefited from training on behavior ($g = 0.93$, CI = 0.58 − 1.27) and health ($g = 0.53$, CI = 0.28 − 0.78), less noticeably on knowledge ($g = 0.37$, 9CI = 0.25 − 0.48). No study in this meta-analysis reported trainings on attitudes or beliefs for this age range. The younger workers' category (<30 years old) exhibited only a single training effect, i.e. a substantial shifting toward more secure attitudes ($g = 1.31$, CI = 0.39 − 2.22). However, this improvement seemed to be stronger than the corresponding change in the 40 to 49 and 30 to 39-year-old workers' category. This result could be explained by the older workers' greater ability to acquire knowledge and to transform attitudes and beliefs corresponding to experiences that already exist in their occupational context, as opposed to a smaller willingness to change well-established behaviors and healthy lifestyles. On the other hand, we found that the 30 to 39-year-old people demonstrated a greater readiness to improve their healthy behaviors, despite a smaller knowledge acquisition, perhaps because of an experience not yet adequately developed. However, other important data (under 30 and over 49 years) are still lacking.

Training factors

Trainer's characteristics. The self-learning training showed a very compelling efficacy when addressed to attitudes ($g = 2.10$, CI = 1.57 − 2.62) and knowledge ($g = 1.95$, CI = 1.56 − 2.33), but it was not satisfying for health training ($g = 0.33$, CI = − 0.20 − 0.85). An expert trainer was suitable for changing behaviors ($g = 0.64$, CI = 0.29 − 0.98) and attitudes (but self-learning seemed again to be a better way; $g = 0.76$, CI = − 0.22 − 1.31) and had only a weak effect on healthy lifestyles ($g = 0.10$, CI = 0.04 − 0.17). The researcher was a good guide to modify behaviors (even more so than an expert: $g = 0.80$, CI = 0.37 − 1.24) and health ($g = 0.64$, CI = 0.33 − .94). The efficacy of a peer trainer was scarcer and restricted to knowledge ($g = 0.28$, CI = 0.10 − 0.46) and attitudes ($g = 0.30$, CI = 0.10 − 0.50). Finally, the trade union representative showed a fair ability to transfer information ($g = 0.43$, CI = 0.27 − 0.58).

Training method. Coherently with the trainer characteristics results, the e-learning method showed its best efficacy when applied to modify attitudes ($g = 2.10$, CI = 1.57 − 2.62) and to pass on knowledge ($g = 1.95$, CI = 1.56 − 2.33). Classroom theory with active learning was quite efficient in managing knowledge transmission ($g = 1.07$, CI = − 0.54 − 2.69); the near-to-threshold significance may be because of the heterogeneous characteristics of the two interventions that the meta-analysis considered. De Souza *et al.* (2012) actually used real classroom lessons, conducted by a trained peer, whereas in Sam *et al.*'s (2008) study the researchers gave lessons at the home of every farm worker. This method turned out to be rather well suitable also for changing attitude and beliefs (g = 0.79, CI = 0.36 − 1.22), but less apt for behaviors ($g = 0.46$, CI = 0.19 − 0.72), and it was definitely inadvisable for health outcomes ($g = 0.12$, CI = 0.05 − 0.20). The ergonomic training resulted to be surely the best technique to induce behavioral changes ($g = 1.08$, CI = 0.86 − 1.29) and, to a lesser degree, to produce positive effects on workers' health dimensions ($g = 0.51$, CI = 0.05 − 0.96). This outcome seemed to be the most difficult to treat because also a hands-on practice had an only moderate efficacy ($g = 0.40$, CI = 0.08 − 0.72).

Number of trainees for session. We will limit ourselves to a few remarks because data were missing for three of the seven studies included in this meta-analysis. Individual teaching was mostly recommendable for attitudes ($g = 1.94$, CI = 1.48 − 2.41) and knowledge outcomes ($g = 1.56$, CI = 0.82 − 2.30; all the four studies interested to this outcome used just this individual approach), but it also showed some interesting effects when applied to behavioral training (g = 0.74, CI = 0.29 − 1.19). Group (<35 participants) activities resulted less efficient than individual tuitions for attitudes (g = 0.76, CI = 0.22 − 1.31) and behavior (g = 0.49, CI = 0.20 − 0.78). Again, health training showed weaker ES, equally for (g = 0.39, CI = 0.17 − 0.60) and group (g = 0.35, CI = 0.16 − 0.54) procedures.

Session duration. Session durations were categorized as <1 h, 1-8 h, >8 h. Results seemed to suggest to apply "the smaller (duration) the better" rule, both for knowledge (<1 h.: g = 1.32, CI = 0.59 − 2.05) and attitudes training (<1 h.: g = 1.76, CI = 1.30 − 2.22), and the opposite "the bigger the better" rule for behaviors (1-8 h.: g = 0.76, CI = 0.53 − 0.98; >8h.: g = 0.70, CI = 0.29 − 1.11) and health (only >8 h. sessions were mildly and significantly helpful: g = 0.40, CI = 0.24 − 0.57).

Mandatory/not mandatory training. When participants could voluntarily choose to participate in training, rather than to be compelled to do so by supervisors, all ESs were stronger, especially for knowledge (g = 1.14, CI = 0.17 − 2.10 versus g = 0.43, CI = 0.27 − 0.58) and attitudes and beliefs (g = 1.37, CI = 0.67 − 2.07 versus g = 0.99, CI = 0.24 − 1.73), both also for behaviors (g = 0.70, CI = 0.43-.96 versus g = 0.54, CI = 0.19 − 0.89) and health outcomes (g = 0.42, CI = 0.26 − 0.57 versus g = 0.13, CI = 0.05 − 0.22). We theorized that this result could suggest that the workers saw training as a mere duty, whose usefulness was not clear to them. They saw it as a waste of time, not as a professional opportunity.

Study characteristics

Measures of effectiveness. The reviewed studies used several instruments to assess training efficacy, including questionnaires, practical tests, observational checklists, physiological data and documentary databases. Practical tests seemed to be the most sensitive measure of pre-post intervention differences for knowledge (g = 1.95, CI = 1.56 − 2.33) and attitudes (g = 2.10, CI = 1.57 − 2.62). Changing in behavioral routines were better evaluated by physiological data of bodily functioning (g = 1.06, CI = 0.15 − 1.97) and by observations in workplaces (g = 0.76, CI = 0.60 − 0.91). Questionnaires scores, instead, resulted only moderately sensitive for knowledge (g=0.66, CI = 0.22 − 1.11), attitudes (g = 0.79, CI = 0.36 − 1.22) and behaviors (g = 0.53, CI = 0.27 − 0.78), and they were the only weakly efficient measure to detect changes in healthy lifestyles (g = 0.34, CI = 0.21 − 0.46).

Follow-up. As for session duration, the knowledge and attitudes training efficacies seemed to share a preference for a brief time-span from intervention to follow-up. Their ESs decreased from an immediate follow-up (g = 1.51, CI = 0.48 − 2.54 and g = 2.04, CI = 1.47 − 2.62, respectively) to < 3 months (only for attitudes: g = 1.67, CI = 1.40 − 1.95) and to three-six months' follow-up (g = 0.42, CI = 0.28 − 0.57 and g = 0.36, CI = 0.19 − 0.53. respectively). On the other hand, behaviors and health training ESs of pre-post intervention differences were not significant when follow-up was immediately subsequent to the intervention; appreciable changes arose only for < 3 months (g = 1.07, CI = 0.72 − 1.42 and g = 0.78, CI = 0.34 − 1.22) and three-six months' follow-ups (g = 0.39, CI = 0.13 − 0.66 and g = 0.28, CI = 0.16 − 0.41).

Randomized clinical trial/non-randomized clinical trial. We did not compare RCTs to non-RCTs involving knowledge outcomes (six of seven studies were non-RCTs) and attitudes changes (all research were non-RCTs). Both the training effects on behaviors and healthy lifestyles resulted stronger when noticed in RCTs than non-RCT. All RCTs (five studies) about behavioral training found a significant and strong pre-post intervention difference (g = 1.20, CI = 0.69 − 1.71), whereas 9 out of 12 non-RCTs evidenced a milder, even if significant, effect (g = 0.47, CI = 0.24 − 0.69). More plainly, only RTCs on health training demonstrated a clear and statistically significant efficacy (g = 0.52, CI = 0.30 − 0.74), whereas the non-RCTs pre-post intervention differences were not consistently significant (five studies out of nine) and their overall combined ES was quite unappreciable (g = 0.16, CI = 0.8 − 0.25).

Discussion

The studies included in our meta-analysis showed that OHS training induced positive effects on workers' attitudes and beliefs toward health protection at work and on their knowledge about the potential harmful effects of certain practices. However, we found a less convincing evidence of training effectiveness on workers' behavior and minor evidence of training effectiveness on workers' health. This result may be because of the fact that the experience of adults is generally rich and this leads to rigidity of habits and to learning resistance (Knowles, 1984). Our results are partially in line with a previous meta-analysis performed by Robson *et al.* (2012), who found strong evidence of the effectiveness of training on workers' safe behaviors but insufficient proof of effectiveness for workers' health.

Indeed, the authors showed that participation in training activities exerted great impact because the training method had the learners more involved (Burke *et al.*, 2006). Thus, the authors concluded that large impact of training on health cannot be expected based on research evidence (Robson *et al.*, 2012). The low effectiveness of training on health could also be because of both the methodologies used to measure this outcome and moderating and mediating factors between training and improvement of health that could be influenced, for example, by the impact of training on behavior.

Reason (1990, 2008) pointed out that safety climate affects compliance with rules and procedures. In fact, safe behavior depends not only on perception and knowledge but also on social conditioning. Many authors demonstrated that safety climate is the more effective predictor of behavior (e.g. Quick *et al.*, 2008). In particular, Zohar (1980) suggested that managers should be involved in safety measures to help increase the effectiveness of training.

Moreover, the training ESs were strong for attitudes and beliefs, moderate for behavior and knowledge and rather modest for health outcome. However, we also considered not RCT studies (75 per cent): this criterion may have lead us to include studies evaluating interventions less effective than those examined by Robson *et al.* (2012) and this could explain why the ESs on knowledge and behavior were weaker. The Robson' ES on attitudes and beliefs was weaker than our result: this could be explained by excluding from the ES calculation those values immediately recorded at the end of training (Lesch, 2008). In this case, considering only the follow-up performed after two weeks, we would observe a result that is less affected by the immediacy of the intervention (we did not exclude the immediate follow-up of Stephenson *et al.* (2011) because we would have had to consider only the follow-up performed one year after the baseline).

The most effective training, in terms of improving safety knowledge and attitudes, seemed to be the individual self-learning modality, supplied by learning sessions no longer than 1 h and not compulsory for the worker. Future research should more deeply investigate the efficacy on knowledge increase of training delivered by experts and researchers, applying different methods, in a small group, with duration of over 1 h.

Future research should also investigate training delivered by peers and by researchers, applying different methods, with duration of over 1 h. As regards attitudes and beliefs, we need to verify the efficacy of interventions led by peers and researchers, applying different methods and durations, as well as if there is an actually different ES for different levels of age. The most significant measures of efficacy were practical tests and questionnaires (administered immediately after the intervention) for knowledge training and only practical tests (in a follow-up time from immediately until three months) for attitudes training.

The best effects on increasing safety behaviors were obtained by ergonomic, not compulsory training (aimed to the reduction of musculoskeletal symptoms) led by a researcher or, to a lesser extent, by an expert, individually supplied and for a longer duration (more than 1 h). The efficacy of this training, recorded by physiological data of bodily functioning, was better not immediately after the intervention (best interval: three months). The most effective training in terms of health's improvement was delivered by individual or group ergonomic training sessions led by a researcher or, to a lesser extent, by hands-on practice with additional physical exercise, with a duration of more than 8 h, not compulsory. Another important aspect of the training was the compulsoriness. The effectiveness was, in fact, higher in voluntary learning conditions.

Regarding the measurement of the effectiveness, the most significant measures were obtained by questionnaires, administered up to three months after the intervention. Similar to the behaviors' results, the interventions showing the greatest effects were those mainly aimed at improving behaviors in order to reduce the risk of musculoskeletal disorders (ergonomic risk). This would explain such similar results and the greater emphasis on the provision of ergonomic training, assessed by self-reported data of perceived harm to health.

Although our analysis tends to confirm previous studies, it is the most recent meta-analysis on safety training. Our goal was to identify all the detailed factors that influence this type of training with less restrictive criteria, trying to also explain the lack of its effectiveness. A large body of researches had been omitted by previous meta-analyses.

Conclusion

Our meta-analysis represents the first step to understand the effectiveness of safety training in terms of modality, trainers' characteristics, setting, session duration and assessment instruments and their consequences on workers' knowledge, attitudes and behaviors.

Overall, our meta-analysis suggests that classroom training, although the most widely used and studied, did not always prove to be very effective: its outcomes were not significant in terms of knowledge, with a decreasing efficacy for attitudes and beliefs, behaviors and health. It seemed that there was a distinction between interventions on knowledge, attitudes and beliefs, which were more effective when delivered in e-learning and behavioral interventions and health, which were more effective if provided in the form of ergonomic training (behavior), ergonomic practice or hands-on practice completed by physical exercise activities (health). We suggest that the self-learning by e-learning method could be perceived by participants as potentially appropriate for their training objectives. The instructional content, focusing on knowledge of risks and standards, as well as attitudes and beliefs toward the correct use of tools and equipment (e.g. personal protective equipment) well corresponded to the workers' practical needs. These can be met individually, in terms of effectiveness and efficiency, within a time not exceeding 1 h. Consequently, the outcome of this training can be tested through a practical test.

As for the behavior and health, we suggest that a greater effect can be achieved with provisions by experts and trained researchers, in particular through ergonomic training or coaching with additional physical exercise. The qualified trainer could be perceived as authoritative and, consequently, he/she could facilitate the learning process, preferably outside the context of a traditional classroom and with greater effect on individual training (even if for the health we did not detect differences between individual and group settings). In this case, the training required a longer time to be effective and, consequently, it took longer to detect its effects.

The clearer distinction between outcomes in terms of behavior and health concerns measures for the detection of the effect. Physical data, but to a lesser extent also the observation of behavior, allowed us to detect large effects for behavior, presumably when dealing with ergonomic risks and training. On the other hand, the questionnaire proved to be the most suitable method to detect the effects of training for health.

The optimal session duration for knowledge and attitudes targets was a short period of time, whereas behavioral and, above all, health outcomes needed longer sessions. In addition, the most effective training was always the individual, except for the improvement of health outcomes. We thus suggest to put in greater efforts to arouse workers' motivation and, even if the training is compulsory, to bring attention to the opportunities that professional training can provide.

Among the assessment tools, questionnaires were the most commonly used, although not always the most effective: practical tests detected a greater effect for knowledge, attitudes and beliefs, whereas physical data better highlighted behavioral outcomes. Considering the follow-up intervals, we could conclude that, regardless of the type of outcome, the training effects were significantly reduced over three months. Therefore, we suggest to continue training over time.

Even if we did not include (this is a limitation of our meta-analysis) studies in languages other than English, unpublished studies and dissertations or abstract from conference proceedings, our meta-analysis suggested, in any case, that our knowledge in this field is far from complete. Many questions still remain unanswered: in particular, future research should investigate trained workers younger than 29 and older than 49. Workers in these age groups are particularly vulnerable to fatalities (in 2012, among all the fatalities in Italy the 11.8 per cent involved <30 years old workers and 38.1 per cent involved >50 years old workers, INAIL, 2013). Ethnicity should also be considered a risk factor for injuries (14.1 per cent of fatalities recorded in Italy during 2012 occurred to migrant workers, INAIL, 2013). We also suggest to investigate trained workers employed under precarious employment contracts, to measure the presence of a relationship between precariousness and harmful events. This aspect seems to be very important. For example, in Italy, 82.5 per cent of employment contracts signed in 2012 were for short-term jobs (Isfol, 2013). Similarly, it may be useful to consider other moderators (e.g. schooling and years of work experience) and different hazards compared to accident and ergonomic risks, which are the most studied, so as to involve a larger number of business sectors and countries.

Another aspect that should be investigated is related to the importance of safety management in the workplace.

Improvement of behavior and health are ambitious objectives and the mere training is probably not enough to induce significant effects. There is evidence that shows the importance of management communication style and communication frequency on workers' cognitive failure, in relation to perception of convenience (Liao *et al.*, 2014).

In particular, to improve health indicators, the worker's participation is a major success factor when ergonomics and work organization factors are integrated (Eklöf *et al.*, 2004). For example, injury rates changed trend in relation with improvements in internal health and safety organizations performance and safety culture indicators (Nielsen, 2014). We know that participated and long-term interventions are more frequent in companies that adopt a well-organized systematic OHS management, for policy, goals and plans for action (Dellve *et al.*, 2008). In these cases, we noticed that safety climate affected safety performance with a partial mediation of safety knowledge and motivation (Neal *et al.*, 2000). In addition, we noticed that motivation is related to the degree of participation (Hedlund *et al.*, 2016). Future researches will have to focus on these managerial and organizational factors.

From an applicative point of view, our study will help those who intend to implement effective training in response to specific needs of OHS. For an effective implementation, organizations should develop the capabilities of supporting mechanisms necessary to achieve their safety and health policy, objectives and targets, knowing that training adult workers is often a challenge because they are all motivated in different ways, have different sets of experiences, different expectations and different sets of skills and knowledge. The evidence presented could be considered the first step to identify the factors related to the efficacy of OHS training to plan adequate interventions. The awareness of these factors is pivotal for organizational active leadership and can foster a positive safety and health culture.

In this sense, our analysis should be directed to improve strategies of action designed to prevent accidents and occupational diseases and promote a systematic approach to safety and health management.

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