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INFORMATION PAPER

Is activity-based working impacting health, work performance and perceptions? A systematic review

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ABSTRACT

Numerous claims have been made about the benefits of activity-based working (ABW) on workers' health and work performance. Yet, it is unclear if these claims are proven. This systematic review aims to establish whether there is an evidence base for the effects of ABW on health, work performance and perceptions of the work environment. Eight databases were searched in September 2016. Three reviewers independently screened titles and abstracts and assessed the studies and extracted the data. Seventeen studies involving 36,039 participants were included. The study designs varied in rigorousness from qualitative studies to pre–post-trials and in sample size ranging from 12 to 11,799. This review found that ABW has positive merits in the areas of interaction, communication, control of time and space, and satisfaction with the workspace; however, it is unfavourable for concentration and privacy. For physical and mental health, the evidence is equivocal. ABW seems to be a promising concept that can be implemented and promoted based on some benefits for work performance and perceptions of the work environment when it is coupled with appropriate management support and organization. More high-quality research is needed to strengthen the evidence base further and establish its health effects.

KEYWORDS

activity-based working; agile working; job performance; occupants; office; workplace; workspace

Introduction

'Today's office is a wasteland. It saps vitality, blocks talent, frustrates accomplishment,' said Robert Probst of the office in the early 1960s (Designer Robert Probst–Herman Miller, n.d.). Probst went on to invent the Action Office, an open-plan office system of reconfigurable components. With the Action Office system, Probst challenged traditional, complacent office design with a concept that would fit the way people really work. In reality, however, the Action Office, originally conceived with flexibility in mind, became a precursor of fixed cubicles in open-plan office landscapes, hence the standard office design, driven largely by cost savings.

Now, relatively recent changes in digital technology have created opportunities for new ways of working that were not previously possible. Activity-based working (ABW) is an emergent way of working based on a holistic approach to work style that harnesses the intersection of the people (behavioural environment), place (physical environment) and technology including knowledge sharing (virtual environment) (Veldhoen + Company, 2014). ABW is a style of working that allows employees to perform activities in an environment tailored to the task at hand, and is supposed to support work activities optimally. A workplace that supports ABW typically has design features such as team desks, sit–stand workstations, quiet rooms, break-out areas, telephone and meeting rooms, and a lounge area. They are often characterized as non-territorial workplaces where workers do not have allocated seating, although there are sometimes home zones or neighbourhoods allocated to a team or group. Many ABW workplaces have a workstation to employee ratio of 0.7–0.8 (Wyllie, Green, Nagrath, & Town, 2012), based on occupancy studies showing that each workstation is occupied for at the most 70% of the time. Some workplaces have adopted a 'hybrid' system where there are allocated workstations, but in addition have extra spaces that support certain activities. There are a number of terms used to describe

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this way of working/these office types besides ABW, such as 'agile', 'flexible', 'new ways of working' (NWW), 'future ways of working', 'flexi-office' *etc.* Hence, ABW is supposed to facilitate the freedom for people to individualize their work style and work location. The culture of an ABW workplace is dependent on the fact that management supports and empowers the workers to work flexibly, and that workers are supportive of a work environment where they do not have an allocated base desk or workstation (Wohlers & Hertel, 2017). The two main reasons for organizations to adopt ABW are cost savings in office space, including general and technical services and increased flexibility of office use, and organizational improvement to enhance the effectiveness and efficiency of costly resources (Brunia, de Been, & van der Voordt, 2016; Medik & Stettina, 2014). There have been several reports on the many perceived issues with standard open-plan offices, especially related to noise (De Croon, Sluiter, Kuijer, & Frings-Dresen, 2005; Kim & de Dear, 2013), but it is not clear if similar issues are present in ABW environments.

Large claims are made of the benefits of ABW, often by building developers and designers, and there is an expectation that workers will interact more and develop a stronger team-based culture and be happier at work with ABW (NAB, 2015). However, it is not evident if there is a solid foundation to these claims.

The aim of this systematic review is to establish whether there is an evidence base for the effects of ABW on health, work performance, and perceptions of the physical and psychosocial work environment, and to evaluate the relative advantages and disadvantages of ABW.

Methods

Search strategy

To answer the research question, a search was performed in September 2016. The authors searched Scopus, Pubmed, CINAHL, Business Source Complete, Health Business, PsychInfo, Embase and Web of Science. This set of databases was selected to ensure a wide search across disciplines. The search results were collated into an online systematic review platform, Covidence (www.covidence.org), in which title and abstract, followed by full-text screening was conducted.

This systematic review was registered on PROSPERO (www.crd.york.ac.uk/prospero), under the registration number CRD42016043659, where the search terms can be found in detail. These terms (summarized in Table 1) were chosen to identify interventions of interest that measured a specific emotional, physical and social outcome. Initial searches returned a high number of irrelevant articles as 'ABW' is a term used in various sectors. Subsequent revised searches included the exclusion terms 'actual body weight' and 'robot'. There were no date restrictions on the searches.

Inclusions and exclusions

Studies were included if they: (1) reported an intervention including an ABW concept, where employees did not have an allocated desk or workspace and were provided with a variety of tailored work environments; (2) were conducted in an office environment with adults; (3) measured a specific outcome related to health, work performance and perceptions of the physical and psychosocial work environment; (4) had pre–post, natural experiment, post-occupancy or case study designs; and (5) had full-text articles available in English. Exclusions were those studies that reported on active design, mobile working, information technology (IT) systems, agile projects and hot desking only. Only peer-reviewed publications were included.

Screening

Three co-authors independently screened each article's title and abstract initially in pairs (L.E., J.Y.C., D.J.).

Table 1. Search terms used for the systematic searches.

Activity-based working	Indoor built environment	Connectivity	Motor activity
ABW	Mobile work	Disruption	Movement
Activity-based environment	New ways of work	Exercise	Noise
Activity-based management	Non-territorial work	Health promotion	Occupational sitting
Agile work	Task-based work	Incidental	Physical activity
Flexible work	Task-centred work	Interaction	Postural balance
Future ways of work	Collaboration	Knowledge transfer	Prevention
Productivity	Sedentary	Space utilization	Workplace health
Profitability	Social	Walk	Workplace utilization
Satisfaction	Social networking	Wellness	

Any disagreements were resolved through discussion with a third reviewer to reach a consensus. The same process was repeated for full-text screening, with the final included abstracts of included papers exported for data extraction.

Figure 1 shows a flowchart of database searches, screening and selection of articles according to the PRISMA statement (www.prisma-statement.org).

A total of 1946 articles were found through database searches and 13 through additional searches and added to Covidence for title/abstract screening; 556 duplicates were removed, and of the remaining 1403 articles, 1347 were deemed irrelevant, leaving 56 articles for full-text screening. Of the 56 full-text articles screened, a further 39 studies were excluded because they were not about an intervention or exposure in an ABW setting ($n = 19$); the studies did not measure any outcomes related to health, work performance and perceptions of the work environment ($n = 10$); were duplicates ($n = 7$); and did not have a full text available ($n = 3$). A final total of 17 articles was selected for full data extraction.

Data extraction

Three co-authors (L.E., J.Y.C., S.Y.) extracted the following information from the 17 articles included for review: study design; study objective; population; sample size; intervention(s) or exposure(s); outcomes; outcome measures; data analysis; findings; and implications. The principal summary measure was the impact ABW had on the health, productivity and perceptions of the physical and psychosocial work environment, which were recorded quantitatively or qualitatively depending on the study. These results were categorized by the outcome measured and are presented descriptively below. The description 'mixed evidence' is used when some studies reported a positive effect, while others reported a negative effect of ABW on the various outcomes.

A basic assessment of the quality of the included studies to assess the impact of ABW was made based on the study design, sample size and number of workplaces, statistical analyses, description of the sample characteristics (demographics) and response rates (Table 2). With this scoring system, the studies could score between 3 and 13 points.

Results

For summary information of data extraction and quality scores, see Table S1 in the supplemental data online. The quality scores of the included papers vary from 4 to 11 out of 13. Note that the studies included in this review originate from disparate disciplines with different purposes and conventions on reporting and analyses, hence the quality scores are indicative only.

Figure 2 shows the main positive or negative outcomes associated with ABW.

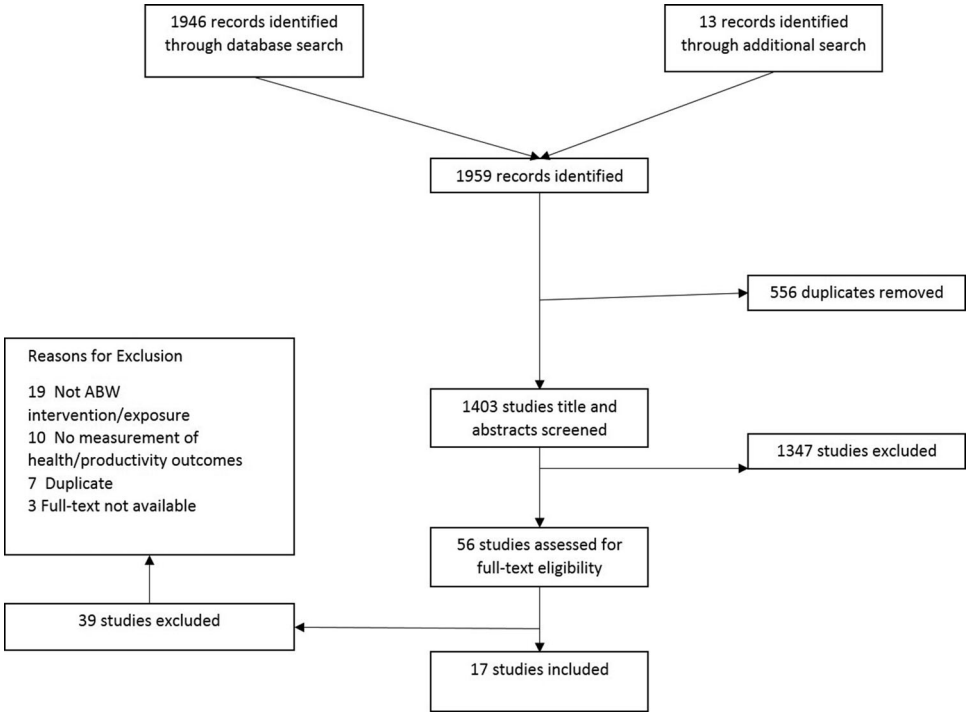

Figure 1. Flow diagram of the searched and included papers.

Table 2. Quality scoring template for the included papers.

		Score
Study design	Qualitative only	1
	Post-occupancy	2
	Pre–post-design	3
	Pre–post + objective measure	4
Sample size	< 50	1
	50–999	2
	> 1000	3
Setting	One study location	1
	Two or more study locations	2
Statistical analyses[a]	None reported	0
	Basic statistics	1
	Appropriate statistics	2
Description of sample demographics	No	0
	Yes	1
Reporting of the response rate	No	0
	Yes	1

Note: [a]Basic statistics = methods describing the outcomes and high-level relationships (descriptive statistics, *t*-tests, correlations). 'Appropriate' statistics = methods that test for statistical changes in the variables of interest, using confounders, covariates and taking repeated measures into account *etc.* able to detect causal relationships, interactions or effects.

Types of studies

Five pre–post-studies (Blok, de Korte, Groenesteijn, Formanoy, & Vink, 2009; Foley, Engelen, Gale, Bauman, & Mackey, 2016; Nijp, Beckers, van de Voorde, Geurts, & Kompier, 2016; Robertson, Huang, O'Neill, & Schleifer, 2008; van der Voordt, 2004), where office workers who moved from a standard office environment to an ABW environment permanently or temporarily, were included. Sample size varied from 64 to 2391. The majority (11) of the included studies were post-occupancy (sample sizes = 110–11,799) (Appel-Meulenbroek, Groenen, & Janssen, 2011; Brunia et al., 2016; Candido et al., 2016; Danielsson & Bodin, 2008; de Been & Beijer, 2014; de Been, Beijer, & den Hollander, 2015; Gorgievski, Van der Voordt, Van Herpen, & Van Akkeren, 2010; Keeling, Clements-Croome, & Roesch, 2015; Kim, Candido, Thomas, & de Dear, 2016; Seddigh, Berntson, Bodin Danielson, & Westerlund, 2014; Ten Brummelhuis, Bakker, Hetland, & Keulemans, 2012). These studies investigated a range of outcomes in ABW environments in comparison with open-plan offices or private/cellular offices. One qualitative study (Medik & Stettina, 2014) was included in this review.

Health and health behaviour

Eight included studies collected data on health-related outcomes (Candido et al., 2016; Danielsson & Bodin, 2008; Foley et al., 2016; Kim et al., 2016; Nijp et al., 2016; Robertson et al., 2008; Seddigh et al., 2014; Ten Brummelhuis et al., 2012).

General health

The available evidence about the impacts of working in an ABW environment on general health were equivocal and derived from five studies (Candido et al., 2016; Danielsson & Bodin, 2008; Kim et al., 2016; Nijp et al., 2016; Seddigh et al., 2014). One study found significantly lower general health scores among employees working in an ABW environment at follow-up approximately 16 months from baseline ($p < 0.001$) (Nijp et al., 2016). In two studies, no significant change in self-rated health was observed among employees working in different office types (Danielsson & Bodin, 2008; Seddigh et al., 2014). Danielsson and Bodin (2008) also assessed the impact of the flexible workspace on employees taking sick leave and found a significantly smaller proportion of employees taking any sick leave in the flex office type ($p < 0.05$) than in the open-plan office types.

Candido et al. (2016) asked occupants about how they perceived their work area to influence their health. Those working in an ABW environment had significantly more positive ratings than those working in hive or cell office types ($p < 0.05$). Kim et al. (2016) examined office features and negative ratings of health and found that employees with fixed desks were more likely than those working in flexible spaces to rate their health negatively (32% versus 20% respectively). They also noted that specific workspace features affect perceptions of health, where uncomfortable furnishings showed a 49% increased likelihood of negatively rated health influences by the workplace.

Musculoskeletal discomfort and complaints

Overall, two studies provided limited and mixed evidence that working in an ABW environment has an impact on employees' self-reported musculoskeletal complaints or discomfort (Foley et al., 2016; Robertson et al., 2008). In one study, participants reported less lower back discomfort when working in an ABW trial space compared with the usual office ($p < 0.05$), but no changes in discomfort at other body parts, such as neck, shoulders, wrists and hands, and legs (Foley et al., 2016). In another study, general musculoskeletal discomfort over eight body parts was significantly reduced among employees after six months working in a new flexible office workspace with added ergonomics training, and reduced discomfort in the legs, and wrists or hands, among employees who worked

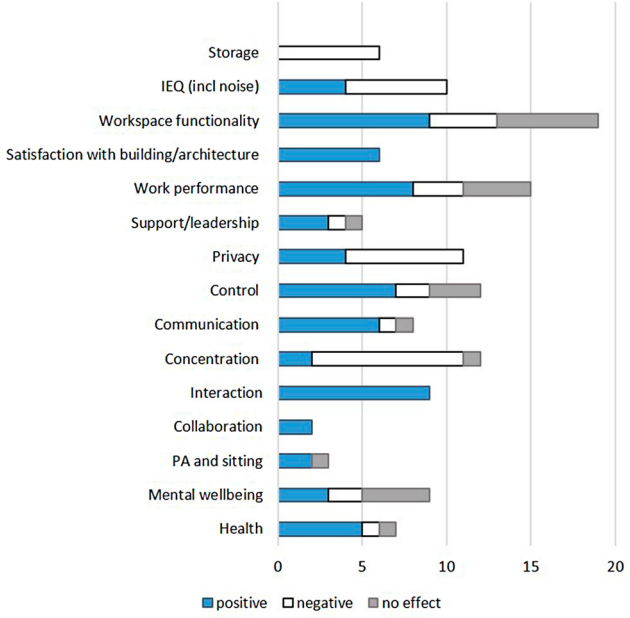

Figure 2. Summary of the number of studies that found a positive, negative or no effect on an outcome in the activity-based working (ABW) environment. Sample size or the quality of the study have not been taken into consideration.

in the flexible office space and did not receive ergonomics training, compared with controls ($ps < 0.05$) (Robertson et al., 2008).

Physical activity and sitting

There is limited evidence that ABW affects workers' physical activity or sitting at work based on two studies (Blok et al., 2009; Foley et al., 2016). The data are suggestive of ABW enabling more movement in the office, but it would be premature to attribute changes in occupational physical activity and sitting to ABW due to the current limited research testing of these behaviours.

Foley et al. (2016) found no significant differences in accelerometer-assessed time spent sedentary or in moderate-to-vigorous intensities in office workers when occupying their 'regular' office and when in an ABW trial space. Accelerometer-assessed step counts and breaks in sedentary time showed patterns suggesting greater movement and variation in posture, although non-significant. However, participants' self-reported occupational sitting decreased (–14%) and standing increased (11%) when they worked in the ABW trial space compared with their 'regular' office set-up ($p < 0.01$).

Blok et al. (2009) objectively measured the number of times workers switched workstations during a working day, which can be interpreted as an indication of incidental physical activity (*e.g.* walking). They found an increased number of workstation switches among workers in the ABW environment compared with the traditional office in one of two departments, but these were not statistically tested. Blok et al. also found that the proportion of time workers were on the move in the office appeared to increase in the ABW environment versus the traditional office in both company departments (not statistically tested).

Mental wellbeing

Stress

Two studies assessed stress as an outcome (Nijp et al., 2016; Seddigh et al., 2014). In one (Seddigh et al., 2014), employees working in cell offices reported lower cognitive stress than all open-plan office types (small, medium, large, flexible) ($p < 0.001$), but there was no difference in cognitive stress levels when employees in the flexible office space were compared with other open-plan office types ($p > 0.05$). Additionally, employees with a high need for concentration reported higher levels of cognitive stress in all office types except in cell and flexible offices ($p < 0.05$). In another study, Nijp et al. (2016) found no significant changes in employees' stress levels after working in an ABW environment for about 16 months ($p > 0.05$).

Exhaustion/fatigue

There is limited evidence indicating that ABW affects employee perceptions of exhaustion or fatigue based on three studies (Nijp et al., 2016; Seddigh et al., 2014; Ten Brummelhuis et al., 2012). Seddigh et al. (2014) asked participants about emotional exhaustion and found no difference between employees working in different types of offices (cell or open-plan varieties, including flexible style) ($p > 0.05$). Ten Brummelhuis et al. (2012) reported no direct relationship between working in an ABW environment and daily exhaustion. Nijp et al. (2016) observed that working in an ABW space increased self-reported fatigue at follow-up approximately 16 months from baseline ($p < 0.01$).

Communication, interactions and collaboration

Twelve studies were identified with outcomes relating to communication, interactions and/or collaboration (Blok, Groenesteijn, Schelvis, & Vink, 2012; Brunia et al., 2016; Candido et al., 2016; Danielsson & Bodin, 2008; de Been & Beijer, 2014; de Been et al., 2015; Gorgievski et al., 2010; Keeling et al., 2015; Kim et al., 2016; Medik & Stettina, 2014; Robertson et al., 2008; Ten Brummelhuis et al., 2012). There is emerging evidence that ABW has positive effects on communication ($N = 5$) and interactions ($N = 9$), with less evidence available for collaboration ($N = 2$).

Communication

Five studies found positive associations between communication and ABW-type environments (Blok et al., 2012; Brunia et al., 2016; de Been et al., 2015; Robertson et al., 2008; Ten Brummelhuis et al., 2012) and one study (de Been & Beijer, 2014) showed no effect.

Blok et al. (2012) found that the new flexible work environment better supported communication with colleagues as well as visitors. Employees moving from a traditional to a task facilitating (ABW) office rated their productivity significantly higher in relation to communication and cooperation. Similarly, Robertson et al. (2008) found that communication was positively impacted over time for both the experimental groups as compared with the control group. Ten Brummelhuis et al. (2012) found that NWW was positively associated with engagement and enhanced connectivity among co-workers, as well as effective and efficient communication.

De Been et al. (2015) found a positive relationship between an ABW-type environment, communication and knowledge sharing. Case interviews showed that, generally, people experience more communication, knowledge exchange and interact with a more diverse range of colleagues as a result of the openness of the workspace. While this study found overall levels of satisfaction relating to communication opportunities increased, employees reported a decrease in communication with their direct colleagues, as well as difficulties discussing private issues in open spaces.

Interactions

Nine studies found a positive relationship between ABW and interactions (Blok et al., 2012; Danielsson & Bodin, 2008; Gorgievski et al., 2010; Keeling et al., 2015; Kim et al., 2016; Robertson et al., 2008; Ten Brummelhuis et al., 2012).

Gorgievski et al. (2010) found that the new work environment scored higher on employees' perceptions of the possibility to meet and have informal face-to-face conversations. They found similar positive associations relating to ABW-type environments and communication, such as the extent to which the work environment was experienced as functional for 'conducting group meetings with colleagues', 'informal conversations with colleagues' and 'conducting individual meeting with colleagues'. Researchers' interviews with participants and key decision-makers found qualitative themes supporting an increase in collaboration and social interaction. De Been and Beijer (2014) reported mixed findings in the relationship between employee satisfaction with communication and social interaction in 'combi' and 'flex offices' compared with individual and shared-room offices. Employees working in a 'combi-office', described as a 'flex office' with allocated desks, were more satisfied with the opportunities for communication and social interaction compared with those working in individual and shared-room offices. However, these findings were not transferable to an ABW (flex) environment.

Collaboration

Two studies found a positive association between ABW and collaboration (Blok et al., 2012; Robertson et al., 2008). Robertson et al. found that collaboration was significantly higher after moving to an ABW environment for both of the experimental groups (ABW and ABW plus ergonomic training) as compared with the control group. Blok et al. (2012) found that the new flexible work environment better supported cooperation with colleagues as well as visitors.

Concentration

There was mixed evidence of the effect of ABW on concentration. Of the identified studies, two found positive effects on concentration (Blok et al., 2012; van der Voordt, 2004), or a reduction in distractions in an ABW environment, while eight studies reported ABW to influence concentration negatively (Appel-Meulenbroek et al., 2011; Brunia et al., 2016; Candido et al., 2016; de Been & Beijer, 2014; de Been et al., 2015; Kim et al., 2016; Seddigh et al., 2014; Ten Brummelhuis et al., 2012). One study reported both positive and negative effects (Keeling et al., 2015) and another found no effects on concentration (Gorgievski et al., 2010).

Blok et al. (2009) reported that concentration increased and distractions decreased after the participants had moved to the ABW environment in comparison with the traditional office environment. Van der Voordt (2004) reported that there were fewer disruptions by colleagues in concentration workspaces.

More than half the respondents reported to be distracted by others' conversations and one-third by other sounds, *e.g.* doors, photocopiers and air-conditioning (Appel-Meulenbroek et al., 2011). Seddigh et al. (2014) reported higher levels of rated distraction in flex offices (3.30) as compared with cell offices (2.69), but less than in large open-plan offices (3.64). Kim et al. (2016) found a slight increase in unwanted interruptions between fixed- and flexi-desk groups, and many participants commented on how noise levels and unwanted interruptions affected their ability to concentrate. Candido et al. (2016) also found there was a higher level of unwanted interruption in the ABW environment as compared with individual offices. Ten Brummelhuis et al. (2012) reported that working in NWW offices

increased interruptions, especially by e-mail and phone calls, which in turn led to greater exhaustion.

People working in combi- or flex offices rated concentration less positively than those in individual and shared-room offices (de Been & Beijer, 2014). Similarly, respondents in a flex environment scored low satisfaction on their ability to concentrate (de Been et al., 2015). Brunia et al. (2016) reported that, on average, 35% of respondents were satisfied with the opportunities to concentrate in the flex office. Keeling et al. (2015) found that agile workspaces were considered to be better than open-plan offices and as good as cellular offices for working without visual and acoustic distractions, but scored less on concentration.

Control

Based on eight studies, there is evidence that perceptions of time and space control, where the worker feels they can decide when and where to do the work, are higher in an ABW environment. Six studies (Appel-Meulenbroek et al., 2011; Kim et al., 2016; Medik & Stettina, 2014; Nijp et al., 2016; Robertson et al., 2008) reported positive effects of ABW environments on perceptions of control. Gorgievski et al. (2010) reported a negative effect on control, while two studies reported no effect of ABW on any aspects of control (Brunia et al., 2016; Nijp et al., 2016).

Nijp et al. (2016) found a significant increased access to, use and satisfaction with work location, as well as in the work hours, evening hours, home hours and number of days per week working at home following a move to an ABW environment as compared with a non-moving control group with pre-allocated desks. They also found a significant decrease in the number of commute hours, as well as the number of office hours.

Robertson et al. (2008) reported higher ratings of job control after moving to an ABW environment. Keeling et al. (2015) found that agile workspaces were perceived as better than open-plan offices for control of information and perceived as similar to traditional open-plan offices for control of interactions with colleagues. Kim et al. (2016) reported that flexi-desk users reported higher satisfaction of the ambient condition, which the authors explained by higher work location control where flexi-desk users could move around to areas they preferred (less glare, cold air). Appel-Meulenbroek et al. (2011) reported that the control of privacy and interaction was more important than the control of the indoor climate in the ABW environment. More than half the participants said different types of workstation allowed them to regulate the amount of social interactions with others.

Medik and Stettina (2014) reported that all respondents associated NWW with greater job autonomy and flexibility in working time and location, due in part to the fact that all organizations implemented flexibility in work location, flexibility in work time and result-oriented management practices. Gorgievski et al. (2010) found that employees were less satisfied with lack of control of the office environment in the flexible office plan compared with traditional, cellular offices.

Privacy

There is mixed evidence of ABW's effect on privacy based on 10 studies, where four reported a positive (Appel-Meulenbroek et al., 2011; Blok et al., 2012; Keeling et al., 2015; Robertson et al., 2008) and seven (Brunia et al., 2016; Candido et al., 2016; de Been & Beijer, 2014; de Been et al., 2015; Gorgievski et al., 2010; Keeling et al., 2015; Medik & Stettina, 2014) a negative effect of ABW on different aspects of privacy.

Robertson et al. (2008) found there was a significantly increased perception of privacy in the two intervention groups compared with the control group; Keeling et al. (2015) found that agile workspaces were felt to be particularly good for having confidential conversations and as good as cellular offices for working with confidential documents. However, the latter study also found that agile workspaces were considered less private than cellular offices. In Appel-Meulenbroek et al. (2011), the perception of privacy in the ABW environment varied by the type of workspace. In the open workspaces, two-thirds of the participants reported feeling comfortable having confidential conversations and half the participants said workstations were not too much in sight of others.

De Been & Beijer (2014) found that people working in combi- or flex offices evaluated privacy negatively in comparison with those working in individual and shared-room offices. De Been et al. (2015) found low satisfaction scores for privacy from surveys, and interviews highlighted that the participants found it 'troublesome' that they could not have private conversations. Gorgievski et al. (2010) and Candido et al. (2016) also found that employees in a flexible office plan were less satisfied with visual and auditory privacy as compared with a traditional, cellular office, and they mentioned lack of space for confidential phone calls.

Work performance

Eleven studies examined the impact of ABW on at least one aspect of work performance, which was measured variously as changes in productivity, job satisfaction,

job demands, job motivation/engagement, in- and extra-role performance, work/non-work hours balance, and work ability (workers' perception of how well they can cope with their work with respect to work demands; Vänni, Virtanen, Luukkaala, & Nygård, 2012). Eight studies reported a positive effect (Blok et al., 2012; Candido et al., 2016; Danielsson & Bodin, 2008; Kim et al., 2016; Medik & Stettina, 2014; Nijp et al., 2016; Ten Brummelhuis et al., 2012; van der Voordt, 2004), three reported a negative effect of ABW on work performance (de Been & Beijer, 2014; Nijp et al., 2016; van der Voordt, 2004), and four found no effect on at least one measure of work performance (Danielsson & Bodin, 2008; Foley et al., 2016; Nijp et al., 2016; Seddigh et al., 2014).

Of the eight studies reporting a positive impact on work performance, five found work productivity improved in an ABW environment (Blok et al., 2009; Candido et al., 2016; Kim et al., 2016; Medik & Stettina, 2014; van der Voordt, 2004), another found productivity was lower (de Been & Beijer, 2014), while yet another found no effect of ABW on productivity (Seddigh et al., 2014). Van der Voordt (2004) reported conflicting results for the impact of ABW on productivity, which increased in one company and decreased in another. Candido et al.'s (2016) post-occupancy survey study found respondents reported higher scores on productivity in an ABW environment than in either hive (open plan) or cell (closed/private office) environments. Two studies (Ten Brummelhuis et al., 2012; van der Voordt, 2004) reported improvement in job motivation or engagement in ABW, while Danielsson and Bodin's (2008) cross-sectional occupancy survey found higher job satisfaction for workers occupying shared-room offices and flex (ABW) offices compared with open plan. Nijp et al. (2016) reported on the impact of ABW across five measures of work performance finding a positive impact on job demands, no effect on both job satisfaction and work/non-work hours balance, and both positive and negative effects on in- and extra-role performance respectively, though for these latter measures effects were due to changes in the reference group not the intervention group. Interestingly, Foley et al. (2016) found that while perceived work ability of office employees was not different compared with baseline after a four-week trial of ABW, work ability fell significantly after workers reoccupied their standard open-plan office.

Satisfaction with the physical workspace

There is evidence that occupants are more satisfied with the physical ABW environments on most aspects. Six studies found that the participants were satisfied with the building aesthetics or architecture (Brunia et al., 2016; Candido et al., 2016; de Been et al., 2015; de Been & Beijer, 2014; Keeling et al., 2015; Kim et al., 2016). There is evidence that occupants in ABW are satisfied with the functionality of the workspaces (Appel-Meulenbroek et al., 2011; Candido et al., 2016; de Been & Beijer, 2014; Medik & Stettina, 2014; Robertson et al., 2008; van der Voordt, 2004), although three studies found no effect of the ABW environment on perceptions of functional workspaces (Brunia et al., 2016; de Been et al., 2015; Gorgievski et al., 2010). Although 60% of respondents in Appel-Meulenbroek et al. (2011) were happy with the functionality and comfort of the open spaces, they reported that the spaces for quiet work within the ABW environment were not comfortable to work in. Two studies (Candido et al., 2016; Kim et al., 2016) reported satisfaction with physical spaces intended for break and collaboration, while one study reported the opposite (Appel-Meulenbroek et al., 2011). There are suggestions that the ABW environment is not used fully as intended. In Appel-Meulenbroek et al. (2011), only 12% of the respondents used more than three types of workstations each week and 68% never switched workstations on a regular day.

Although the number of workspaces was not a big issue (two positive: Blok et al., 2009; de Been & Beijer, 2014; one negative: Kim et al., 2016); four no effect: Brunia et al., 2016; de Been et al., 2015; Gorgievski et al., 2010; Medik & Stettina, 2014), there was a clear consensus that there was not enough storage in the ABW environment (Brunia et al., 2016; Candido et al., 2016; de Been et al., 2015; Gorgievski et al., 2010; Kim et al., 2016; Medik & Stettina, 2014), where the storage of both work-related files and personal items was mentioned. The satisfaction with the IT facilities was mixed, where de Been and Beijer (2014) reported positive perceptions, de Been et al. (2015) negative and Brunia et al. (2016) found no effects.

There were mixed reports on the indoor environmental quality, where occupants reported to be satisfied with the light and ventilation (Candido et al., 2016; de Been et al., 2015; Kim et al., 2016; Robertson et al., 2008), but reported increased noise distractions from co-workers (Appel-Meulenbroek et al., 2011; Brunia et al., 2016; Candido et al., 2016; Medik & Stettina, 2014), from photocopiers, doors and air-conditioning (Appel-Meulenbroek et al., 2011), and poor temperature control (Brunia et al., 2016). De Been and Beijer (2014) and de Been et al. (2015) found that those who worked in the flex office were less satisfied with the indoor climate than those in individual or shared rooms.

Robertson et al. (2008) reported that occupants were significantly more satisfied with the ergonomic environment in the intervention groups than in the control group.

Discussion

Purpose of the review

This systematic review endeavours to establish the current evidence for the effects of ABW on health, work performance and perceptions of the physical and psychosocial work environment. The 17 included studies were from a range of disciplines, and of varying quality, and had differences in study design, sample size and scientific rigour in reporting and analyses, hence limiting the opportunity to draw strong conclusions about the effects of ABW. Nevertheless, some recurring outcomes were found in many of the studies and it is a timely effort to summarize the current evidence base.

Implications and recommendations

There was limited evidence of ABW affecting *health-related outcomes and physical activity*. There is some evidence suggesting that occupants rate their general health more positively in ABW environments and that there are some improvements in health behaviour. However, it is not clear if these results reflect actual improvements in health.

A strong positive for ABW was the opportunities for *communication, collaboration and interaction*, which was reported in 12 of 17 studies. This could be attributed to the available spaces to meet and interact, such as break-out areas and cafes, in comparison with standard office environments, which often have little space dedicated to communal eating or meeting areas. These findings suggest that ABW work style can support employees to work more collaboratively, with efficient and effective communication methods, through increased opportunities for formal and informal knowledge exchanges. These findings suggest, that in relation to communication and cooperation, workers could experience a positive effect on productivity, employees' relationships and outcomes (Blok et al., 2012). However, there is also good evidence that occupants find it hard to concentrate in ABW environments, often due to increased interruptions and distractions, such as high noise levels, predominantly in comparison with private/cellular offices, but often perform better than open-plan offices. Workplaces that provide sufficient and well-designed workspaces for quiet/concentrated work seem to perform better, hence it is recommended that a thorough needs assessment takes place before construction or refurbishment to assess the workers' needs. Different workplaces and organizations have different needs depending on the type of work performed and personalities. For example, a software team where a majority of the tasks involve highly concentrated coding tasks will have a higher need of spaces in which to concentrate than a marketing group, and it is important to take these differences into account when designing these spaces.

There seems to be a consensus that ABW is associated with greater *control* of where and when they perform their tasks. This fits well with the basic premise of ABW, where the workers choose where they perform their duties based on the task at hand, such as a collaborative space, a quiet room or at home. This was also accompanied by a few studies reporting less commuting time and more work time. Being granted control over where and when you work is strongly related to a supportive management style. Beyond providing the appropriate physical environment, it is therefore of greatest importance that the psychosocial environment provides this support, too. Hence, the transition to an ABW environment must also be accompanied by a revision of the organization's management style and support.

ABW's relation with privacy was predominately a negative one, at least in comparison with private offices. This finding was also reported by van der Voordt and van der Klooster (2008). It is recommended that strategies need to be implemented to ensure private conversations can be held comfortably, as well as providing workstations where screens make sure workers can be out of sight of others. ABW environments have the potential to provide both these with thoughtful design.

Improved combined *work performance and productivity* has often been promoted as one of the positive outcomes of ABW (Leesman, 2017). This notion is supported by the present review, where 70% of the studies investigating the impact on work performance/productivity in ABW environments relative to standard offices (cell or open plan) showed positive effects on work performance and/or productivity. This finding is internally consistent with the finding of higher perceptions of *control* in the ABW relative to the standard office environments. It is not surprising that work performance/productivity would improve in a work environment that provides greater opportunities for control. However, it is worth noting that as work performance measures in this review were generally self-reported and about *perceived* work performance, there is limited *objective* evidence for this assertion and, hence, it is suggested that future studies endeavour to include objective productivity measures.

Participants in these studies consistently rate the *physical work environment* positively. Many of these effects are likely to be related to the newer environment rather than the ABW environment per se. Although the data suggest there were no issues with the number of workspaces, qualitative data suggest that occupants are concerned that it is hard to find an appropriate place in which to sit unless one arrives early in the morning. This creates some stress and less-than-optimal work conditions (de Been et al., 2015; Kim et al., 2016). As mentioned above, a design based on an organization-specific needs assessment in addition to a flexible design and iterative process that can easily respond to the changing needs of an organization would likely improve function and satisfaction.

The notion that the ABW environment might not be used as intended, where occupants change workspace or workstation according to their task (Appel-Meulenbroek et al., 2011) is in concordance with a recent study by Hoendervanger, de Been, Van Yperen, Mobach, and Albers (2016), where only 4% of people switch locations multiple times per day. However, the people who report to be most positive about ABW are those who embrace it and use several work locations each day to suit their tasks (Leesman, 2017).

Strengths and limitations

A strength in this field is the diversity of disciplines conducting and reporting on ABW settings and their effects, but this also raises a number of issues that make it hard to draw solid conclusions based on the studies included for review. One challenge is the variation in research methods due to the nature of the multidisciplinary backgrounds of researchers investigating ABW. While more rigorous scientific methods including pre–post-studies with comparison groups may generate usable evidence, such studies are often limited in scale. In comparison, post-only studies involving large samples (up to 12,000 respondents; de Been et al., 2015) common to the architecture and corporate property (real-estate) fields may provide more generalizable data, but with weaker evidence of causality (*i.e.* that changes in observations are due to the ABW environment). Other studies just assess the use and implementation of ABW spaces, and provide process measures, but not evidence of actual impacts. For these reasons, cross-disciplinary reviews have challenges in reaching clear conclusions, and this is a limitation of the current review.

In the reviewed papers there was often lack of clear descriptions of the former situation before the adoption of ABW, which somewhat limited the understanding and quantification of change due to the office environment.

Although ABW has been implemented for several decades in some countries, in others it has started to gain popularity only in the last five to ten years. Scientific studies have been limited to date and most of the literature is from the Netherlands and a handful of other countries, hence, generalizability to other types of cultures is limited. Another issue is that most studies are based in the corporate industry and there is limited information about the public sector; in the latter settings, less positive outcomes are reported (Gorgievski et al., 2010; van der Voordt, 2004; van der Voordt & van der Klooster, 2008).

Recommendations for future research

Based on the outcomes of this review, it is evident that a number of gaps in the literature around ABW exist, and especially lack of objective measures and of evidence on any health and health behavioural effects. It is recommended that future research uses consistent and appropriate evidence-generating research methods and designs across disciplines to ensure comparability. Health outcomes need to be more specific than 'overall health' to tease out if the effects are physical, mental or whether they are a reflection of the organization.

It is also suggested that the impacts of ABW on health and wellbeing must be examined using a cross-disciplinary collaborative approach. For example, data collected from repeated post-occupancy surveys (and similar) are shared by architectural firms with health researchers for secondary analysis using more sophisticated statistical methods. In addition, more research is needed to determine the implications of introduction of ABW in the public sector.

Conclusions

ABW is gaining popularity and becoming increasingly common in various guises. Based on this review, ABW was found to have positive outcomes in the areas of interaction, communication, control of time and space, and satisfaction with the workspace. However, limited evidence exists for the effects on physical and mental health. ABW seems to be a promising concept. It can be promoted as providing some benefits for work performance and perceptions of the work environment when coupled with flexible design based on needs assessment, as well as appropriate management support and organization. However, more high-quality research is needed to strengthen the evidence base further and to establish ABW's effects on health and in the public sector.

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