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Systematic review of the relationship between quick returns in rotating shift work and health-related outcomes

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Running head: Quick returns and health-related outcomes

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Abstract

A systematic literature search was carried out to investigate the relationship between quick returns (i.e., 11.0 hours or less between two consecutive shifts) and outcome measures of health, sleep, functional ability and work-life balance. A total of 22 studies published in 21 articles were included. Three types of quick returns were differentiated (from evening to morning/day, night to evening, morning/day to night shifts) where sleep duration and sleepiness appeared to be differently affected depending on which shifts the quick returns occurred between. There were some indications of detrimental effects of quick returns on proximate problems (e.g., sleep, sleepiness and fatigue), although the evidence of associations with more chronic outcome measures (physical and mental health and work-life balance) was inconclusive.

Key words: Quick return, Quick changeover, Short changeover, Short recovery

Practitioner summary

Modern societies are dependent on people working shifts. This study systematically reviews literature on the consequences of quick returns (11 hours or less between two shifts). Quick returns have detrimental effects on acute health problems. However the evidence regarding effects on chronic health is inconclusive.

1. Introduction

Shift work is a way of organizing working time where 'workers succeed one another at the workplace so that the total operation hours exceed the hours of work carried out by individual workers' (ILO 1995, p.14). Increasing use of shift work and irregular work hours are believed to be driven by major societal changes with a decline in manufacturing and the rise in the service economy (Johnson and Lipscomb 2006). However, shift work often disrupts the alignment between external demands and the individuals' internal circadian rhythm. This biorhythmic disruption is believed to be an important contributor to the increased risk of various sleep difficulties (Åkerstedt 2003) and negative health effects associated with shift work such as breast cancer, cardiovascular disease, diabetes, obesity, gastro-intestinal problems and peptic ulcer disease, among others (Baron and Reid 2014, Monk and Buysse 2013, Costa, Haus, and Stevens 2010, Gan et al. 2014, Knutsson and Bøggild 2010, Vyas et al. 2012, Wang et al. 2011). Furthermore, there is evidence to suggest that shift work may impair mental wellbeing and increases the risk for psychological distress (Vogel et al. 2012, Baron and Reid 2014). It has been suggested that some of the effects of shift work on mental health may be mediated by social difficulties in terms of imbalance between work and private life (Haines et al. 2008). Shift work has also been inferred as a risk factor for sick leave; currently, however, this seems primarily to apply to female healthcare workers on fixed evening work (Merkus et al. 2012). One recent study also indicated that shift work was associated with a chronic impairment of cognition (Marquié et al. 2014).

Some shift schedules are believed to affect workers' health to a greater extent than others. Night and early morning shifts cause the largest biorhythmic disruption and have accordingly been associated with the largest effects on sleep and health (Åkerstedt 2003, Sallinen and Kecklund 2010). A number of other shift characteristics have also been shown to impact sleep and health, such as the length of the shift (e.g., 8h or 12h shifts) (Lowden et al. 1998), type of shift schedule, and direction and speed of rotation (Tucker et al. 2000, Barton and Folkard 1993). An important aspect with rotating shifts concerns to what extent the time between shifts facilitates adequate rest. Quick returns refers to changeovers from evening to morning/day shifts, night to evening shifts, or morning/day to night shifts, where 11.0 hours or less free time are scheduled between shifts (European Parliament 2003). Although there are no statistics on the prevalence of quick returns, one survey on Norwegian nurses found that 81.2% reported exposure to quick returns in the past year (n = 1990; mean annual number of quick returns = 33.2) (Eldevik et al. 2013). Although 11.0 hours between shifts defines the upper duration of time off for quick returns, the number of hours between two shifts is often far less. The actual time for rest may be further shortened by long commutes, time for self-care and domestic chores, which consequently may result in substantial sleep deficiency in quick returns (Kecklund and Åkerstedt 1995), again possibly affecting wellbeing and health. Consequently, it is recommended that shift schedules should not feature quick returns (Knauth 1996, Kecklund and Åkerstedt 1995). This is also reflected in the recommendations of the European Working Time Directive, which emphasizes that workers are entitled to a minimum daily rest period of 11.0 consecutive hours per 24.0-hour period (European Parliament 2003).

Recent studies have shown that the effects of quick returns on sleep and fatigue can be equally severe as, or even more severe than, those of night shifts (Eldevik et al. 2013, Flo et al. 2014). Such findings highlight the need to examine the wider potential impact of quick returns. While the consequences of quick returns have been examined in previous reviews to some extent (Knauth 1996, Sallinen and Kecklund 2010, Kecklund and Åkerstedt 1995, Åkerstedt 2003), none of these reviews focused exclusively on quick returns and none used a systematic approach. The current study addresses these shortcomings by conducting a systematic literature search with the aim of consolidating the evidence on the relationship between quick returns and outcome measures ranging from health, sleep, functional ability and work-life balance.

2. Methods

Systematic searches were carried out in order to identify relevant studies for this literature review. The search combined the keywords “shift work*” OR shiftwork* OR “night work*” OR nightshift* OR “night shift*” with various thesaurus-obtained terms for quick return; including "quick return*" OR "quick change over" OR “short off-duty” OR “short turn-around*” OR “quick turn-around*” OR “short turnaround” OR “quick turnaround” OR “quick shift-change period*” OR "short rest" OR "short break*" OR "short free time" OR recovery OR "short sleep" OR "restricted sleep" OR advan* OR rotat*. The searches were conducted in the databases Web of Science, Pubmed and PsycINFO and resulted in 1214, 1100, and 455 hits, respectively. An overview of the search and selection process is presented in **Figure 1.** No year restriction was used and the searches were carried out throughout October 2014. The total number of hits after sorting for document type article and deleting duplicates was 1839. The search strategy

and selection of eligible studies were carried out by a single reviewer (first author). The articles were first screened for relevance by reading the title alone – a recently validated approach (Mateen et al. 2013) – which led to an initial rejection of 1210 articles. This required a further review of 629 abstracts, and finally 78 full text articles were studied. Forward citation searches were used to track down references cited by relevant sources.

Studies eligible for inclusion in the review were evaluated against a set of pre-defined inclusion criteria. The studies had to be written in English and published in peer-review journals (e.g., governmental reports were excluded). The studies had to report results from data on workers in a naturalistic or simulated shift work setting. Furthermore, the inclusion criteria were quite broad in terms of study design and quality of investigation, in an attempt to provide a complete overview of the limited research done on the subject of quick returns. However, the studies had to use a quantitative design allowing inferences about the association between health-related parameters and quick returns; and quick returns had to be clearly defined as 11.0 hours or less between two shifts. Furthermore, specific restrictions were set regarding split-shifts and sea-watch systems. These are often rotating shifts with less than 11.0 hours off between them, but were deemed different from quick returns due to the fact that these shifts are often substantially shorter and the free period between the shifts are not necessarily used for sleep. Sea-watch systems also occur in a special off-shore context where aspects such as commuting time and domestic demands are more or less eliminated, in contrast to standard land-based shift work.

3. Results

In total, 22 studies published in 21 articles were included in this review (**Table 1**). Taken together these studies included 14 028 subjects in which the weighted average age was 38.5 years (from the 16 studies that reported age). Eight studies were cross-sectional survey studies (Barton and Folkard 1993, Eldevik et al. 2013, Flo et al. 2012, Geiger-Brown, Trinkoff, and Rogers 2011, Kandolin and Huida 1996, Tucker et al. 2000, Tucker et al. 2010, Tucker et al. 2015), one was a longitudinal survey study (Flo et al. 2014), three were intervention studies (where quick returns were reduced or abolished) (Hakola, Paukkonen, and Pohjonen 2010, Kandolin and Huida 1996, Lowden et al. 1998), five were field studies (data collection over time in natural settings) (Axelsson et al. 2004, Sallinen et al. 2003, Signal and Gander 2007, Karhula et al. 2013, Costa et al. 2014), one was a field study which included laboratory assessments (Härmä et al. 2002) and one was a pure laboratory study (Cruz et al. 2003), one was a registry study (analyzed objective records from an injury report database) (Macdonald et al. 1997), and two studies labeled themselves as time-budget studies (i.e., they employed time-use diaries to identify activities occupying each hour of each day for a fixed period of time) (Knauth et al. 1983, Kurumatani et al. 1994). Most of the studies were based on self-report diaries and a mixture of standardized questionnaires and unstandardized questions (Barton and Folkard 1993, Eldevik et al. 2013, Flo et al. 2012, Geiger-Brown, Trinkoff, and Rogers 2011, Kandolin and Huida 1996, Tucker et al. 2000, Flo et al. 2014, Lowden et al. 1998, Karhula et al. 2013, Sallinen et al. 2003, Signal and Gander 2007, Härmä et al. 2002, Cruz et al. 2003, Kurumatani et al. 1994, Knauth et al. 1983, Hakola, Paukkonen, and Pohjonen 2010, Tucker et al. 2010, Tucker et al. 2015). Three studies used actigraphy recordings to monitor sleep and activity objectively (Axelsson et al. 2004, Signal and

Gander 2007, Costa et al. 2014), and one used objective records of injuries from the medical department at the workplace (Macdonald et al. 1997).

3.1 Sleep duration and disturbed sleep

The most common quick return appears to occur between evening and the following morning/day shifts (**Table 2.**). Three field studies (Axelsson et al. 2004, Sallinen et al. 2003, Costa et al. 2014), one time-budget study (Knauth et al. 1983) and one intervention study (Hakola, Paukkonen, and Pohjonen 2010) found that quick returns between evening and morning/day shifts caused shorter sleep duration. Quick returns between night and evening shifts was found to shorten sleep duration in one field study (Axelsson et al. 2004). The sleep/nap between morning/day and night shifts was investigated in one time-budget study (Kurumatani et al. 1994), one field study (Costa et al. 2014) and two laboratory studies (Signal and Gander 2007, Cruz et al. 2003). Although this sleep appeared to have a short duration (**Table 2.**), Cruz et al. (Cruz et al. 2003) argued that this sleep should be viewed as a nap that add to the major sleep period prior to the morning/day shift. Their analysis showed no significant differences between advancing (with quick returns) and delaying (without quick returns) shift rotations in terms of sleep duration when the nap before the night shift was combined with the major sleep period (Cruz et al. 2003). Furthermore, sleep duration appeared to increase the first night after a quick return, which is attributed to the need to recover from the quick returns (Tucker et al. 2000, Axelsson et al. 2004).

An overview of the association of quick returns and health related outcome beyond sleep duration is provided in Table 3. One field study showed that nurses reported significantly lower sleep quality after quick returns of 10.0 hours from evening to

morning shifts in an 8-hour system, compared to those with longer changeovers in a 12-hour system (Costa et al. 2014). One cross-sectional study showed that quick returns of 10.0 hours were positively associated with more frequent reports of inadequate and restless sleep among nurses (Geiger-Brown, Trinkoff, and Rogers 2011). Three survey studies support a positive association between quick returns and shift work disorder (Eldevik et al. 2013, Flo et al. 2014, Flo et al. 2012), of which one was a longitudinal study (Flo et al. 2014). One cross-sectional study also showed a positive association between quick returns and insomnia (Eldevik et al. 2013). In these survey studies exposure to quick returns were defined as occurrence within the last month (Geiger-Brown, Trinkoff, and Rogers 2011) or frequency last year (Eldevik et al. 2013, Flo et al. 2014, Flo et al. 2012). These survey studies did not report between which shifts the quick returns occurred. In contrast to these findings, however, one cross-sectional survey found that workers on a shift system with quick returns reported less sleep disturbances than workers on a system without (Barton and Folkard 1993).

3.2 Sleepiness and fatigue

The presence of quick returns from evening to morning/day shifts and night to evening shifts were associated with increased sleepiness in five studies (Axelsson et al. 2004, Eldevik et al. 2013, Flo et al. 2014, Karhula et al. 2013, Costa et al. 2014) and increased fatigue in six studies (Knauth et al. 1983, Flo et al. 2014, Eldevik et al. 2013, Barton and Folkard 1993, Lowden et al. 1998, Tucker et al. 2010). Two intervention studies found that reduction in the number of quick returns of 9.0 hours between evening and morning shifts improved self-reported sleep and alertness (Hakola, Paukkonen, and Pohjonen 2010) and caused less tiredness compared to a control group (Kandolin and Huida 1996).

It should however be noted that the intervention in the latter study consisted of both reducing quick returns and increasing personal involvement in shift planning, thus it was not possible for the authors to separate the effect of the two parallel interventions (Kandolin and Huida 1996). One survey study suggested quick returns of 8.0 hours (from night to evening and morning to night shifts) as the likely cause of a marginally more rapid decline in workers self-report alertness levels over the duration of a shift, compared to shift systems without quick returns (Tucker et al. 2000). One study used archival accident records to compare two shift systems which differed with respect the presence of a quick return of 8.0 hours between the night and evening shifts (Macdonald et al. 1997). Risk for accidents appeared to be higher during evening shifts that followed a quick return, which was initially interpreted as a detrimental effect of quick returns on risk for accidents (Macdonald et al. 1997). However, it was subsequently suggested by one of the study's authors that the difference may have been attributable to the different shift sequences of the two shift systems (Spencer, Robertson, and Folkard 2006).

Two field studies have investigated sleepiness and quick returns from morning/day to night shifts. One found quick returns of 10.0 hours in a 8-hour system to increase sleepiness compared to longer changeovers in a 12-hour system (Costa et al. 2014). The other found quick returns of 8.0 hours or less represented a smaller risk for sleepiness than a changeover period of 16.0 hours or more (Härmä et al. 2002). The latter observation was believed to be due to the fact that a significantly larger proportion of people with quick returns took naps before night work compared to those with longer changeover periods (Härmä et al. 2002, Cruz et al. 2003). In addition, the nap between morning/day and night shifts in quick returns tends to be of longer duration (2.8 hours)

compared to those with longer changeover periods to the night shifts (1.9 hours) (Cruz et al. 2003).

3.3 General health and wellbeing

Quick returns were positively associated with self-reported stress in one cross-sectional study (Tucker et al. 2015). Two intervention studies found that reduction of quick returns of 9.0 hours from evening to morning shifts led subjects to report better general health and social wellbeing (Hakola, Paukkonen, and Pohjonen 2010) as well as less mental strain and stress (Kandolin and Huida 1996). The former study did however not find any effects of reduction of quick returns in terms of reported occurrence of diseases or sickness absence (Hakola, Paukkonen, and Pohjonen 2010). One survey study found that workers on a shift system with quick returns reported poorer physical health than among those on systems without quick returns (Barton and Folkard 1993). However, this was not observed in another survey study comparing workers on a shift system which included quick returns of 8.0 hours (from night to evening and morning to night shifts) to those on other systems without quick returns (Tucker et al. 2000). In addition, three survey studies, of which one was longitudinal, did not find any associations between quick returns and measures of mental health (Flo et al. 2014, Eldevik et al. 2013, Barton and Folkard 1993), nor did changes in the number of quick returns have any effect on reported symptoms of depression or anxiety over time (Flo et al. 2014).

One survey study found that workers on a shift system with quick returns reported more social and domestic disruption and less job satisfaction, than those working on a shift system without quick returns (Barton and Folkard 1993). In one intervention study, reduction of quick returns of 9.0 hours between evening and morning shifts improved the

workers self-reported wellbeing at work and their leisure time activities (Hakola, Paukkonen, and Pohjonen 2010). The reduction of quick returns in this study also led workers to report higher mental work ability, although there were no significant changes on the more general work ability index (Hakola, Paukkonen, and Pohjonen 2010). In one intervention study, reduction of quick returns of 9.0 hours between evening and morning shifts improved the social climate at work regarding support from supervisors and relationship with colleagues (Kandolin and Huida 1996). As pointed out earlier, the intervention in the latter study also included increased personal involvement in shift planning that unfortunately represents an obvious confounding variable. Reduction of quick returns of 9.0 hours from evening to morning shifts in another intervention study did not have any effect on the workers' social and family life (Hakola, Paukkonen, and Pohjonen 2010). No negative effect was observed on self-reported social and domestic disruption in a cross-sectional study comparing workers on a shift system which included quick returns of 8.0 hours (from night to evening and morning to night shifts) to those on other systems without quick returns (Tucker et al. 2000).

4. Discussion

The aim of this review was to synthesize evidence on the relationship of quick returns (i.e., a break between shifts of 11.0 hours or less) and health-related outcomes. It is reasonable to expect that limited time for rest between shifts will impose a corresponding shortening of sleep duration. In most cases, quick returns involve short rests of 8.0 or 9.0 hours between shifts. The actual time for rest between the shifts may however be significantly shorter than this, when subtracting actual time for departure from work, long commutes, time to unwind before sleep, and to eat and freshen up before the next shift.

Time-use studies have shown that social- and leisure activities remain a priority for individuals and are likely to be exchanged for sleep time (Basner et al. 2007). Domestic chores may further shorten the time for sleep in quick returns, which may affect female workers more than men due to gender inequality in households (Rotenberg et al. 2008, Silva, Rotenberg, and Fischer 2011). In line with this, the result from this review indicated a shortening of sleep duration to 6.5 hours or less with quick returns. Previous studies have shown that repeated restriction of sleep to 6.0 hours or less per night substantially impairs neurobehavioral functions (Van Dongen et al. 2003). This is of particular concern, given that the typical occupations exposed to quick returns are within health care, industrial production facilities, transport industry and aviation, where high levels of cognitive functions are critical for safety and where lapses in attention easily can have fatal outcomes. However, few studies have investigated partial sleep deprivation that occurs at intermittent intervals, as is often the case with quick returns. Although one study appeared to suggest detrimental effects of quick returns on risk for accidents (Macdonald et al. 1997), a retrospective re-analysis of the results have called into doubt that interpretation of the findings (Spencer, Robertson, and Folkard 2006).

Sleep duration appeared to be differently affected depending on which shifts the quick returns occur between. The results from this review indicate that while the shortest sleep durations seemed to occur between morning/day and night shifts, somewhat longer sleeps took place between night and evening shifts and the longest sleeps were between evening and morning/day shifts. This is consistent with the fact that the time for rest between shifts in the three types of quick returns occurs at different points within the circadian rhythm and the homeostatic sleep drive. The free periods associated with the

three types of quick returns fall during the evening, day and night, respectively. The desire and the possibility to spend the free time asleep may also be less during daytime or evening, due to social and family activities, as in the case with the free periods between night to evening and morning/day to night shifts. A night shift followed by an evening shift may be the worst quick return in terms of sleep deficit (Kecklund and Åkerstedt 1995). Sleep is rapidly initiated after a night shift, but often difficult to maintain compared to a normal night's sleep

kerstedt, Kecklund, and Knutsson 1991). The sleep time between morning/day and night shifts should be appended to the major sleep period that occurs before the morning/day shift, as this will serve as a more accurate indicator of how much rest the workers have actually attained compared to those with longer changeover periods to the night shifts (Cruz et al. 2003). The number of hours needed for rest between shifts may also vary depending on which shifts the quick returns occur between, where time needed for recovery presumably is highest after night shifts.

The reduced sleep duration with quick returns is probably also an important contributor to the reports of restless sleep and increased occurrence of sleep disturbances with quick returns. The biorhythmic disruption caused by quick returns, particularly by those that include night shifts, may underlie the associations between quick returns and shift work disorder – as also pointed out by others (Eldevik et al. 2013, Flo et al. 2014). Moreover, it is easy to imagine that the recognition of limited hours available for rest during a quick return may increase individuals' intention to sleep. Increased sleep effort is identified as one of the key elements of insomnia maintenance (Broomfield, Gumley, and Espie 2005), which may throw light upon the positive association found between quick returns and insomnia (Eldevik et al. 2013). The presence of quick returns was in

most studies associated with increased sleepiness and fatigue, which highlight the need for more time to recover between shifts. One exception however was quick returns from morning/day to night shifts, which in one study was suggested to reduce the risk for sleepiness during the night shifts (Härmä et al. 2002). This was believed to be due to the more frequent and longer sleeps/naps taken by the workers before the night shifts during quick returns, compared to those with longer changeover periods before the night shifts (Härmä et al. 2002, Cruz et al. 2003). As noted above, this sleep/nap should be appended to the major sleep period, which introduces a more accurate indicator of how much rest the individual actually has attained. These observations nevertheless suggest that a quick return to the night shift may enable more sleep closer to the night shift, which subsequently may enhance the individual's level of functioning on the night shift. Such effects would be consistent with evidence that naps on the night shift improve alertness and functional ability (Ruggiero and Redeker 2014). However, it remains unclear whether these apparent benefits of quick returns to the night shift outweigh any disadvantages of such double shifts, and it should be noted that one study observed increased sleepiness with these quick returns (Costa et al. 2014).

The consequences of shift work on physical and mental health-related outcomes are widespread and well documented (Baron and Reid 2014, Monk and Buysse 2013, Costa, Haus, and Stevens 2010, Gan et al. 2014, Knutsson and Bøggild 2010, Vyas et al. 2012, Wang et al. 2011, Vogel et al. 2012). The mechanisms believed to underlie the negative health outcomes of shift work include biorhythmic disruption and sleep deprivation (Knutsson 2003), both of which are also present with quick returns. There were some indications of better general health and wellbeing when fewer quick returns

were introduced in an intervention study, but no substantial changes in occurrence of diseases or sickness absence (Hakola, Paukkonen, and Pohjonen 2010). In terms of mental health, there were consistent reports of no relations with exposure to quick returns (Flo et al. 2014, Eldevik et al. 2013, Barton and Folkard 1993). Taken together there is as of yet no clear indication of quick returns as a substantial risk factor for physical or mental health-related problems. Needless to say, more research is warranted before firm conclusions can be drawn on this matter. Meanwhile, many workers are supportive of quick returns due to the longer consecutive free periods they generate (Kandolin and Huida 1996, Schroeder, Rosa, and Witt 1998). It is a matter of speculation as to whether the cost of enduring quick returns on chronic outcome measures – such as physical and mental health – may be equalized by the recovery gained from the extra free time it contributes to.

Work outside regular daytime has been found to complicate family and private life activities (Albertsen et al. 2008). Overall, most reports on the balance between work and private life in this review portray quick returns as an unfavorable shift characteristic (Barton and Folkard 1993, Hakola, Paukkonen, and Pohjonen 2010, Kandolin and Huida 1996). However, some of the results indicated no effect of quick returns on social and family life (Hakola, Paukkonen, and Pohjonen 2010). The results from one study are difficult to interpret due to a parallel intervention with increased personal involvement in shift planning (Kandolin and Huida 1996), and not all studies found an effect of quick returns on work-life balance (Tucker et al. 2000). In an intervention study that aimed at increasing work-life balance, it appeared that more work time control and the ability to adjust working hours to personal needs were more important for the work-life balance-

related measures than actual changes in working hours (Albertsen et al. 2014). Taken together, there is little evidence to conclude on the relation between quick returns and work-life balance. The ambiguity in the studies may reflect the fact that despite the proximate problems associated with quick returns, the workers seem to favor the longer free periods it generates (Kandolin and Huida 1996, Schroeder, Rosa, and Witt 1998). For example, the midwives studied by Kandolin and Huida (1996) reported that the longer free periods accumulated due to quick returns made it easier to combine shift work and social life.

4.1 Limitations and further direction

A potential limitation is that, while the inclusion criteria were agreed by all authors, only one of the authors conducted the literature search (first author). In mitigation, it should be noted that previous research has shown that single reviewers on average miss less than 10 percent of eligible reports (Edwards et al. 2002). Relevant findings may have been lost due to stringent inclusion criteria; for example, some studies were deemed relevant by content but excluded due to the fact that they were not published in peer review journals (Saito and Kogi 1978, Della Rocco and Cruz 1995, 1996, Cruz and Della Rocco 1995, Schroeder, Rosa, and Witt 1995). Relevant studies may also have been excluded prematurely after reading the abstract in cases where quick returns were not highlighted in the abstract. However, forward citation searches were carried out that may have intercepted important studies where this was the case. Another limitation with this review, which also reflects a limitation in the literature, pertains to the fact that quick returns are often defined as short rest of 11.0 hours or less between shifts. Since workers

are entitled to a minimum daily rest period of 11.0 hours (European Parliament 2003) it seems more correct to define quick returns as less than 11.0 hours in future studies.

In general, the predominance of cross-sectional studies of quick returns is a limitation as it precludes inferences about causality. There is also a predominance of female subjects due to the large survey studies on health personnel (Geiger-Brown, Trinkoff, and Rogers 2011, Flo et al. 2014). This may reflect a bias within the field since research results are not always generalizable between the sexes (Holdcroft 2007). Many studies also rely on subjective measures, which increases the risk for systematic errors due to inaccurate recollections and other biases related to subjective reports (Weiss 1995, Podsakoff et al. 2003). Furthermore, quick returns were often not the primary target for investigation in studies but nevertheless suggested as an explanatory factor. The study designs are thus not always ideal to make inferences about the specific ramifications of quick returns, primarily due to rudimentary definitions of quick returns and lack of control over the confounding effect of other variables (e.g., parallel interventions, direction of rotation, shift length). The three quick returns differentiated in this review (evening to morning/day, night to evening, morning/day to night) are distinct both from a theoretical and practical point of view, and future studies should make an effort to differentiate between their respective consequences. Moreover, the combined nap and major sleep period in quick returns between morning/day and night shifts should be used in future studies, as this appears to serve as a more accurate indicator of how much rest the workers in total have achieved compared to those with longer changeover periods (Cruz et al. 2003). This issue also has a bearing on the interpretation of previous studies where this is has not been taken into account.

Future field, laboratory and intervention studies should attempt to compare the three quick returns with longer changeovers to the same respective shifts, which will give a more accurate indication of the specific consequences of short time for recovery between shifts. Both acute and long-term consequences of quick returns need to be studied. The acute consequences of quick returns may include the immediate detrimental impacts on sleep between the shifts, and sleepiness, functioning (e.g., cognitive and motoric) and risk of accidents during the second shift in a quick return. The accumulated detrimental impact of quick returns on these outcomes across the workweek should also be investigated. The long-term consequences of quick returns warrant large-scale prospective studies on physical and mental health-related outcomes, sickness absence and work-life balance. Future studies should also prioritize objective measurement of both shift exposure (e.g., by use of payroll data) and of the various outcome measures, so as to reduce the risk for systematic errors due to subjective reports (Weiss 1995, Podsakoff et al. 2003). Some individuals are able to work shifts without experiencing negative consequences (Saksvik et al. 2011). Research is needed to identify personality variables that predict tolerance of shift characteristics, such as quick returns, so as to inform personnel selection and individualized shift scheduling. Furthermore, an important question for future research is whether female workers experience more detrimental effects of quick returns than males, due to the extra burden placed on the former group in terms of domestic chores (Rotenberg et al. 2008, Silva, Rotenberg, and Fischer 2011). In this regard it should also be noted that females on average report a somewhat longer sleep need than males (Ursin, Bjorvatn, and Holsten 2005). In determining how much recovery time is needed between shifts it seems important to assess the amount of time needed for

commuting and other activities (time to eat, self-care, social and leisure activities, domestic chores, etc.) during a quick return.

4.2 Conclusion

In summary, the results from this review suggest that quick returns shorten sleep duration, cause more disturbed sleep, and in most cases increase reports of sleepiness and fatigue. There are some indications of a detrimental effect of quick returns on the balance between work and private life. The degree to which quick returns disrupt workers general health and wellbeing remains unknown. However, there have been relatively few studies to date examining how quick returns affect sleep and health-related outcomes, and even fewer that have had this as their primary target for investigation. Consequently, the quality of evidence regarding the impact of quick returns remains rather weak, thereby limiting the certainty of these conclusions.

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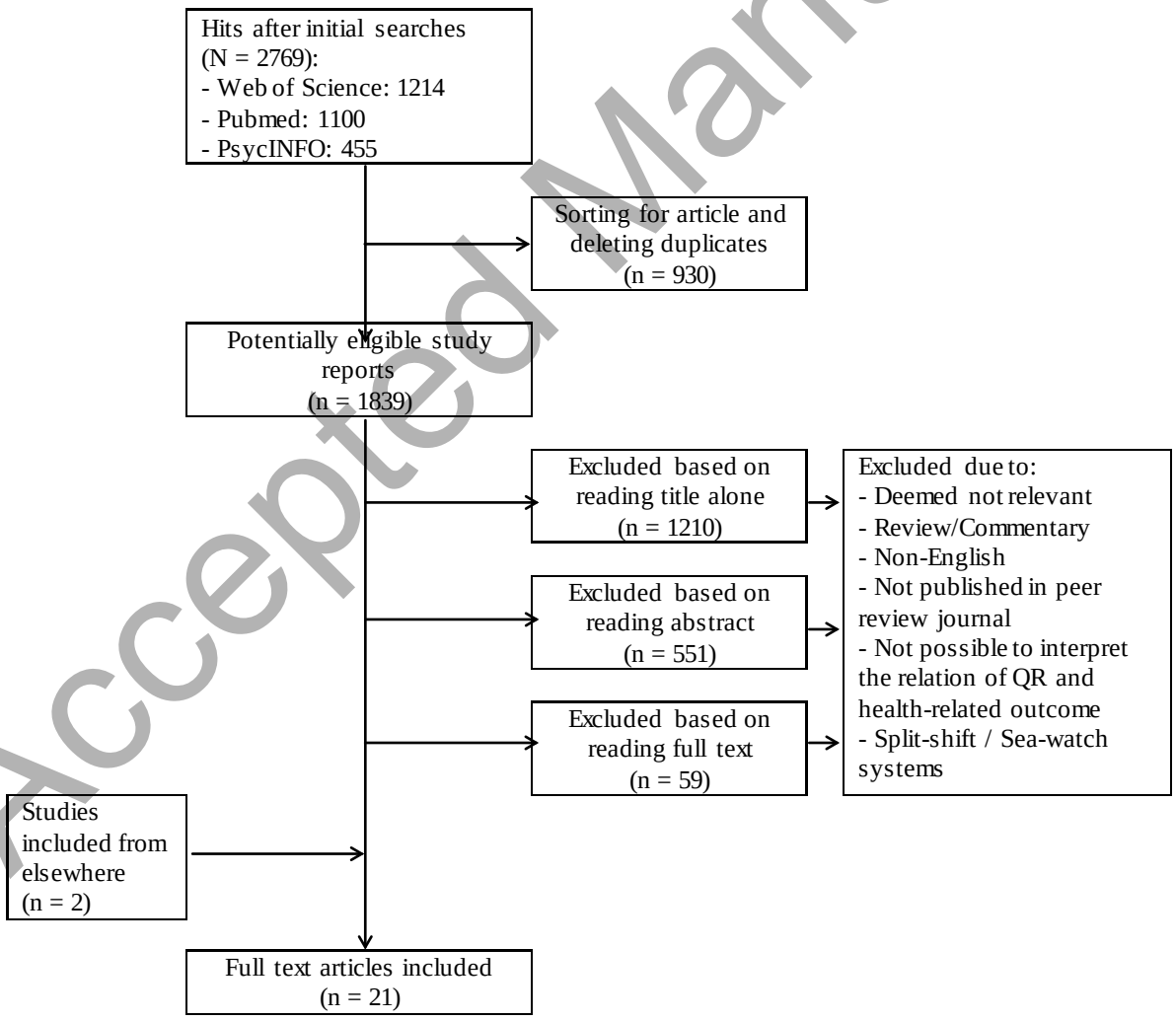

Figure 1. Literature search and selection on quick returns and health-related outcome.

Table 1. Literature review summary of studies on the relationship between quick returns and health.

Author	Sample	Shift system	Quick returns			Outcome variables	Results
			E-M/D	N-E	M/D-N		
Field studies:							
Axelsson et al. (2004)	N = 56 20 female 36 males	Rapidly rotating three shifts (N-E-M) with two quick returns within 36.0h.	8.0-9.0h	8.0-9.0h	-	Sleep (actigraphy) Sleepiness	QR shortened sleep duration to 4.8h (N-E) and 5.5h (E-M), relative to a reported habitual sleep need of 8h and a recovery

							sleep of 8.6h. QR increased sleepiness.
Costa et al. (2014)	N_{field} = 30 17 female 13 male 34.3 yrs.	Fast rotating 3x8 (incl. QR) compared to 2x12 schedules.	10.0h	-	7.0h	Sleep (actigraphy) Sleepiness Sleep quality	QR from E-M shifts reduced sleep quality and sleep duration to 5.6h (7.8h on rest days). Sleepiness was higher with QR (3x8 system) to morning and night shifts compared to longer changeovers to these shifts (2x12 system).
Karhula et al. (2013)	N = 95 All female 47.0 yrs.	Three shift system.	9.9h	-	-	Sleepiness Physical and mental workload	A high job strain group had more quick returns

							(among others) than a low job strain group. QR caused more sleepiness in the high job strain group. Subjective recovery was lowest in shift combinations of short time-off periods before the shifts.
Sallinen et al. (2003)	N = 230 All male 43.2 yrs.[a] Rr. = 55.4[a]	Irregular shift system.	8.3h	-	-	Sleep (diary data)	QR (E-M) shortened sleep duration to 5.0h. In 30% of the E-M combinations, the free time between the shifts was

								shorter than the subjects' mean sleep need.
Signal and Gander (2007)	N = 28 9 female 19 male 35.4 yrs.[a] Rr. = 78.0%	Counterclockwise, rapidly rotating schedule (afternoon, day, morning, and night shift).	-	-	11.0h	Sleep/nap (actigraphy and sleep diary)	Ninety percent slept/napped in the QR from M/D-to-N, with an average duration of 2.2h.
Field and laboratory study:								
Härmä et al. (2002)	N = 230 All male 43.2 yrs.[a] Rr. = 55.4[a]	Irregular shift system.	< 8.0h	< 8.0h	< 8.0h	Sleepiness Napping	QR of <=8.0h from M/D-to-N was associated with a smaller risk of sleepiness than changeover

							of >=16.0h. Sixty two percent of QR-subjects took a nap before the night shift compared to 27% non-QR.
Laboratory study:							
Cruz et al. (2003)	N = 28 16 female 12 male 40.9 yrs.[a] Rr. = 93.3	Rapidly rotating advancing (with QR) compared to delaying three shift.	8.0h	-	8.0h	Sleep (actigraphy and sleep diary)	Sleep duration was 5.5h for QR (E-M) and 5.6h for non-QR to morning shift, not significant. Sleep/nap duration was 2.8h for QR (M-N) and 1.5h for non-QR to night

							shift, not significant when nap was combined with major sleep period. QR-subjects napped more often before the night shift, 79% compared to 57%, respectively.
Registry study:							
Macdonald et al. (1997)	N = 3 337 Steel industry workers	Three shift system.	-	8.0h	-	Archival accidents records	Workers with QR (N-E) had a higher relative risk for accidents during evening shifts compared to morning

							shifts, relative to workers without QR.
Survey studies:							
Barton and Folkard (1993)	N = 261 18 female 242 male 1 unknown 39.4 yrs.	Advancing (with and without QR of 8.0h) and delaying shifts were compared.	Not specified	Not specified	Not specified	Sleep Fatigue Mental health Social disruption Job satisfaction	QR was associated with reports of more fatigue, social and domestic disruption and less job satisfaction; but not with mental health-related outcome. Also, advancing shifts without QR were associated with more sleep

							disturbances compared to those with QR.
Eldevik et al. (2013)	N = 1990 90,4% female 33.1 yrs. Rr. = 38.1%	Permanent schedules and rotating two and three shifts. Annual number of QR (<=11.0h).	Not specified	Not specified	Not specified	Sleepiness Fatigue Anxiety and depression Shift work disorder Insomnia	Annual number of QR was associated with excessive sleepiness and fatigue, shift work disorder and insomnia. Symptoms of anxiety or depression was not related to QR.
Flo et al. (2012)	N = 1968 90.2% female Rr. = 38.1%	Permanent schedules and rotating two and three shifts. Annual number of QR (<=11.0h).	Not specified	Not specified	Not specified	Shift work disorder	Annual number of QR was positively associated with shift work

							disorder.
Flo et al. (2014) (longitudinal)	N = 1224 90.3% female 33.6 yrs. Rr. = 38.1% and 80.9% followed-up	Permanent schedules and rotating two and three shifts. Annual number of QR (<=11.0h).	Not specified	Not specified	Not specified	Shift work disorder Sleepiness Fatigue Anxiety and depression	Annual number of QR predicted future shift work disorder and pathological fatigue; but not sleepiness, anxiety or depression. A reduction of QR decreased the risk of pathological fatigue.
Geiger-Brown, Trinkoff, and Rogers (2011)	N = 2246 95.0% female 45.0 yrs. Rr. = 62.0%	Fixed, rotating or long shifts. QR (>10.0h) once or more per month.	Not specified	Not specified	Not specified	Inadequate sleep Restless sleep	QR associated with increased odds of reporting inadequate and restless

							sleep.
Kandolin and Huida (1996) Study I	N = 640 All female Rr. = 74.0%	Three-shift work.	9.0h	-	-	Tiredness	Twenty eight percent of the midwives on the morning shifts experienced tiring, which was suggested mostly due to QR.
Tucker et al. (2000)	N = 61 98.0% male	Rapidly rotating 8.0h systems.	-	8.0h	8.0h	Sleep Shift alertness Physical and mental health Social and domestic disruption	QR increased sleep duration on recovery nights. QR was associated with a marginal decline in alertness during a shift. No association between QR and physical

							and mental health or social and domestic disruption.
Tucker et al. (2010)	N = 336 50.0% female 28.7 yrs. Rr. = 46.0%	Junior doctors on various shift schedules (QR of <10.0h the last 7 days)	Not specified	Not specified	Not specified	Sleep duration Fatigue	QR were likely to occur after on-call shifts, and shorter sleep duration was reported after these shifts. The restricted sleep increase risk for insufficient recovery, resulting in greater fatigue the next day.
Tucker et al. (2015)	N = 799 53.5% male	Physicians on various shift schedules	Not specified	Not specified	Not specified	Sleep Stress	QR were positively associated

	42.9 yrs. Rr. = 53.1%	(frequency of QR)					with stress and short sleep. Work time control did not moderate the effects of QR.
Intervention studies:							
Hakola, Paukkonen, and Pohjonen (2010)	N =75 95% female 46.0 yrs.	A change from backward to forward two/three shift rotation.	9.0h	-	-	Sleep Alertness General health Leisure-time activities Work ability	Reduction of QR increased sleep duration from 6.5h[1] to 7.0h[1], improved sleep and alertness, general health, wellbeing both social and at work, and leisure time activities. Reduced QR

							did not decrease occurrence of diseases or sickness absence, and did not affect social and family life, among others.
Kandolin and Huida (1996) Study II	N = 58 All female 39.2 yrs.[a]	Two parallel interventions: fewer QR and increased personal involvement in shift planning.	9.0h	-	-	Mental strain and stress Tiredness Social climate and support from superiors and colleagues	Reduces QR (and more self-roster) caused less tiredness, less mental strain and stress, and improved the psychosocial climate at work. But, 68% wanted back to the old schedule (with QR)

							because of the longer free periods generated between working weeks.
Lowden et al. (1998)	N = 34 82.6% male[a] 38.1 yrs.[a] Rr. = 85.0%	A change from rotating three-shift (8-hour system with QR) to two-shift (12-hour system).	8.0h	8.0h	-	Sleep and alertness Fatigue	QR in the 8-hour system increased sleep problems and fatigue. The QR in the 8-hour system was suggested as substantial explanatory factors as to why the 12-hour system seemed superior on satisfaction with work hours, sleep,

							and time for social activities.
Time-budget studies:							
Knauth et al. (1983)	N = 120	Three shift system.	8.0h	-	8.0h	Time-budget diary on working time, leisure time, sleeping time	After 50% of the afternoon shifts the night sleep was limited to about 6.5h due to a QR to the morning shift. Reports of persistent fatigue were believed to come about due to the QR.
Kurumatani et al. (1994)	N = 182 All female	Three-shift system.	-	-	7.5h	Time-budget diary	QR between D-N shortened

28.8 yrs. Rr. = 80.8%		including sleep time, work time, etc.	sleep duration to 2.4h. A strong positive correlation was observed between total sleep time and the period between two consecutive shifts, which indicated that >16h between shifts is required to allow >7h of sleep.

Note. QR = Quick Returns (11 hours or less between two shifts). E-M/D, N-E and M/D-N refer to the quick returns from Evening to Morning/Day, Night to Evening, and Morning/Day to Night, respectively. Rr. is short for Response rate.

[a] Weighted mean of a given quality that in the original study was reported from two or more sub-groups.

Table 2. Differences in sleep duration between three types of quick returns.

	Quick returns (QR)	Sleep duration without QR	Sleep duration with QR		
			E to M/D	N to E	M/D to N
Axelsson et al. (2004)	8.0-9.0h	8.0h[a]	5.5h	4.8h	-
Costa et al. (2014)	10.0h/7.0h[b]	7.8h	5.6h	-	2.3h
Cruz et al. (2003)	8.0h	-	5.5h	-	2.8h
Sallinen et al. (2003)	8.3h	-	5.0h	-	-
Knauth et al. (1983)	8.0h	-	6.5h	-	-
Hakola, Paukkonen, and Pohjonen (2010)	9.0h	7.0h[c]	6.5h[c]	-	-
Signal and Gander (2007)	11.0h	-	-	-	2.2h
Kurumatani et al. (1994)	7.5h	-	-	-	2.4h

Notes: QR = Quick Returns; E = Evening shift; M/D = Morning/Day shift; N = Night shift. [a]Reported habitual sleep need. [b]Quick returns from E-M = 10.0h and from M-N = 7.0h. [c]The weighted average sleep duration of the three age groups studied by Hakola et al.

Table 3. Summary of associations of quick returns on health-related outcome.

	Three types of quick returns			
	E to M/D	N to E	M/D to N	QR type not specified
Quick returns associated with detrimental effects on:	sleep quality[1], sleepiness[1,7,8], fatigue[9,10,12,13], general health[12], social wellbeing[12], stress[13], wellbeing at work and leisure time activities[12], mental work ability[12], social climate at work[13]	sleepiness[7], fatigue[10,14], accidents*[15]	sleepiness[1], fatigue[9,14]	sleep quality[2], shift work disorder[3,4,5], insomnia[3], sleepiness[3,4], fatigue[3,4,6,11], stress[17], physical health[6], social and domestic disruption[6], job satisfaction[6]
Quick returns associated with beneficial effects on:			sleepiness[16]	sleep disturbances[6]
Quick returns not associated with effects on:	occurrence of diseases[12], sickness absence[12], general work ability[12], social and family life[12]	physical health[14], social and domestic disruption[14]	physical health[14], social and domestic disruption[14]	mental health[3,4,6]

Notes: QR = Quick Returns; E = Evening shift; M/D = Morning/Day shift; N = Night shift.
*A retrospective re-analysis of the results called into doubt the interpretation of the findings in terms of accidents (Spencer, Robertson, and Folkard 2006).

[1]Costa et al. (2014)
[2]Geiger-Brown et al. (2011)
[3]Eldevik et al. (2013)
[4]Flo et al. (2014)
[5]Flo et al. (2012)
[6]Barton and Folkard (1993)
[7]Axelsson et al. (2004)
[8]Karhula et al. (2013)
[9]Knauth et al. (1983)
[10]Lowden et al. (1998)
[11]Tucker et al. (2010)
[12]Hakola et al. (2010)
[13]Kandolin and Huida (1996)
[14]Tucker et al. (2000)
[15]Macdonald et al. (1997)
[16]Härmä et al. (2002)
[17]Tucker et al. (2015)