Feature

Omega-3 and sleep: New insights from the DHA Oxford Learning and Behaviour (DOLAB) study

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Summary

Does dietary intake of omega-3 DHA influence children’s sleep? Sleep problems affecting 40% of UK schoolchildren aged 7–9 years were reported in a recent University of Oxford study and lower blood concentrations of omega-3 DHA predicted more serious sleep problems in these otherwise healthy, normal children. In a randomised controlled trial, dietary supplementation with omega-3 DHA (docosahexaenoic acid) for 16 weeks improved parent-rated sleep in children with such problems. Furthermore, objectively measured sleep duration was increased by almost one hour by DHA vs placebo.

Introduction

Good sleep is essential for general health, cognitive functioning and emotional wellbeing, and yet sleep problems are very common in most developed countries, even when sufficient time is available. Poor sleep is particularly associated with childhood behaviour and learning difficulties such as ADHD and autistic spectrum disorders; and in adolescents and adults, also with anxiety, depression and other psychological disorders – but persistent sleep problems are also widespread in the general population.

In both children and adolescents, good sleep facilitates both working memory and memory consolidation [1], hence persistent sleep problems at this age may particularly impair children’s cognitive and educational development, as well as increasing their risks for physical and mental health disorders. Lifestyle factors are known to play an important role in the development and maintenance of sleep disorders (e.g. shift working, and exposure to artificial light at night, which can disrupt sleep-wake cycles). By contrast, diet is rarely considered to be of much relevance, except via the known links between obesity and sleep apnoea, for example. However, nutrition is critical to the proper functioning of the brain and nervous system, as it is to the rest of the body. Increasing evidence is now pointing to dietary fats – and the balance of omega-3 and omega-6 polyunsaturates in particular – as another potential influence on sleep that merits serious consideration.

Long-chain polyunsaturated fatty acids (LC-PUFA) are important in the initiation and maintenance of sleep, particularly via the many regulatory substances we derive from them. For example, it has long been known that the sleep-promoting prostaglandin D2 is made from arachidonic acid (AA), the most important long-chain omega-6 fatty acid. More recently, studies have revealed that the balance of DHA and AA in the pineal gland affects the production of melatonin, a key hormone involved in sleep initiation and the maintenance of a normal sleep-wake cycle [2]. Specifically, higher levels of DHA are associated with increased levels of melatonin production, as DHA is needed for one of the enzymes involved in transforming serotonin into melatonin once darkness falls. DHA is also known to affect dopamine metabolism, which can impact on sleep and wakefulness via its effects on arousal and activity levels.

In line with these mechanisms, higher blood omega-3 LC-PUFA status has been associated with better sleep in both infants and adults, and in children with ADHD; but studies in this area remain few, and very little is yet known about how fatty acid status may relate to sleep in healthy, normal children of school age. Similarly, few randomised controlled trials (RCT) have investigated whether supplementation with omega-3 LC-PUFA might improve sleep. Omega-3 DHA alone given to mothers-to-be in pregnancy has been found to improve sleep patterns in their infants, and a few small trials have reported that treatment with both omega-3 and omega-6 fatty acids along with other nutrients can improve sleep quality and reduce sleep disorders in children with behavioural problems. However, the use of different nutrients in combination in these studies leaves open the question of whether supplementation with omega-3 alone may be of benefit – and it is the omega-3 LC-PUFA that are particularly lacking from modern, western-type diets. Furthermore, no clinical trials appear to have involved children from the general population.

We therefore decided to investigate links between omega-3 and sleep as part of the DHA Oxford Learning and Behaviour (DOLAB) study, which was set up to find out how omega-3 DHA may relate to, and influence, the behaviour and learning of healthy children from mainstream UK schools [3, 4].

The aims of this aspect of the study were twofold:

1. To explore associations between children’s sleep and their blood fatty acid status.
2. To assess the effect of DHA supplementation on children’s sleep.

On the basis of the existing literature we predicted that

1. Higher blood concentrations of long-chain omega-3 fatty acids would be associated with better sleep.
2. DHA supplementation would lead to improvements in children’s sleep.

The DHA Oxford Learning And Behaviour (DOLAB) study

This study was designed in two discrete stages, as reported in detail elsewhere [3, 4].
Stage One was an epidemiological (population) study, initially involving a representative sample of 675 healthy children aged 7–9 years recruited from 74 schools in Oxfordshire, UK. All were assessed on standardised measures of cognition and behaviour, as reported elsewhere [3, 4]. In addition, the children’s sleep was assessed via parent ratings using a well-validated measure normed on UK children, the Child Sleep Habits Questionnaire (CSHQ) [5]. Most children also gave a small ‘fingerstick’ blood sample for fatty acid analysis.

Stage Two was a double-blind, fixed dose, parallel group randomised controlled trial (RCT) involving 362 of the same children. Selection criteria were: reading < 33rd centile and English as a first language; not taking omega-3 supplements or eating fish more than twice a week; and no specific medical disorders, general learning difficulties, or medications expected to affect learning or behaviour, including sleep.

Eligible children whose parents gave consent were randomised to receive either 600 mg/day of algal-source DHA (supplied by DSM Nutritional Products, USA) or a taste/colour-matched placebo containing corn/soybean oil for 16 weeks, after which the assessments carried out at Stage One were repeated. In addition to subjective measurement of sleep via the CSHQ in all children, sleep was measured objectively via actigraphy in a random subsample (n = 43) both at baseline and post-intervention. This involved the child wearing a motion-sensitive wrist sensor for five nights, and parents keeping a simple diary with which to compare the recorded data.

Results

STAGE ONE: Sleep problems in UK children, and their relationship with blood fatty acids

Blood samples were analysed for their fatty acid composition by an independent laboratory (DSM Nutritional Lipids, USA). Missing data on blood fatty acids (n = 182) or sleep (n = 98) yielded a final sample of 395 children for this study (55% male, mean age 8.1 years) on whom data from both measures were available.

The children’s sleep as rated by their parents was found to be poor. Total sleep disturbance scores >41 on the CSHQ indicate ‘clinical-level’ sleep problems. The mean score for our sample was 41.05 (sd = 6.98), with almost 41% (n = 161) of children scoring in the clinical range, as shown in Figure 1.

Average blood concentrations of omega-3 LC-PUFA were also very low from a health perspective, as discussed elsewhere [4], with a mean DHA concentration of 1.93% (sd = 0.54) and EPA mean 0.56% (sd = 0.21). For comparison, EPA+DHA concentrations in adults of <4% would signify a high risk of cardiovascular disease, with >8% considered optimal for cardiovascular health.

Higher total sleep disturbance scores were associated with lower blood DHA (rho = –0.131, p < 0.009) and a lower DHA : AA ratio (rho = –0.133, p < 0.008) on simple correlational analyses; and these associations remained significant when controlling for age, gender, weight and socioeconomic status: DHA std. coeff. –0.105 (p < 0.026), DHA:AA std. coeff. –0.119 (p < 0.009).

STAGE TWO: The effects of dietary supplementation with DHA on children’s sleep

Our randomised controlled trial included 362 children (53% male, mean age 8.8 years). Objective sleep measurement via actigraphy was carried out in a random sub-sample of 43 of these children (51% male, mean age 8.2 years). After 16 weeks of supplementation, the two treatment groups were compared on both subjective and objective sleep measures.

Figure 1. Distribution of total sleep disturbance scores on the Child Sleep Habits Questionnaire for the children in the epidemiological sample. Scores >41 indicate clinical-level sleep problems (from Montgomery et al., 2014, J. Sleep Res. 2014, 23(4): 364–388, license via Creative Commons).
Subjective sleep measures

No significant effect of DHA supplementation on parent-reported sleep was found for the sample as a whole. However, DHA significantly reduced sleep problems in the 188 children (i.e. 52% of the RCT sample) whose initial CSHQ total sleep disturbance scores indicated a clinical-level sleep problem (p < 0.05, post-hoc analysis).

Objective sleep measures

Actigraphy results showed that total sleep duration increased by 58 minutes more in children receiving the active treatment compared with those on placebo (p < 0.029), as shown in Figure 2. This was largely the result of significantly fewer night awakenings (7 fewer episodes per night, p < 0.013) in the DHA-supplemented group, and therefore greater ‘sleep efficiency’ (i.e. time asleep as a proportion of time in bed), as reported in more detail elsewhere [6].

Discussion

Sleep problems are known to impair behaviour and learning ability as well as general health. Following evidence that omega-3 status may influence sleep, and controlled trials showing benefits of omega-3 for child behaviour and learning, we decided to investigate sleep in relation to omega-3 status in a large sample of healthy UK schoolchildren as part of the DHA Oxford Learning and Behaviour (DOLAB) study.

In an initial epidemiological study, we found evidence of clinical-level sleep problems in 40% of 7–9 year old children from mainstream UK schools, which is broadly consistent with reports from other developed countries. We also found that more serious sleep problems were associated with lower blood concentrations of omega-3 DHA, and a lower DHA : AA ratio in particular. This confirmed our prediction that poorer sleep would be associated with lower omega-3 status, and is in keeping with other evidence linking lower DHA : AA ratios to reduced melatonin production and impaired dopamine metabolism.

In a subsequent randomised controlled trial, we then found that 600 mg/day of DHA for 16 weeks significantly improved the parent-rated sleep of those children who initially showed clinical level sleep problems (52% of the sample). No significant effect was seen in the sample as a whole, although this was not unexpected given that almost half of the children had few initial sleep problems, and hence little room for improvement.

Objective measurement (via actigraphy) in a random subsample of the RCT children revealed that DHA significantly improved their total sleep duration – increasing this by almost one hour compared with placebo. This improvement was largely attributable to fewer and shorter episodes of night waking in the DHA-treated group. More detailed studies would be needed to elucidate possible mechanisms, but the observed improvements could reflect changes in melatonin production, dopaminergic activity or both [2].

To our knowledge, this is the first study to show that increasing children’s dietary intake of omega-3 DHA can improve their sleep. Given the serious impact of sleep problems on behaviour, cognition and general health, these findings clearly deserve further investigation. The treatment effect observed using objective measures of sleep was strikingly large, but as it was only possible to use these measures in a small subset of our RCT children, these results must be regarded as preliminary until replicated.

Further studies of omega-3 in relation to sleep are clearly warranted. For further clinical trials, a focus on children with clinical sleep problems would make sense, although the links we have found between fatty acid profiles and sleep also deserve further exploration in both experimental studies and large general population

![Figure 2. Total minutes of sleep by treatment group, as assessed using actigraphy: Baseline, post-intervention, and changes after 16 weeks of supplementation with DHA or placebo (from Montgomery et al., 2014, J. Sleep Res. 2014, 23(4): 364–388, license via Creative Commons).](image-url)
samples. Meanwhile, these initial findings indicate that dietary supplementation with omega-3 DHA could provide a simple, safe and effective way to improve children’s sleep. In addition, there seems little a priori reason why these findings might not generalise to other age groups, so this too deserves investigation.

Conclusions

- Child sleep problems are common, and are associated with behaviour and learning difficulties. We and others have already shown that such difficulties are linked with low omega-3 LC-PUFA status, and can be improved by dietary supplementation. We therefore investigated (1) potential links between omega-3 status and children’s sleep, and (2) the effects of supplementation with omega-3 DHA on their sleep.
- Of 395 healthy children aged 7–9 years from mainstream UK schools, 40% showed clinical-level sleep problems according to a well-validated parent questionnaire.
- Sleep problems in these children were found to be related to blood fatty acid profiles as predicted. Specifically, those with more serious sleep problems had lower blood concentrations of DHA, and lower ratios of DHA : AA in particular.
- In a subsequent randomised controlled trial (RCT), supplementation with 600 mg/day of omega-3 DHA for 16 weeks significantly improved parent-rated sleep in those children who initially had clinical-level sleep problems (n = 188), although no effect was found in the sample as a whole (n = 362).
- Objective measurement of sleep (via actigraphy) in a random subsample of the RCT children (n = 43) showed that children receiving DHA gained almost an hour of additional sleep compared with those on placebo.
- Replication studies are clearly needed, but given the safety and general health benefits of increased dietary intakes of omega-3 LC-PUFA, these findings appear to offer a very promising addition to existing methods of managing sleep problems in children. Their generalisability to other age groups also merits investigation.

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In the last five years, the author has carried out some paid consultancy work (talks, lectures, and advisory work) for a number of different companies involved in the sale or manufacture of foods and supplements, including some that contain omega-3 fatty acids.

References