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Expert report

Coffee and sleep in everyday lives

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Introduction

Consuming coffee forms a part of many people's daily routine, chosen not only for its unique aroma and flavor but also for its ability to increase alertness and concentration, owing to its caffeine content[1]. Research has suggested that the motives for choosing to consume a caffeinated drink include alertness, taste, mood, social reasons, perceived health benefits and habit[2].

The effects of coffee or caffeine are often sought by those requiring alertness and increased concentration, such as during the working day[3,4] or when driving[4]. Caffeinated drinks can also be chosen by people if they are sleep-deprived or when adjusting to new sleep/wake cycles such as coping with jet lag[5,6].

For some people, the increase in alertness and concentration triggered by caffeine may also hinder restful sleep if coffee is consumed close to sleep time[5]. Therefore, it can present a contrast of effects; it is often chosen to kickstart the morning and to reduce feelings of fatigue at key points during the day, however some also choose to limit coffee consumption close to sleep time. This report considers the impact of coffee and caffeine consumption on sleep, including in those whose circadian sleep/wake cycles are disrupted and those experiencing sleep deprivation.

How does coffee help to increase alertness?

Caffeine is the main psychoactive compound found in coffee and its effect on alertness is associated with a compound in the body called adenosine[7,8]. Adenosine adheres to adenosine receptors and in doing so, is known to trigger feelings of tiredness. Caffeine and adenosine have similar structures, and caffeine acts as an antagonist on adenosine receptors, which blocks the actions of adenosine at the site of the receptor, replacing the feelings of tiredness with feelings of alertness[7,8]. A video explaining the effect of coffee on the brain can be viewed here.

The European Food Safety Authority (EFSA) has concluded that a cause and effect relationship has been established between a 75mg serving of caffeine — the amount found in approximately one regular cup of coffee — and both increased attention (concentration) and alertness, mainly in situations of low arousal[1].

In a review on the safety of caffeine, the European Food Safety Authority (EFSA) concluded that moderate caffeine consumption, of around 400mg caffeine per day (the equivalent of up to five cups of coffee), can be safely enjoyed as part of a healthy balanced diet and an active lifestyle[9]. Pregnant and breastfeeding women are advised to limit their caffeine intake to 200mg per day[9]. A typical cup of coffee provides 75–100mg caffeine.

= 75mg

increased attention (concentration) and alertness[1]

= 400mg

can be safely enjoyed as part of a healthy balanced diet and an active lifestyle[9]

efsa
European Food Safety Authority

What is the effect of coffee on sleep?

In addition to increasing alertness, the action of caffeine at the adenosine receptors can have an impact on sleep. Research suggests that consuming caffeine can prolong the time taken to fall asleep as well as reducing total sleep time and perceived sleep quality. More specifically, caffeine reduces a deep phase of sleep classified as 'slow wave' and can increase wakefulness and arousal from sleep[8,11,12].

The effects of caffeine on sleep depend not only on the amount of caffeine consumed in the hours before bed, but also on the amount of caffeine consumed over the course of the day, as well as individual susceptibilities and consumption habits[8,11,12].

Research suggests that each individual's genetic make-up may impact their response to caffeine. More specifically, research suggests that a mutation to a specific gene (the adenosine A2A receptor gene, ADORA2A) may influence the impact of caffeine intake on an individual's sleep[8], thereby suggesting that the same amount of caffeine may affect two individuals differently.

"Research suggests that consuming caffeine can prolong the time taken to fall asleep as well as reducing total sleep time and perceived sleep quality[8, 11, 12]."

Can drinking coffee help when the daily cycle of sleep is disrupted?

Most of us have a regular daily sleep/wake cycle known as the circadian rhythm, which is driven by internal circadian clocks spanning an approximate 24-hour cycle and is linked to external light/dark cycles[13]. The disruption of the circadian rhythm arises when sleep/wake cycles are disrupted, which can occur in individuals who change their working hours from day to night or when travelling across time zones and experiencing jet lag.

When the clocks go back for daylight saving in autumn, sleep cycles may also be affected, although to a lesser extent. While some may perceive this as an additional hours' sleep, the cumulative effect of earlier rise times could result in a net loss of sleep across the week[14].

Our circadian rhythm may also affect caffeine metabolism (or breakdown), which occurs through a system that is thought to be regulated in a circadian manner[15]. This is believed to be due to the differing effect of caffeine during the circadian rhythm cycle and caffeine's effect on sleep, which

can in turn impact levels of the enzymes that metabolize caffeine. It is therefore suggested that the effects of caffeine may be more noticeable during changes to circadian rhythms[15].

Research has also suggested that consuming caffeine in the evening can delay the circadian melatonin rhythm. Melatonin is the hormone involved in communicating the message of darkness to the body clock and in turn, encouraging sleep[16]. In a study lasting approximately 49 days, it was found that those who consumed 200mg of caffeine three hours prior to their usual bedtime, experienced a delay to their circadian melatonin rhythm of approximately 40 minutes[5]. However, the authors suggested that their results may also be impacted by genetic variations in sensitivity to caffeine.

"Research has also suggested that consuming caffeine in the evening can delay the circadian melatonin rhythm."

Will a cup of coffee help with alertness if sleep is restricted?

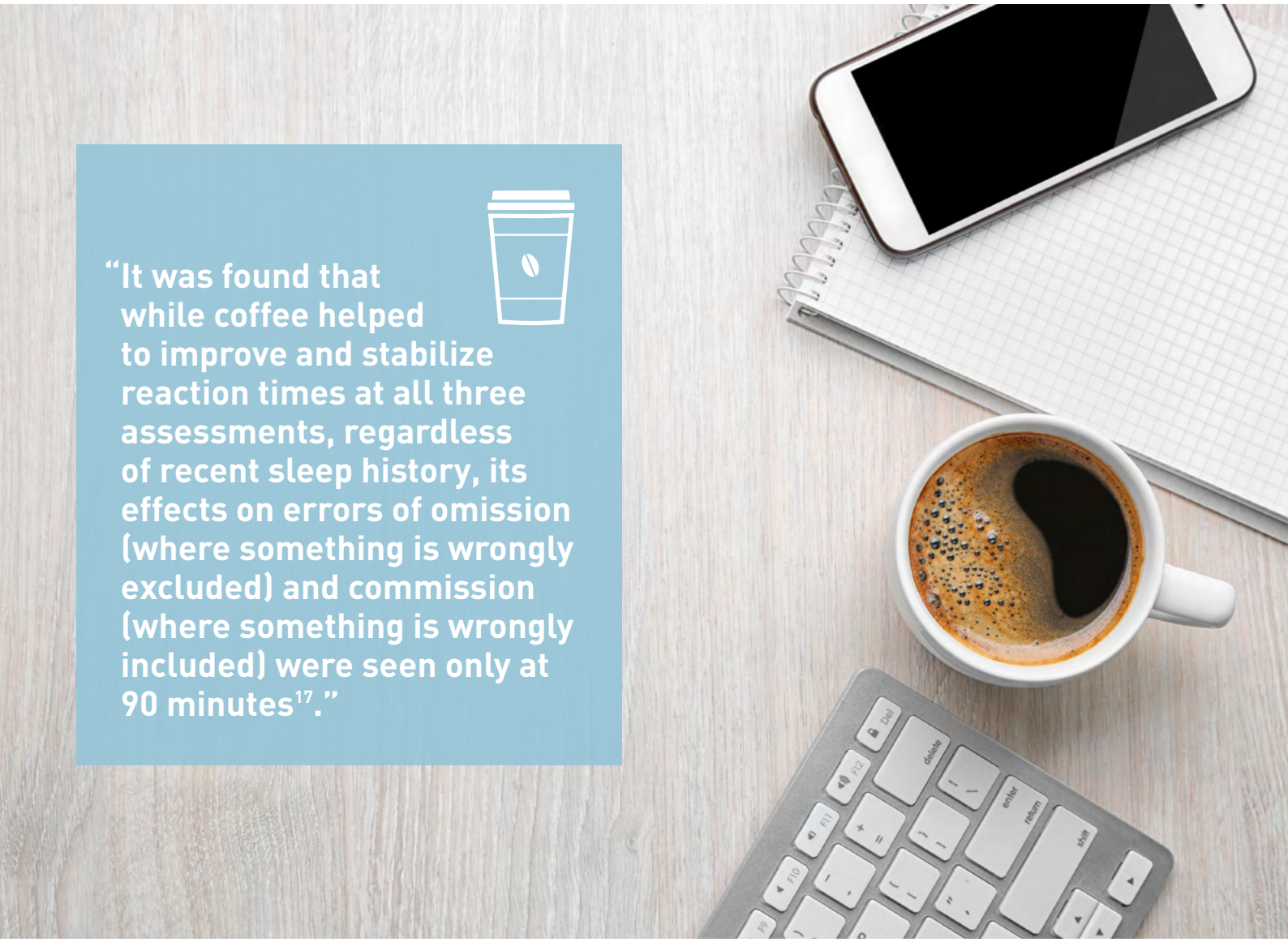
A 2020 study considered whether coffee consumption during a simulated busy five-day working week is able to counteract the consequences of inadequate sleep (five hours per night)[10]. The study compared the effect of caffeinated and decaffeinated coffee against measurements of vigilance, alertness, reaction time, accuracy and working memory in sleep-restricted individuals. Importantly, this study took account of genetic differences, selecting those whose genetic profile made them more susceptible to the impact of caffeine on alertness.

The study suggested that 300mg caffeine intake per day helps to preserve attention and cognitive function in the first three-to-four days of restricted sleep in genetically caffeine-sensitive individuals. However, by the fifth and final day, no difference was seen between regular and decaf coffee drinkers. This, therefore, suggests regular coffee could help in the short term, but is no substitute for sufficient sleep[10].

"300mg caffeine intake per day helps to preserve attention and cognitive function in the first three-to-four days of restricted sleep in genetically caffeine-sensitive individuals[10]."

The authors also noted that understanding an individual's genetic sensitivity to caffeine could provide a clearer indication of the potential usefulness of drinking coffee as a countermeasure against impaired attention in sleep-restricted individuals[10].

A 2018 study examined the effects of coffee on vigilance, comparing individuals based on recent sleep quality. 69 participants completed two randomized, counterbalanced trials consisting of 237ml water or coffee (100mg caffeine), followed by continued vigilance performance testing over 30, 90, and 120 minute periods, respectively. It was found that while coffee helped to improve and stabilize reaction times at all three assessments, regardless of recent sleep history, its effects on errors of omission (where something is wrongly excluded) and commission (where something is wrongly included) were seen only at 90 minutes. It was found that coffee increased commission errors and only partially reduced omission errors in individuals reporting poor sleep quality. The use of coffee to combat poor sleep may therefore be detrimental in situations requiring inhibitory control[17].

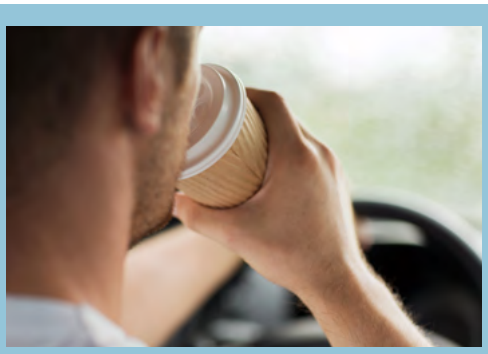


"It was found that while coffee helped to improve and stabilize reaction times at all three assessments, regardless of recent sleep history, its effects on errors of omission (where something is wrongly excluded) and commission (where something is wrongly included) were seen only at 90 minutes[17]."

Are there times when a cup of coffee can be helpful during the sleep/wake cycle?

Drinking coffee can be helpful in situations where maintaining alertness is important, such as driving and on occasions where sleep may be compromised, such as those experiencing jet lag[5,18-20].

Caffeinated drinks such as coffee are regularly chosen by shift workers, especially those working night shifts[21,22]. Some research has suggested that the overall caffeine intake of shift and non-shift workers may be similar, due to shift workers consuming less caffeine during working hours[23]. It is also thought that some shift workers may use caffeine, in part, to optimize off-duty alertness[23]. Research of emergency medical team's shows that caffeine can improve psychomotor performance and vigilance when working night shifts, although it may affect later sleep quality and duration[24].



"Results suggested that drinking one-to-two cups of caffeinated coffee is as effective as a 30-minute nap in reducing driving impairment without altering the quality of subsequent sleep nor the time taken to fall asleep[20]."

Research has considered the efficacy of consuming a cup of coffee versus taking a nap on night-time highway driving. The results suggested that drinking one-to-two cups of caffeinated coffee is as effective as a 30-minute nap in reducing driving impairment without altering the quality of subsequent sleep nor the time taken to fall asleep[20]. A further study concluded that subjective driving quality during a simulated two-hour monotonous highway driving test was significantly improved in the first hour after consuming a single cup of caffeinated coffee[18]. In addition, a case-control study showed drinking caffeinated beverages, such as coffee, was associated with a reduced risk of crashing for long distance commercial motor vehicle drivers[19]. However, since caffeine may cause sleep disturbance in some, it follows that there is a potential risk of caffeine consumption resulting in increased sleepiness, which may pose a safety risk when driving[25].

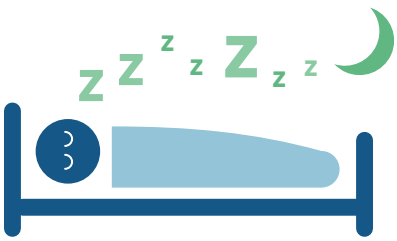
In relation to jet lag, research has indicated that drinking caffeine can help to combat jet lag-induced daytime sleepiness among passengers traveling eastward and that an intake of 300mg of caffeine (in this case, through a format specifically designed to be released slowly into the body) enhanced alertness. However, it is important to manage the timing of caffeine intake carefully to avoid the potential exacerbation of jet lag-induced insomnia[26].

How can coffee be enjoyed while reducing its impact on sleep?

While many people like to enjoy coffee for its effect on alertness, a common question among consumers is how they can do so without impacting their sleep in the evening.

When we drink coffee, caffeine is absorbed into the blood and body tissues and this absorption occurs within about 45 minutes[7]. Peak levels of plasma caffeine concentration are reached after 15–120 minutes after ingestion. Caffeine's effects will last for several hours, depending on how quickly or slowly it is metabolized by the body[7].

As everyone's metabolism varies, individual advice is difficult to offer — however, avoiding caffeine-containing drinks in the hours before bedtime is sensible advice for those who experience wakefulness when they drink caffeine. As a guide, a 2013 study assessed the impact of caffeine consumption at different periods before sleep and suggested that caffeine consumed up to six hours beforehand may reduce total night sleep and reduce sleep quality[27].



"A 2013 study assessed the impact of caffeine consumption at different periods before sleep and suggested that caffeine consumed up to six hours beforehand may reduce total night sleep and reduce sleep quality[27]."

Those who find that consuming coffee later in the day disrupts their sleep patterns may wish to swap to low caffeine drinks, or decaffeinated coffee during the afternoon and evening. The key is finding a balance between enjoying coffee, while limiting consumption close to bedtime for those that are sensitive to the stimulating effects of caffeine.

In summary, consuming coffee forms a part of many people's daily routines and can provide benefit to those seeking improved alertness and concentration[1]. This can include individuals who have restricted sleep[10], shift workers[21,22], people driving long distances[18] or experiencing jet lag[6]. Alongside these effects, research also indicates that coffee can impact total sleep time and quality, especially when consumed close to sleep time[8]. Those who find that consuming coffee later in the day disrupts their sleep patterns may wish to swap to low caffeine drinks, or decaffeinated coffee during the afternoon and evening. The key is finding a balance between enjoying coffee, while limiting consumption close to bedtime for those that are sensitive to the stimulating effects of caffeine.

About Dr Renata Riha

Dr Riha has been a consultant in Sleep and Respiratory Medicine at the Royal Infirmary of Edinburgh since 2004. She qualified in medicine at the University of Queensland and is a Fellow of the Royal College of Physicians in Edinburgh and a Fellow of the Royal Australasian College of Physicians. She continues to be involved in sleep medicine education in both the European Respiratory Society and European Sleep Research Society, is an associate editor and review editor on a number of international sleep, respiratory and neurological journals and actively pursues clinical research in a variety of sleep disorders. She has also authored the book 'Sleep: Your Questions Answered'.

About ISIC

The Institute for Scientific Information on Coffee (ISIC) is a not-for-profit organization, established in 1990 and devoted to the study and disclosure of science related to "coffee and health." Since 2003 ISIC also supports a pan-European education programme, working in partnership with national coffee associations in nine countries to convey current scientific knowledge on "coffee and health" to healthcare professionals.

ISIC's activities are focused on:

- the study of scientific matters related to "coffee and health"
- the collection and evaluation of studies and scientific information about "coffee and health"
- the support of independent scientific research on "coffee and health"
- active dissemination of balanced "coffee and health" scientific research and knowledge to a broad range of stakeholders.

ISIC respects scientific research ethics in all its activities. ISIC's communications are based on sound science and rely on scientific studies derived from peer-reviewed scientific journals and other publications.

ISIC members are six of the major European coffee companies: illycaffè, Jacobs Douwe Egberts, Lavazza, Nestlé, Paulig, and Tchibo.

About coffeeandhealth.org

The website www.coffeeandhealth.org is a science-based resource developed for health care and other professional audiences and provides the latest information and research into coffee, caffeine and health.

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