

Physical activity and sickness absence? A review.

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## **Does physical activity have an impact on sickness absence? A review.**

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Neha Mukesh Amlani and Fehmidah Munir

School of Sport, Exercise & Health Sciences, Loughborough University, Loughborough,  
Leicestershire, LE11 3TU, United Kingdom.

**Corresponding author:** Dr Fehmidah Munir, School of Sport, Exercise and Health  
Sciences, Loughborough University, Loughborough, Leicestershire, LE11 3TU. UK  
Tel +44 (0)1509 228228; Fax +44 (0)1509 223940; E-mail: [f.munir@lboro.ac.uk](mailto:f.munir@lboro.ac.uk)

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**Abstract**

Increasing levels of physical activity are proven to have a positive impact on physical health and mental well-being. Physical activity is also known to influence work-related outcomes such as reducing sickness absence. Sickness absence is a major public health problem with wide economic impact on society and there may be much to gain from physical activity interventions aimed at preventing long-term sickness absence. Examining the relationship between physical activity and sickness absence is therefore important as it may provide benefits to organisations globally. This article provides a review of the evidence on the relationship between physical activity and sickness absence among employees. A search of databases (Web of Science, ScienceDirect, Medline and Google Scholar) and references of published studies (from inception to 14th November 2012) were conducted to identify intervention studies and observational studies involving employees. A total of 37 studies published between 1981 and 2012 met the inclusion criteria. Evidence from the review suggests that physical activity is effective in reducing sickness absence. However, the studies highlighted a number of methodological concerns including lack of description of the physical activity programme in intervention studies and use of self-report physical activity in observational studies. We conclude that overall, the available evidence provides limited support that physical activity is effective in reducing sickness absence, due to the low quality of many of these studies. Future research should provide more detailed descriptions of the physical activity programme and use more reliable objective measures of physical activity such as accelerometers and fitness tests.

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## 1. Introduction

Many adults in developed countries do not meet the recommended guidelines for physical activity in order to achieve the health, fitness and well-being benefits associated with participating regularly in this activity.<sup>[1,2]</sup> The consequences of physical inactivity has direct detrimental effects on health<sup>[3]</sup> and is a significant risk factor for coronary heart disease, stroke, hypertension and type 2 diabetes.<sup>[1,3]</sup> Furthermore, a clear causal relationship has been shown between amount of physical inactivity and all-cause mortality.<sup>[3]</sup> In a summary of the evidence for physical activity, the World Health Organization reports that 150 minutes per week of moderate to vigorous intensity physical activity can significantly lower these risks.<sup>[3]</sup>

Promoting regular exercise is therefore crucial for improving and maintaining societal health and well-being. There is also an economic benefit to promoting physical activity such as reducing healthcare costs<sup>[3]</sup> and public health policy worldwide has recommended various community settings such as schools and workplaces to create a culture that encourages regular physical activity<sup>[3]</sup>. Employers are therefore encouraged to play a key role in promoting health and well-being of their employees. Furthermore, evidence suggests that adults who undertake regular physical activity are more productive at work<sup>[4]</sup> and have a lower prevalence of sickness absence.<sup>[5, 6-8]</sup> Moreover, medically certified sickness absence has been found to be a strong predictor of future disability<sup>[9]</sup> and all-cause mortality.<sup>[10]</sup>

Examining the relationship between physical activity and sickness absence is extremely important in current society given the financial impact that sickness absenteeism has on the wider economy. With a direct cost of £17billion across the economy in 2010, for the UK alone,<sup>[11]</sup> sickness absence costs are considered to be a burden for many western economies. Moreover, as employers bear the financial burden of reduced productivity and sickness absence and cover employee healthcare costs in many countries, a clear

understanding and synthesis of the relationship between physical activity and sickness absence is required.

Although a number of intervention studies and prospective studies have reported relationships between increased physical activity and reduced sickness absence,<sup>[6, 7]</sup> these results are not shared by other intervention studies.<sup>[12,13]</sup> Furthermore, there are a lack of randomised controlled trials (RCTs) that specifically examine the impact between physical activity and sickness absence, making it difficult to firmly draw conclusions on whether physical activity interventions reduce sickness absence. Many workplace health promotion intervention studies include physical activity as a component of their intervention, but do not /are unable to report its direct effects on sickness absence. An additional difficulty is provided by the lack of consistency between studies in measuring sickness absence and in distinguishing the type or intensity (low, moderate or vigorous) of the physical activity undertaken by workers. Clarity on both these variables is important in order to understand how different physical activity levels impact on sickness absence.

Although the associations between regular physical activity and reduced sickness absence are accepted, the emerging evidence remains unclear. The purpose of this review is therefore to clarify the relationship between physical activity and employee sickness absence by providing an overview of research on physical activity and sickness absence. This review therefore summarises the evidence for the impact of physical activity interventions on sickness absence to: 1) further our understanding on the effectiveness of workplace physical activity interventions on reducing sickness absence, and 2) evaluate which type of physical activity and its intensity are most effective. In addition to evaluating intervention studies, this review also summarises the evidence on associations between physical activity and sickness absence among working adults (observational studies). These latter types of studies are included to allow for a comprehensive understanding of the relationship between physical activity and sickness absence, particularly with regard to: 1) understanding what type of

physical activities are undertaken by individuals and their intensities and 2) comprehend the type of physical activities that individual are most likely to participate in, and that are effective in reducing sickness absence.

## **2. Literature Search and Evaluation Methodology**

### *2.1 Literature search*

A literature search was undertaken in November 2012 to identify published papers on the relationship between physical activity and sickness absence (including physical activity intervention studies). The literature search included a computerised database search, whereby Web of Science, Science Direct, PubMed, Google Scholar and Cochrane Central Register of Controlled Trials (Cochrane CENTRAL accessed by Wiley Science) were searched.

The following search terms were used in a series of different combinations: (absentee\* OR disability days OR sickness absence OR sick leave OR sick days) AND (workplace OR work place, OR work site OR work setting) AND (exercise OR physical activity OR fitness). For intervention studies, the researchers re-ran the searches combined with one of the following terms: (intervention OR programme OR program OR Randomized controlled tria\*I OR trial\*). Adding the wildcard (\*) to the end of the search term enabled the researchers to search for variations of the term e.g. absentee, absenteeism. The literature base was expanded by searching the reference lists from included studies and their citations. Review articles were also hand searched for any relevant references.

### *2.2. Inclusion and exclusion criteria*

All articles which included the following were initially selected for the review: 1) some form of physical activity (e.g. exercise, sport) as a study variable, 2) at least one of the following outcome measures –disability days, sickness absence, sick leave, sick days, and 3) research

that was conducted in a workplace setting with its employees. Included studies were therefore original research (either intervention studies or observational studies) that contained data on at least 20 participants (greater than or equal to) of 18 years of age and above. Articles before 1980, those that were unpublished and those that were not written in English were excluded from the current review. Articles that did not examine associations between physical activity and sickness absence, or involved a population with a specific illness or condition were excluded. For intervention studies, these were further considered eligible if they assessed sickness absence in terms of number of sick days/sick leave measured using one of two methods: either personnel records from the organisation itself, or from registers of insurance boards. In total, 37 studies fulfilled the inclusion criteria.

### *2.3 Data extraction and analysis*

The final sample of selected studies was reviewed by the lead author who extracted the data. The data was extracted from each of the identified studies, including 1) the study year, location and design, 2) description of intervention/description of physical activity, 3) intervention duration, 4) number of participants (n), 5) workplace setting, 6) assessment period and outcome measures 7) method of analysis and 8) the results of the study. This information is presented in tables I-V.

### *2.4 Study type and methodological quality assessment*

Each study was categorised by study type as well as examined for quality by the two authors. Firstly, the studies were categorised into the following study types as shown in tables I-V: type I) randomised controlled trials (RCT's), type II) non-randomised controlled trials, type III) comparison intervention trials, type IV) prospective cohort studies, and type V) cross-sectional studies. Secondly, studies were assessed in terms of quality by examining sample, study design, methods, assessments and outcomes. For the RCT intervention studies, the quality assessment was performed in accordance with the Cochrane Collaboration<sup>[14]</sup> to independently assess the quality (risk of bias) in each study that met the

inclusion criteria. These were: randomization of participants, adequate sequence generation, allocation concealment, blinding of participants of the intervention, blinding of personnel of the intervention, blinding of outcome assessment, description of intention-to-treat analyses (outcome assessment), description of attrition data and reporting of results. These were assessed using the three categories described by Cochrane Collaboration guidelines: A (low risk), B (medium risk) and C (high risk). For non-RCT studies an adapted checklist was used and for observational studies, a checklist was devised by the authors.

### 3. Findings

A summary of the research process is shown in figure 1. A total of 37 articles met the inclusion criteria. Seventeen of the studies were categorised as physical activity/exercise interventions (see tables I-III; nine RCT's; four non-RCT's and four comparison intervention trials). Eleven studies were prospective cohort studies and nine were cross-sectional studies. The characteristics of the studies, impact on sickness absence and a quality assessment are reported for each study type.

#### 3.1 Evidence from randomised controlled trials

Nine of the studies were categorised as randomised controlled trials.<sup>[6,12, 15-21]</sup> Two of these studies offered a physical activity/exercise intervention as part of a larger workplace health programme<sup>[15, 20]</sup> but reported the direct impact of the physical activity/exercise component on sickness absence. Details of the studies are presented in Table I.

**3.1.1 Study characteristics:** The sample size of these studies ranged from 96 to 522 participants with a mean age from 39.0 to 42.5 years. One study focused solely on male employees<sup>[21]</sup> and one study focused solely on female employees.<sup>[12]</sup> Three studies had a majority of female participants (>51%),<sup>[15,16-18, 19]</sup> one study had a majority of male participants<sup>[20]</sup> and one study did not clarify the sex of employees.<sup>[6]</sup> Participants were white-

collar and blue-collar employees from a variety of workplaces including offices and transport companies.

*3.1.2 Effect of interventions on sickness absence:* The duration of the physical activity/exercise interventions ranged from 8 months to 12 months. Four studies offered moderate-vigorous intensity exercise and none of these studies found a significant difference between the intervention group or control group on sickness absence.<sup>[16-18,12]</sup> One study offered light intensity exercise<sup>[15]</sup> and one had physical activity of various intensities.<sup>[19]</sup> Neither intervention had an effect on sickness absence. Brox and Froystein<sup>[15]</sup> actually found sickness absence to increase in both the exercise and control groups. Three studies did not make the intensity of their physical activity intervention clear.<sup>[6, 20, 21]</sup> However, two of these studies<sup>[6, 21]</sup> reported a significant reduction in sickness absence in the intervention group compared to the control group. Both interventions consisted of weekly resistance/endurance training aimed at two different populations of employees: white-collar workers and blue-collar workers (see Table I for further details).

*3.1.3 Quality assessment:* Two studies had a low risk of bias;<sup>[12, 19]</sup> the rest of the studies had a medium risk of bias. All studies were randomised at the individual level. Three studies were matched-random designs<sup>[6, 15, 21]</sup> and two reported that the groups were similar at baseline.<sup>[19, 20]</sup> Only two studies did not report attrition data.<sup>[6, 21]</sup> Blinding of the investigator was outlined in three of the studies.<sup>[12, 15, 19]</sup> None of the studies blinded the participants. All studies took baseline measures and provided information on the length of follow-up. All studies used objective sickness absence data taken from either personnel records or medical records. Except for one study,<sup>[21]</sup> all other studies included both short-term and long-term sickness absence data. The use of intention-to-treat analysis was described in only two studies.<sup>[12, 19]</sup>

*3.2 Evidence from non-randomised controlled trials*



Four of the studies were categorised as controlled trials.<sup>[22-25]</sup> One of these studies offered a physical activity/exercise intervention as part of a larger workplace health programme<sup>[22]</sup> but reported the direct impact of the physical activity/exercise component on sickness absence. Details of the studies are presented in Table II.

*3.2.1 Study characteristics:* The sample size of these studies ranged from 453 to 534 participants with a mean age from 30.2 to 40.1 years. The studies had a majority of female participants (>55%) and were mainly white-collar employees from a school district<sup>[22]</sup> and an assurance company.<sup>[23-25]</sup>

*3.2.2 Effect of interventions on sickness absence:* The duration of the interventions ranged from 6 months to 12 years. Three studies offered exercise and sport of various intensities<sup>[23-25]</sup> and found overall, that those in the intervention group who adhered to the intervention had lower sickness absence (22%) compared to those who did not adhere within the group. Furthermore, high adherents also reported reduced sickness absence compared to the control group (see Table II for further details). Blair et al<sup>[22]</sup> offered weekly exercise classes but it is not clear from their study regarding the intensity of the exercises. However, they reported a positive effect for their intervention reducing sickness absence.

*3.2.3 Quality assessment:* Attrition data is reported in three studies.<sup>[23-25]</sup> The same studies also reported similar characteristics between the intervention and control group at baseline. Blair et al<sup>[22]</sup> controlled for differences in characteristics in the analysis. All studies took baseline measures and provided information on the length of follow-up. All studies used objective sickness absence data taken from personnel records and included both short-term and long-term sickness absence data.

*3.3 Evidence from comparison intervention trials (no control group)*

Four of the studies were categorised as comparison intervention trials.<sup>[26-29]</sup> One study offered a physical activity/exercise intervention as part of a larger workplace health programme<sup>[28]</sup> but reported the direct impact of the physical activity/exercise component on sickness absence. Details of the studies are presented in Table III.

*3.3.1 Study characteristics:* The sample size of these studies ranged from 43 to 884 participants with a mean age from 33.0 to 38.1 years. Two studies had a majority of female participants (>60%)<sup>[26, 28]</sup> and one study had a majority of male participants.<sup>[29]</sup> Participants were white-collar and blue-collar employees from a range of workplace settings.

*3.3.2 Effect of interventions on sickness absence:* The duration of the interventions ranged from 8 weeks to 12 months. Two studies offered moderate-vigorous intensity exercise/fitness programmes for 12 months and both found significant reductions in sickness absence.<sup>[27, 29]</sup> However, in one of these studies,<sup>[27]</sup> the intervention was effective in reducing sickness absence for female exercisers only. One study offered a moderate intensity aerobic exercise for 12 weeks in postal workers and reported no significant reductions in sickness absence.<sup>[28]</sup> One study offered low intensity exercise classes for 8 weeks and reported no statistical findings.<sup>[26]</sup>

*3.3.3 Quality assessment:* All studies reported baseline and follow-up data. Two studies<sup>[28, 29]</sup> controlled for confounders in their analyses. Two studies used objective sickness absence data taken from personnel records and included both short-term and long-term sickness absence data.<sup>[26, 29]</sup> One study used self-report sickness absence data<sup>[28]</sup> and one study did not make it clear whether sickness absence was taken from personnel records or self-report.<sup>[27]</sup>

*3.4 Evidence from prospective cohort studies*

Eleven longitudinal studies examined the association between physical activity and absenteeism through a prospective cohort design<sup>[5, 7, 8, 30-37]</sup> (See Table IV for further details).

*3.4.1 Study characteristics:* All eleven of the studies were conducted in Europe (Sweden, Denmark, Finland, Norway or the Netherlands). Three of the studies have presented new information or analyses using the same dataset<sup>[7, 34, 35]</sup> Two other studies have also used the same dataset.<sup>[8, 37]</sup> The follow-up period ranged from 1.5 years to 8 years and a variety of physical activity behaviours were studied, including leisure-time physical activity (walking, jogging, running and aerobics) and exercise undertaken as part of workplace wellness programmes.<sup>[30]</sup> The sample size of these studies ranged from 580 to 8902 participants with a mean age from 37 to 60 years. Five studies had a majority of female participants (>52%)<sup>[7, 32-35]</sup> and four studies had a majority of male participants (>70%).<sup>[8, 30, 31, 36]</sup> The sex of the participants in two studies was not stated.<sup>[5, 37]</sup> Participants were white-collar and blue-collar employees from a range of workplace settings.

*3.4.2 Association between physical activity and sickness absence:* One study examined moderate-vigorous intensity physical activity,<sup>[37]</sup> eight studies examined a variety of exercise intensities,<sup>[7, 8, 31-36]</sup> and two studies did not state the intensity of exercise examined.<sup>[5, 30]</sup> Eight studies showed a positive effect of physical activity on sickness absence.<sup>[5, 7, 8, 32, 34-37]</sup> However, Holtermann et al<sup>[33]</sup> actually found that occupational physical activity specifically increased the risk for long-term sickness absence, whereas leisure-time physical activity decreased the risk. Only two studies found no statistically significant findings between exercise habits and sickness absence.<sup>[30, 31]</sup>

*3.4.3 Quality assessment (including measurement of sickness absence and physical activity):* All studies measured physical activity using self-report methods such as questionnaires, except for one study which measured physical activity using exercise tests on a cycle ergometer or treadmill.<sup>[36]</sup> Six studies<sup>[8, 31, 33-35, 37]</sup> controlled for confounders in their

analyses. All studies used objective sickness absence data taken from personnel records or social sick registers. Two studies<sup>[5, 32]</sup> also examined self-report sickness absence. The majority of studies examined both short-term and long-term sickness absence data. Three studies<sup>[31-33]</sup> examined only long-term sickness absence and one study<sup>[5]</sup> examined only short-term sickness absence.

### *3.5 Evidence from cross-sectional studies*

Nine studies examined the association between physical activity and absenteeism with a cross-sectional design.<sup>[8, 13, 38-44]</sup> Details of the studies are presented in table V.

*3.5.1 Study characteristics:* Five of the studies were conducted in the USA,<sup>[38, 41, 43, 44]</sup> three in Europe<sup>[8, 40, 42]</sup> and one in the UK.<sup>[39]</sup> The sample size of these studies ranged from 143 to 79,070 participants with a mean age from 21 to 60 years. Three studies had a majority of female participants (>50%)<sup>[13, 38, 40]</sup> and four of the studies had a majority of male participants (>53%).<sup>[8, 41, 43, 44, ]</sup> One study had half male participants and half female participants,<sup>[39]</sup> and one study only examined male participants.<sup>[42]</sup> Participants were white-collar and blue-collar employees from a range of workplace settings including financial services, health care organisations, airlines and other public sectors.

*3.5.2 Association between physical activity and sickness absence:* Four studies measured moderate-vigorous intensity physical activity<sup>[8, 13, 41, 42]</sup> and two of these studies reported significant associations between moderate-intensity physical activity and lower sickness absence.<sup>[41, 42]</sup> One study<sup>[8]</sup> found an association between vigorous-intensity exercise and lower sickness absence. One study examined physical activity of various intensities<sup>[40]</sup> and found a significant association between physical activity and lower sickness absence. Four studies did not state the intensities of the physical activity in their studies but reported a significant association between physical activity and lower sickness absence.<sup>[38, 39, 43, 44]</sup>

### 3.5.3 Quality assessment (including measurement of sickness absence and physical

*activity*): Six studies used self-report physical activity data.<sup>[8, 13, 38-41]</sup> Two studies assessed physical activity by fitness tests<sup>[42, 43]</sup> and one study used both fitness testing and self-report data.<sup>[44]</sup> Five studies controlled for confounders in their analyses.<sup>[8, 40-43]</sup> The majority of the studies used objective sickness absence data obtained from personnel records.<sup>[38-40, 42, 43, 44]</sup> The remaining studies used self-reported sickness absence data.<sup>[8, 13, 41]</sup> Most studies measured both short-term and long-term sickness absence.<sup>[8, 39-43, 44]</sup> One study only examined short-term sickness absence<sup>[38]</sup> and one study was unclear about which they examined.<sup>[13]</sup>

## 4. Discussion

The aim of this article was to review the literature and summarise the evidence for physical activity interventions on reducing sickness absence and summarise the evidence on the association between physical activity and sickness absence from observational studies. Evidence from RCT studies suggest that overall, moderate-intensity physical activity interventions do not reduce sickness absence. However, RCT interventions involving weekly resistance/endurance training do have a positive effect in reducing sickness absence but the two studies reporting these findings did not make the intensities of their physical activity intervention clear.<sup>[6, 21]</sup> Although these two studies were matched-random designs, they were considered to have a medium risk of bias. Therefore, there is at best limited evidence from RCT studies that workplace physical activity interventions are effective in reducing sickness absence. This is a similar conclusion to that drawn by Proper and colleagues<sup>[45]</sup> in their 2002 review of physical activity interventions on absence. This highlights how randomised controlled trials since 2002 have not provided any further scientific evidence on the effectiveness of physical activity interventions for reducing sickness absence.

Evidence from non-RCT interventions and from comparison intervention studies (no control group) suggest that overall physical activity interventions reduce sickness absence, particularly among those who adhere to the physical activity programme<sup>[23-25]</sup> or undertake moderate-vigorous intensity physical activity.<sup>[27, 29]</sup> Despite being non-RCT or comparison studies, some of these studies have a number of merits such as reporting of attrition data, reporting similar characteristics in intervention and control group and the length of intervention. It is often difficult or impractical in a workplace setting to randomise participants or to include a control group depending on the size of the organisation and the level of exchange that takes place between employees in the different groups (e.g. exchanging information about the intervention), which could introduce contamination bias. Nevertheless, due to the lack of a true control group, the real effectiveness of these interventions is potentially obscured.

A key limitation with many of the intervention studies is the lack of detail provided on the physical activity intervention, particularly around the intensity of the physical activity introduced. This makes it difficult to adequately compare the studies and to assess the effectiveness of specific physical activity interventions. For the RCT studies, randomisation was at the individual level which could have introduced contamination bias. A preferred method is to randomise at the worksite level (i.e. different worksites take part in either control or intervention group) but this would mean that interventions can only take place in very large organisations. Studies are required to examine the effects of physical activity interventions in reducing sickness absence in small and medium sized enterprises as these organisations often have fewer resources to deal with employee health and wellbeing than large organisations.

Evidence from prospective cohort studies suggests those who are physically active are more likely to have low sickness absence. The strength of these studies is their long timeframe for assessing the effect of physical activity on reducing sickness absence. However,

weaknesses include the use of only self-report data in assessing physical activity and the lack of clarity in some studies over the intensity of the physical activity undertaken. Furthermore, the studies use a variety of self-report measures for physical activity and different statistical analyses thereby making it difficult to compare across the studies. Overall, the prospective cohort studies in this review revealed a mixture of results in terms of frequency, intensity, time and type of physical activity and further evidence is required to clarify which combinations are the most effective as well as most preferred by individuals for reducing sickness absence.

Evidence from cross-sectional studies suggest an association between participating in physical activity and having lower sickness absence. Three of these studies objectively assessed physical activity by fitness tests<sup>[42-44]</sup> and found that employees who had better physical fitness had lower sickness absence (12 month sickness absence data). The remaining studies are weak in that they use self-report measures for physical activity and some studies also use self-report for sickness absence. In terms of physical activity and their intensities, the findings are not clear, although some studies suggest cycling, jogging and walking are most popular choices via self-report.

One of the aims of this review was to identify what type of physical activities are frequently reported (preferred) by participants; and what type of physical activity and its intensity is most effective for reducing sickness absence. Unfortunately, this has been difficult to determine as most of the studies reviewed here do not report clearly the type of physical activity undertaken and/or its intensity. The RCT studies however, do suggest that resistance/endurance training may be most effective in reducing sickness absence. Evidence from cohort studies and cross-sectional studies report a broad range of physical activities undertaken by participants (e.g. aerobics, walking, swimming, jogging) but not enough information is presented across the different studies for us to pool the evidence

together and identify the physical activities (and their intensities) that individuals are most likely to participate in.

Overall, a key strength across all types of studies reviewed here are their use of objective sickness absence data. Absence data from personnel records or sickness absence registers may contain errors or limitations, but they are more likely to be accurate than relying on participant recall of frequency and duration of sickness absence over the past 12 months. However, analysing sickness absence data is complex and a variety of methods have been used to analyse sickness absence data in the studies reviewed here. There are a number of key limitations across the studies, the first being the lack of detail in describing physical activity and/or using self-report measures for physical activity. This makes it difficult to ascertain whether physical activity has an effect on sickness absence, and if so, what intensity or type of physical activity is most effective. Other limitations include the different sex balance between studies, the different population size between studies with the smallest groups reported for some intervention studies and the largest groups reported for prospective and cross-sectional cohort studies where the latter studies may be biased as they tend to result in larger estimates of effect and the intervention studies may not be sufficiently powered to show an effect.

In this review, the interventions were categorised into groups based on our understanding of their intervention and their content and therefore open to interpretation. The major strengths of our review were the broad inclusion criteria for both intervention and non-intervention studies, thereby allowing a more complete understanding of the evidence for the effect of physical activity on sickness absence. Furthermore, our study focused solely on the direct findings between physical activity/exercise and sickness absence in the general population. Other reviews that have examined physical activity and sickness absence have included multicomponent intervention studies where the direct effect of physical activity on sickness absence is not measured, therefore making it difficult to draw conclusions about the direct



effects of physical activity on sickness absence.<sup>[46]</sup> Our findings therefore add to the literature and suggest that overall, the available evidence provides limited support that physical activity is effective in reducing sickness absence, due to the poor quality of many of these studies.

In review of our findings, future RCT studies need to be more high-quality and ensure they are reporting descriptions of the physical activity intervention more thoroughly. Standardised ways of reporting physical activity interventions is perhaps required so that studies can be compared more easily. Future cohort studies should include more objective measures of physical activity such as the use of pedometers or accelerometers and fitness tests. This will allow for a more detailed comparison of findings across studies. Finally, studies should include psychosocial measures of physical activity behaviours to identify which type of behaviours can be targeted in physical activity interventions.

## **5. Conclusions**

To our knowledge, this is the first review to directly examine the effect of physical activity on sickness absence. Overall, the findings suggest that the evidence base is limited due to the low quality of many of these studies.

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Table I: PA workplace intervention studies – randomised controlled trials

Study (year)	Study location and design	Intervention description	Intervention duration	No. of participants – n (% female); mean age (y)	Workplace setting	Assessment period and outcome measure	Method of analysis	Results
Brox and Froystein <sup>[15]</sup> (2005)	Norway RCT: intervention group vs. control	Weekly exercise class (light aerobic exercise, muscle strengthening and stretching). Classes regarding PA, nutrition and stress management also offered  Control group: carry on with normal activities  Light intensity exercise	6 months	n = 119 (97); 42.5	Team-based community nursing home	Pre/post intervention  Sickness absence (total sickness absence included self certified sick days and doctor certified sickness absence)  Examined ST and LT sickness absence	Matched random design  Mann-Whitney rank sum test	↓ The intervention did not reduce sickness absence (mean sickness absence increased from 6.8 to 15.6 days in the exercise group and from 10.4 to 14.5 in the control group)
Halfon et al. <sup>[16]</sup> (1994), Rosenfeld et al. <sup>[17]</sup> (1989), Rosenfeld et al. <sup>[18]</sup> (1990)	Israel RCT: intervention group vs. control	Regular physical exercise, cardiorespiratory and muscular fitness, stretching, relaxation and strengthening exercises 5 times a week, 15 minutes  Control group: social games 5 times a week, 15 minutes  Moderate-vigorous intensity exercise	7 months	n = 522 (51); 40.0  416 used for the analysis	Pharmaceutical workers	Pre/post intervention  Absenteeism: (number of hours absent due to illness / total number of hours expected to work x 100)  Examined ST or LT sickness absence	ANCOVA	↔ No effect shown on absenteeism
Kerr and Vos <sup>[6]</sup> (1993)	Amsterdam, Netherlands RCT: intervention group vs. no intervention	Exercises aimed at improving endurance, strength, flexibility, body posture; once a week, 60 minutes  Intensity of exercise not stated	12 months	n = 152 <sup>a</sup> ; 37.6-39.4	Bank workers in a Dutch bank	Pre/post intervention  Absenteeism: absence time registered in bank records  Examined ST and LT sickness absence	Matched random design  ANOVA	↑ Positive effect shown on absenteeism – mean total absence significantly decreased (p < 0.01)

Table I: Contd.

Study (year)	Study location and design	Intervention description	Intervention duration	No. of participants – n (% female); mean age (y)	Workplace setting	Assessment period and outcome measure	Method of analysis	Results
Nurminen et al. <sup>[12]</sup> (2002)	Helsinki, Finland RCT: intervention group vs. control	1 x 30 individual exercise prescription  60 min group exercise session guided by a physiotherapist once a week (26 sessions)  Moderate and vigorous exercise intensity	8 months	n = 260 (100); 40  Intervention group (n = 133)  Control group (n = 127)	Laundry company	Pre/post intervention with 3, 8, 12, 15 month follow-up  Sickness absence data obtained from personnel administration  Examined ST and LT sickness absence	Intention-to-treat principle. ANCOVA.	↔ No statistical significant difference found in the cumulative amount of sickness absence between the intervention, and control groups.
Reijonsaari et al. <sup>[19]</sup> (2012)	Helsinki RCT: intervention group vs. control	Intervention: Distance counseling regarding PA provided, and accelerometers to monitor daily PA during work and leisure periods. Counseling was provided by two exercise specialists.  Control: No distance counseling and monitoring intervention.  Various exercise intensities	12 months	n = 521 (64); 43  Intervention (n=264); control group (n 257)	Finnish insurance company	Pre/post intervention  PA measured by questionnaire at 0, 6 and 12 months. Fitness test conducted at baseline and 12 months.  Sickness-related absence data was obtained from employer records.  Examined ST and LT sickness absence	Not matched at baseline, but no differences in characteristics were observed between groups  Intention-to-treat principle. ANCOVA	↔ No statistical significant difference in PA levels between the intervention and control group.
van Rhenen et al. <sup>[20]</sup> (2007)	Netherlands RCT: PA intervention or cognitive intervention	PA and relaxation exercises versus cognitive intervention. Both training programs consisted of 4 x 1hr sessions given during working hours over a period of 8 weeks.  Intensity of exercise not stated	12 months	n = 237 non-stressed employees (7-11)  PA intervention (n=129); control group: (n=108); received cognitive intervention	Telecom company (mixture from several jobs e.g. engineers, desk workers and office staff)	Pre/post intervention  Sickness absence data from the medical company records  Examined ST and LT sickness absence	Not matched at baseline, but no differences in characteristics between both groups completing.  Non-parametric statistical analyses – Kruskal-Wallis test, Wilcoxon signed-ranks test, Mann-Whitney U test.	↔ No statistical difference shown in absenteeism with PA intervention between groups.



Table I. Contd.

Study (year)	Study location and design	Intervention description	Intervention duration	No. of participants – n (% female); mean age (y)	Workplace setting	Assessment period and outcome measure	Method of analysis	Results
Zavanela et al. <sup>[21]</sup> (2012)	Sao Paulo, Brazil  RCT: intervention vs. control	Intervention/training group: Performed a 24 week periodised resistance training programme designed to improve general health and fitness  Control: maintained normal daily activities  Intensity of exercise not stated	9 months	n = 96 (0); Not stated	Major bus company	Pre/post intervention  Worker absenteeism obtained through the personnel department  Examined ST sickness absence	Matched on age and length of employment  Paired and unpaired t-tests, chi-squared test.	↑ A significant reduction was observed in worker absenteeism rate in the training group vs. the control (p < 0.05).

↑ indicates positive effect, ↓ indicates negative effect, ↔ indicates no effect, RCT = randomised controlled trial, PA = physical activity, ST = short-term, LT = long-term, ANOVA = analysis of variance, ANCOVA = analysis of covariance

Table II: PA workplace intervention studies – non-randomised controlled trials

Study (year)	Study location and design	Intervention description	Intervention duration	No. of participants – n (% female); mean age or age range (y)	Workplace setting	Assessment period and outcome measure	Method of analysis	Results
Blair et al. <sup>[22]</sup> (1986)	USA Controlled trial	Weekly exercises and health education classes; 2 different programme cycles of 10 week phase  Control group: Offered intervention after study  Intensity of exercise not stated	12 months	n = 453 (55); 42.7	School district workers in a large metropolitan school district	Absenteeism data from the district personnel office  Examined ST and LT sickness absence	Absenteeism differences were evaluated by ANCOVA by using age, sex, ethnic group, and the previous year's absenteeism as covariates	↑ Positive effect shown on absenteeism
Cox et al. <sup>[23]</sup> (1981) Song et al. <sup>[24]</sup> (1982), Shephard <sup>[25]</sup> (1992)	Toronto, Canada Controlled trial	Rhythmic calisthenics, jogging and ball games 3 times a week, 30 minutes  Control group: no intervention  Various exercise intensities	6 months (Cox et al., 1981). <sup>[23]</sup>  18 months (Song et al., 1982) <sup>[24]</sup>  12 years (Shephard, 1992) <sup>[25]</sup>	n = 534 (56); 30.2 – 40.1	Two large Canadian Assurance companies  Test company – CLA: 1281 employees  Control company – NALA: 577 employees	Pre/post intervention  Absenteeism data from the personnel records  Examined ST and LT sickness absence	Not matched, but characteristics similar between both populations prior to study  T-test and percentage changes	↑ Absenteeism of high adherents to PA was reduced by 22% relative to other employees. High adherents to the programme also showed reduced sickness absence relative to poor adherents in the same company and to employees in a control company one year later

↑ indicates positive effect, PA = physical activity, ST = short-term, LT = long-term, ANCOVA = analysis of covariance; CLA = Canada Life Assurance Company, NALA = North American Life Assurance Company

Table III: PA workplace intervention studies – comparison intervention trials (no control group)

Study (year)	Study location and design	Intervention description	Intervention duration	No. of participants – n (% female); mean age (y)	Workplace setting	Assessment period and outcome measure	Method of analysis	Results
Altchilder and Motta <sup>[26]</sup> (1994)	New York, USA  Low impact aerobic vs. non-aerobic stretching exercise	Classes of 30 min 3 x a week  Low intensity exercise	8 weeks	n = 43 (88); 33.48 aerobic, 30.40 non-aerobic	Two treatment facilities for children and adults with disabilities	Pre/post intervention  Absenteeism obtained via personnel records  Examined ST or LT sickness absence	T-test analyses	↔ No statistical difference shown in absenteeism
Baun et al. <sup>[27]</sup> (1986)	Houston, USA  Members of the health and fitness centre vs. non-members	Tenneco Health and Fitness Programme, offering employees unsupervised health and fitness activities, and supervised aerobic, calisthenic and health promotion classes  Moderate-vigorous intensity exercise	12 months	n = 517 (43.7); 33 members, 37 non members  Members (n = 273)  Non-members (n = 244)	Tenneco Oil Inc	Pre/post intervention  Absenteeism (total number of recorded sick hours an employee used during the calendar year)  Examined ST and LT sickness absence	T-test analyses	↑ Exercise was associated with less illness absence among female exercisers only (47 hours in exercisers vs. 69 hours in non-exercisers) (p < 0.05)
Eriksen et al. <sup>[28]</sup> (2002)	Bergen, Norway  PE vs. IHP vs. SMT	PE: 2 x 1h/wk aerobic exercise  IHP: 1 h/wk + 1 h/wk information about stress, coping, nutrition  SMT: cognitive-behavioural training  Moderate-vigorous intensity exercise	12 weeks	n = 860 (61); 38.1	29 post offices and 2 postal terminals	Pre/post intervention with 1 year follow up  Self-reported sickness absence  Unclear whether examined ST or LT sickness absence	Differences tested with the chi-squared test and one-way ANOVA.  Sex and time of intervention (location) were included as covariates	↔ No statistical difference shown in absenteeism

Table III: Contd.

Study (year)	Study location and design	Intervention description	Intervention duration	No. of participants – n (% female); mean age (y)	Workplace setting	Assessment period and outcome measure	Method of analysis	Results
Lechner et al. <sup>[29]</sup> (1997)	Netherlands  Longitudinal pretest-posttest design: High participation vs. low participation vs. no participation in employee fitness programme	Fitness programme across three sites. Fitness programme consisted of supervised fitness exercises 2 x wk (work out time – 1hr), warming up, stretching, calisthenics, cardiovascular activities, strengthening, cooling down and stretching  Intensity of exercise not stated	12 months	n = 884 (14); 37.9	A police force, a chemical industry and a banking company	Pre/post intervention  Data on sick days, age and sex for each individual (from administrative data sources). This gave the number of days that subjects had been on sickness absence in the year directly before the fitness programme was implemented, and in the first year after the programme began  Examined ST and LT sickness absence	Age and sex were controlled for.  Data analyses included paired t-tests, ANOVA and chi-squared procedures. ANCOVA was also used.	↑ The high participation group showed a significant decline in sick days (4.8 days). Low and no participation groups showed no change in sick days

↑ indicates positive effect, ↔ indicates no effect, PA = physical activity, PE = physical exercise, IHP = integrated health programme, SMT = stress management training, ST = short-term, LT = long-term, ANOVA = analysis of variance, ANCOVA = analysis of covariance

Table IV: PA and absenteeism prospective cohort studies

Study (year)	Study location and design	Description of PA	Study duration	No. of participants – n (% female); mean age or age range (y)	Workplace setting	Outcome measure	Method of analysis	Results
Bergström et al. <sup>[30]</sup> (2008)	Sweden Cohort design	Self-report exercise habits between those attending an occupational health programme and those who did not.  Intensity of exercise not stated	3 years	n = 4108 (12); 43	The study was carried out at four large workplaces. Companies 1 and 2 were paper mills, company 3 was a steelworks and company 4 a truck manufacturer	Total sickness absence data were gathered from the companies' payrolls and, in aggregated form, for the entire company expressed as a percentage of total working hours absent  Examined ST and LT sickness absence	ANCOVA	↔ No statistically significant findings between exercise habits and sickness absence between those who had access to the programme and those who did not.
Christensen et al. <sup>[31]</sup> (2007)	Denmark Cohort design	Leisure-time PA was measured using a self-report single item (responses: less than two hours per week, 2-4 hours per week, more than 4 hours per week or strenuous, or more than 4 hours a week and strenuous)  Various exercise intensities	1.5 years	n = 5020 (48.6); Not stated	Random: Danish Work Environment Cohort Study	Data on sickness absence was obtained by a linkage to a national register on social transfer payments  Examined LT sickness absence	The Cox proportional hazards model was used to calculate Hazard ratios and 95% confidence intervals adjusted for age	↔ Leisure time PA showed no association with LT sickness absence
Eriksen & Bruusgaard <sup>[32]</sup> (2002)	Norway Cohort design	Leisure-time PA activities were self-reported via the question "during the previous 3 months, what kind of physical exercise have you been doing regularly in the leisure time? By the word 'regularly', we mean 20 minutes or more at least once a week"  Various exercise intensities		n = 4744 (100); Not stated	Nursing personnel – two large occupational groups: graduate nurses and certified nurses	Main outcome measures were the 12-month cumulative incidence of sickness absence lasting longer than 14 days and the 12-month cumulative incidence of sickness absence lasting longer than 8 weeks (self-reported)  Examined LT sickness absence	Chi-squared tests and logistic regression analyses	↑ Brisk walks, aerobics or gymnastics, and other physical leisure activities for 20 minutes or more at least once a week predicted fewer long-term sickness absence (>14 days)

Table IV Contd.

Study (year)	Study location and design	Description of PA	Study duration	No. of participants – n (% female); mean age or age range (y)	Workplace setting	Outcome measure	Method of analysis	Results
Holtermann et al. <sup>[33]</sup> (2012)	Denmark Cohort design	Employees recorded their levels of both occupational and leisure-time PA (self-reported)  Various exercise intensities	2 years	n = 7144 (52); 40.9 - 43	Random: Statistic sample of the Danish population drawn from the Central Population Register	Long-term sickness absence spells of $\geq 3$ consecutive weeks were retrieved from a social-transfer payment register from 2005 to 2007.  Examined LT sickness absence	Cox proportional hazard analyses adjusting for age, sex, smoking, alcohol, body mass index, chronic disease, social support from immediate superior, emotional demands, social class and occupational or leisure-time PA	↓ Occupational PA increased the risk for long-term sickness absence ↑ Leisure-time PA decreased the risk for long-term sickness absence
Laaksonen et al. <sup>[7]</sup> (2009)	Helsinki, Finland Cohort design	PA behaviours that were of a similar intensity to walking, vigorous walking to jogging, jogging and running were self-reported. MET values were calculated  Various exercise intensities	3.9 years	n = 6934 (78.8); 40-60	Civil Services	Absenteeism (personnel records)  Examined ST and LT sickness absence	Poisson regression analysis	↑ Lowest PA level showed an increased absenteeism
Lahti et al. <sup>[34]</sup> (2010)	Helsinki, Finland Cohort design	Helsinki Health Study cohort baseline questionnaire survey data were collected between 2000 and 2002 amongst 40-60 year old employees in Helsinki. PA behaviours that were of a similar intensity to walking, vigorous walking to jogging, jogging and running were self-reported. MET values were calculated  Various exercise intensities	3.9 years	n = 6465 (79); 40-60	Employees of the City of Helsinki, Finland	Sickness absence data (from employer's registers)  Examined ST and LT sickness absence	Controlled for age, smoking status, social class, BMI and physical health functioning  Poisson regression analysis	↑ Those who were vigorously active systematically had reduced risk of subsequent sickness absence, whereas moderately intensive activity with the same volume did not reduce the risk. More emphasis to be placed upon vigorous PA

Table IV. Contd.

Study (year)	Study location and design	Description of PA	Study duration	No. of participants – n (% female); mean age or age range (y)	Workplace setting	Outcome measure	Method of analysis	Results
Lahti et al. <sup>[35]</sup> (2012)	Helsinki, Finland Cohort design	Helsinki Health Study cohort baseline questionnaire survey data were collected between 2000 and 2002 amongst 40-60 year old employees in Helsinki. A follow up survey was conducted in 2007 and leisure-time PA was measured (self-reported). MET values were calculated.  Various exercise intensities	2.8 years	n = 4182 (83); 48	Employees of the City of Helsinki, Finland	Sickness absence data (from employer's registers)  Examined ST and LT sickness absence	Controlled for age, sex, changes in smoking and physical health functioning  Poisson regression analysis	↑ Inactive men and women who increased PA to vigorously active showed a significant decrease in self- and medically certified sickness absence compared with the inactive. More emphasis to be placed upon vigorous PA
Proper et al. <sup>[8]</sup> (2006)	Netherlands Cohort design	Self-reported data were used from SMASH. Looked at general population for PA and sickness absence.  Various exercise intensities	3 years	n = 1593 (29.9); 37.0	34 various companies located throughout the Netherlands	Registered sickness absence data  Examined ST and LT sickness absence	ANOVA, linear and logistic regression analyses conducted, adjusting for age, sex, educational level, body mass index, smoking status and physical (in) activity during work	Mean sickness absence duration per year: <ul style="list-style-type: none"> <li>• 24.44 days for workers who were active 3 x a month or less</li> <li>• 17.66 days for those active once or twice a week</li> <li>• 17.97 days for those active 3 x week or more</li> </ul> <p>↑ Statistically significant effect of frequency of vigorous intensity PA on sickness absence</p>

Table IV. Contd.

Study (year)	Study location and design	Description of PA	Study duration	No. of participants – n (% female); mean age or age range (y)	Workplace setting	Outcome measure	Method of analysis	Results
Strijk et al. <sup>[36]</sup> (2011)	Netherlands Cohort design	Aerobic capacity (VO <sub>2max</sub> ) was determined by a maximal exercise test on a cycle ergometer or by running on a treadmill  Various exercise intensities	8 years	n = 580 (11.9); 39.3	Siemens Netherlands	Sick leave registrations were obtained for 2000-2008. Data consisting of the first and last day of a sick absence period were recorded for each worker  Examined ST and LT sickness absence	Mediation analyses were performed using linear and Cox regression models	↑ Physically fit workers were at lower risk of starting an episode of sickness absence: <ul style="list-style-type: none"> <li>A lower aerobic capacity was found to be significantly related to sickness absence</li> </ul>
van Amelsvoort et al. <sup>[5]</sup> (2006)	Maastricht, Netherlands Cohort design	Self-report data from a prospective cohort study were used: The Maastricht Cohort study <sup>[40]</sup> where workers were followed for 54 months (from May 1998)  Intensity of exercise not stated	1.5 years	n = 8902 <sup>a</sup> ; Not stated	45 Dutch companies	Baseline: Sickness absenteeism provided by the study participants (self-reported) and their employers (sickness absence records)  Examined ST sickness absence	Logistic regression and Poisson regression analysis	↑ Workers active in their leisure time twice or more per week had significantly less sickness absence compared to inactive workers (14.8 vs. 19.5 days/year)
van den Heuvel et al. <sup>[37]</sup> (2005)	Netherlands Cohort design	'Physically demanding' sport in the last 12 months (self-reported)  Moderate –vigorous intensity exercise	4 years	n = 1228 <sup>a</sup> ; 18-59	Variety – employees were pre-selected from SMASH (a large cohort study) which included industrial, administrative and service roles	Absenteeism (personnel records)  Examined ST and LT sickness absence	Age, sex, smoking and alcohol consumption. ANOVA, correlations and survival analysis used in accordance with the Cox proportional hazards model.	↑ All participants showed: a decrease in total duration of sickness absence among those active (p < 0.0005)  No significant difference shown in frequency of sickness absence

↑ indicates positive effect, ↓ indicates negative effect, ↔ indicates no effect, <sup>a</sup> – data unclear, ST = short-term, LT = long-term, ANOVA = analysis of variance, ANCOVA = analysis of covariance, MET = metabolic equivalent of task, SMASH = Study on Musculoskeletal Disorders, Absenteeism, Stress and Health, BMI = body mass index, VO<sub>2max</sub> = maximal oxygen uptake



Table V: PA and absenteeism cross-sectional studies

Study (year)	Study location and design	Description of PA	No. of participants – n (% female); mean age or age range (y)	Workplace setting	Outcome measure	Method of analysis	Results
Burton et al. <sup>[38]</sup> (2005)	Illinois, USA Cross-sectional design (questionnaire survey)	Fitness centre participation (self-reported) Exercise intensity not stated	n = 999 (67.7); 35.1	One financial services company (customer service and call centre)	Absenteeism measured as short-term disability claims records from personnel department. Examined ST sickness absence	No control for confounders	↑ Fitness centre participants showed a significant decreased average days of absenteeism (p=0.018)
Daley and Parfitt <sup>[39]</sup> (1996)	UK Cross-sectional design	Examining the differences between members of a British corporate health and fitness club, those on the waiting list and non-members of the club (self-reported) Exercise intensity not stated	n = 293 (50); 34.6	Leading British food retail company – head office employees	Absenteeism data provided from company records Examined ST and LT sickness absence	ANCOVA	↑ Members were less likely to be absent from work than non-members
Hendriksen et al. <sup>[40]</sup> (2010)	Netherlands Cross-sectional design (self-report questionnaire survey)	Commuter cycling (self-reported) Various exercise intensities	n = 1236 (51); 43.3	Organisations with white-collar workers, a minimum of 1000 employees, and an overall absenteeism of at least 4%	Company absenteeism (all-cause absenteeism) records over one-year period (May 2007 – April 2008) Examined ST and LT sickness absence	Propensity scores were used to adjust for confounders and make groups comparable. Zero-inflated Poisson models also used	↑ Cycling to work is significantly associated with less sickness absence

Table V: Contd.

Study (year)	Study location and design	Description of PA	No. of participants – n (% female); mean age or age range (y)	Workplace setting	Outcome measure	Method of analysis	Results
Jacobson and Aldana <sup>[41]</sup> (2001)	USA Cross-sectional design	Self-reported - Health Profile Questionnaire used to measure exercise habits, separating regular exercise by type, frequency and duration. Only exercises considered to be continuous or aerobic in nature (e.g. walking, jogging, running, cycling, swimming). PA assessed by having participants indicate how many days a week they engaged in aerobic exercise (minimum of 20 mins per session)  Moderate-vigorous intensity exercise	n = 79,070 (46.5); Not stated	250 US worksites	Self-reported absenteeism profiles during the previous 12 months  Examined ST and LT sickness absence	Chi-squared test. Confounding variables (age, sex, education level, smoking, alcohol use, blood pressure, cholesterol, body mass index and stress) were accounted for	↑ A significant (chi-squared = 280.37) relationship was seen between absenteeism and exercise. Differences ( $p < 0.05$ ) in absenteeism were observed between no exercise and all frequencies of weekly exercise. Therefore a significant relationship between exercise frequency and illness-related absenteeism was shown
Kyröläinen et al. <sup>[42]</sup> (2008)	Finland Cross-sectional design	Fitness tests e.g. 12 minute running test and/or cycling test. Tests for muscle fitness e.g. push-ups, sit-ups, grip strength and squats.  Moderate – vigorous intensity exercise	n = 7179 (0); 37	Male military personnel	Sickness absence data obtained from personnel department  Examined ST and LT sickness absence	ANOVA, post hoc tests.	↑ The group with the LT sickness absence exhibited lower muscle fitness in 3 of 4 tests and shorter running distance compared to the groups with ST sickness absence ( $p < 0.001$ ).
Pronk et al. <sup>[13]</sup> (2004)	Minnesota, USA Cross-sectional design	Leisure time PA behaviours (self-report)  Moderate-vigorous intensity exercise	n = 683 (60.8), 46.4	Three healthcare organisations and one airline	Self-reported absenteeism  Unclear whether examined ST or LT sickness absence	Controlled for age, sex and education.  Regression analysis of exercise, cardiorespiratory fitness, and weight with presenteeism	↔ No significant difference shown between higher levels of moderate activity or vigorous activity and absenteeism

Table V: Contd.

Study (year)	Study location and design	Description of PA	No. of participants – n (% female); mean age or age range (y)	Workplace setting	Outcome measure	Method of analysis	Results
Proper et al. <sup>[6]</sup> (2006)	Netherlands  Cross-sectional design (two continuous questionnaire surveys)	Self-report data were used from two large Dutch databases: OBiN and POLS  Various exercise intensities	OBiN: n = 5070 (45.4); 40.2  POLs: n = 8993 (41); 38.5	Variety of workers	Number of days of sickness absence (self-reports asking about the number of days one had been absent from work due to illness in the last two months)  Examined ST and LT sickness absence	ANOVA, linear and logistic regression analyses conducted, adjusting for age, sex, educational level, body mass index, smoking status and physical (in) activity during work	↔ No dose-response relationship between frequency and duration of moderate intensity PA and sickness absence duration  ↑ Based on OBiN and POLS, dose-response relationship seen between frequency of vigorous intensity PA (3 x a week) and sickness absence duration
Steinhardt et al. <sup>[43]</sup> (1991)	Austin, Texas, USA  Cross-sectional design examining active officers vs. sedentary officers	Mandatory fitness testing programme including measurements of cardiovascular fitness (main focus), body composition, muscular strength, endurance and flexibility  Exercise intensity not stated	n = 734 (10.8); 21-60	Law enforcement officers	Absenteeism (total number of days each officer was absent from duty for the one year) and medical care claims (obtained from Austin Police Department Personnel Office)  Examined ST and LT sickness absence	ANCOVA controlling for age, Tukey post-hoc tests	↑ Sedentary officers were absent significantly more often than those active officers  Increased fitness for males was associated with decreased absenteeism, however this relationship was not seen in females
Wattles and Harris <sup>[44]</sup> (2003)	Northwest community, USA  Cross-sectional design	Participants firstly completed a fitness assessment. A questionnaire was then sent out measuring current exercise level, exercise equipment available, and exercise programmes offered at work sites (self-report)  Exercise intensity not stated	n = 143 (34.3); 39.9	Nine departments within the city: fire, police, finance, public works, parks and recreation, library, airport, customer support and services, and administration	Absenteeism data over a one year period obtained from personnel department.  Four health-related components of fitness: body composition, cardiorespiratory endurance, flexibility and muscular strength  Examined ST and LT sickness absence	Stepwise regression analysis	↑ Absenteeism was associated with the employees' level of flexibility exercises – more flexible employees tended to be absent from their jobs less often than inflexible employees

↑ indicates positive effect, ↔ indicates no effect, ST = short-term, LT = long-term, ANOVA = analysis of variance, ANCOVA = analysis of covariance, OBiN = Injuries and PA in the Netherlands, POLS = Permanent Study Living Conditions