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The impact of nutrition on sleep in people with an intellectual disability: An integrative literature review.

Abstract

Background: People with intellectual disabilities are more likely to experience sleep problems. Sleep can impact on health and well-being; therefore evidence-based interventions are required to improve sleep in this population.

Method: An integrative literature review was conducted on the impact of nutrition on sleep in people with intellectual disabilities. Following screening of papers (n=289), fourteen papers met the inclusion criteria.

Results: Themes related to nutrition and improved overall wellbeing, use of nutritional supplements, specific foods, links to health comorbidities and food fussiness.

Conclusion: This is the first comprehensive review completed on nutritional interventions to improve sleep in people with intellectual disabilities. Dietary patterns may be an important factor to improving the quality and quantity of sleep. However, the current literature regarding the benefit of improved nutrition on sleep in people with an intellectual disability needs to be interpreted with caution.

Keywords

Learning disability, intellectual disability, diet, nutrition, sleep.

Introduction The precise role of sleep remains an enigma, with a lack of consensus regarding its function in human beings (Krueger et al., 2015). Nevertheless, consensus exists among researchers that sleep plays an important role for an individual's physical, cognitive and mental well-being. Sleep has been linked to cognitive performance on tasks requiring memory consolidation and learning (Gui et al., 2017), processing speed (Lim et al., 2017), procedural memory used in motor skills (Rangtall et al., 2017), attention (Lehto et al., 2014), decision making and creativity (Seeley et al., 2016). In addition, links between physical health conditions and impaired sleep have been reported in the literature. Health conditions include depression (Paunio et al., 2015), metabolic and cardiovascular

diseases (Hege et al., 2018), inflammatory diseases (Ali and Orr, 2014), infectious diseases (Ibarra-Coronado et al., 2015), cancer (Ji et al., 2017) and Alzheimer's disease (Vanderheyden et al., 2018). Therefore, evidence-based interventions to improve the sleep of individuals with intellectual disabilities are required.

Interventions to improve sleep

The NICE guidelines (2015) state that behavioural or non-pharmaceutical interventions should be used as a first-line treatment for behavioural sleep problems. Non-pharmaceutical approaches include psychological therapies (such as cognitive behaviour therapy and mindfulness), environmental changes, light exposure therapy, and behavioural and lifestyle interventions (Macleod et al., 2018; Miller et al., 2017; Priday et al., 2017).

A combination of interventions is often used to promote sleep efficacy in people with intellectual disabilities (Spruyt and Curfs, 2015). Positive effects of behavioural sleep interventions are reported in 75% of the studies included within a systematic review of 90 studies and a further 17% reported mixed results (Spruyt and Curfs, 2015). However, it is difficult to extrapolate these results for two reasons. Firstly, generalisability of these results is limited given that most studies were case studies that had adapted interventions for children. The lack of adherence to a systematic approach required careful interpretation of the findings with regards to generalizability to the wider population. Secondly, most behavioural interventions used a combination of approaches. Limited research is available that investigates the efficacy of the interventions in isolation (Sutton et al., 2019), and an analysis of specific interventions is needed to make evidence-based recommendations. However, evidence supports the use of integrated, multidimensional approaches to improve sleep (Macleod et al., 2018). Individualised sleep promotion interventions that incorporate different approaches are more likely to be effective (Fullagar et al., 2016) and nutritional interventions may add to the multidimensional approaches already used.

Nutritional interventions to improve sleep

A number of nutrients and foods have received anecdotal attention in the literature to increase sleep quantity and quality, however, recently there has been an increase in research investigating the robustness of these claims.

The literature demonstrates that there is some evidence of effectiveness of the following foods and micronutrients in improving sleep quantity or sleep quality in the general population: reductions in caffeine and an increase in intake of milk and whey, vitamin D, melatonin rich food (e.g., cherries), antioxidants and polyphenols (e.g., isoflavones) (Allen et al., 2016; Navabzedeh et al., 2019; Evatt, 2015; Nodtvedt et al., 2017; Cui et al., 2015; Noorwali et al., 2018).

Other micronutrients have been implicated in sleep quality and/or quantity. Deficiencies in micronutrients such as Iron (Fe), Zinc (Zn) and Magnesium (Mg) negatively impact sleep duration and the organisation of sleep stages (Ji et al., 2017; Esteroff Marano, 2018; Cao et al., 2018). This is important given that, around the world, anaemia and zinc deficiencies are common (WHO, 2013), however, single supplements may be less effective than whole foods that contain multiple nutrients. Failing to consider the interactions between nutrients may lead to inconsistent results (Cao et al., 2019).

Dietary habits of people with intellectual disabilities

To gain insight into dietary deficiencies that are prevalent in people with intellectual disabilities it is important to understand and acknowledge their current dietary habits. The diets of individuals with an intellectual disability are more likely to be inadequately balanced in comparison to a typical dietary pattern from a neurotypical individual (Hamzaid et al., 2019; Franssen et al., 2011). Diets in individuals with intellectual disabilities are lower in essential micronutrients, whole-grains, fruit and vegetables (Hamzaid et al., 2019). In samples of people with intellectual disabilities from different countries micronutrient intakes of magnesium, calcium, iodine, zinc and vitamin A, D and E are deficient (Hamzaid et al., 2019; Hoey et al., 2017). Individuals with intellectual disabilities tend to eat less than 1.5 portions of fruit and vegetables a day (Hamzaid et al., 2019). However, sodium levels exceed the recommended upper limit due to a high intake of processed meats, bread and pre-prepared meals (Hamzaid et al., 2019). Healthy eating indexes have been associated with reduced sodium intake and improved sleep in the general population (Mossaver-Rahmani et al., 2017).

In conclusion, individuals with intellectual disabilities have poor sleep quality and quantity. Sleep affects quality of life, learning, memory and physical health. Therefore, it is important to provide evidence-based interventions to promote good sleep quality and

adequate sleep quantity. Nutritional interventions to improve sleep have been used in the general population with small but significant increases in sleep quality or quantity. Evidence has shown that individuals with intellectual disabilities have poor dietary habits which impact their health. Improving dietary intake may offer a viable intervention to improve health and sleep in individuals with intellectual disabilities.

Objective

To investigate what is currently known about the impact of nutrition on sleep in people with an intellectual disability, by reviewing the quality of evidence that is available, in order to make recommendations for practice and future research.

Methodology

An integrative literature review was undertaken. In addition to reviewing quantitative studies as is the case with a systematic literature review, an integrative literature review includes both quantitative and qualitative studies. As described by Webb and Roe (2007), an integrative literature review is appropriate to perform a broad investigation of the topic, appraise and integrate different types of primary research and produce a summary of the research. This methodology included the following 5 stages: problem identification, location of studies, evaluation of studies, collection of data from individual studies and data analysis.

Evidence gathering and study selection

A number of approaches were used to find relevant literature, including database searches and hand searching for grey material.

- Databases included CINAHL, PsycINFO and MEDLINE.
- Websites manually searched were WHO's Library Database, Cochrane, National Institute of Health and Care Excellence, Mencap, BILD, Royal

College of Nurses, Royal College of Psychiatry, Health Education England reports, trial listed at clinicaltrials.gov, explore at the British Library.

- Grey material was searched for at www.opengrey.eu/
- A search of unpublished PhD theses on Ethos
- Bibliographic databases through Google Scholar
- Reference searches using the bibliographies from relevant articles found (backward chasing) as well as forward citation chasing.

Database searches used a combination of the search terms presented in Table 1 using OR for each list in the columns and then AND to combine the three datasets. All papers reviewed have one of the terms from each column in the title or abstract of the article. [see table on page 24]

Eligibility criteria

Papers that demonstrate causative links, no positive effect or correlations between diet and sleep, either as a primary or a secondary outcome or a finding from sub-analysis of the results were included. Papers related to behavioural sleep problems were included and those relating to sleep disordered breathing, epilepsy syndrome and restless leg syndrome were excluded. All papers written in English were eligible. Given the sparsity of research available on this topic, no date of publication was specified.

All types of studies were included and studies were not selected on methodological rigour or quality. Literature reviews and opinion pieces that did not contain primary research evidence were excluded.

A two-staged approach was used to review the relevance of the literature. Initially the titles and abstracts were viewed, followed by reading full text articles and papers. If papers did not have an abstract, further review of the full text was completed to ascertain relevance.

Results

Study selection

Studies were predominantly found through database searches using CINAHL, PsycInfo and Medline (n=309). A further 12 articles were located through searching for grey materials. Of

these, two theses were located through Ethos, 6 papers through Google Scholar, one article found through forward chasing, one paper submitted to the National Institute for Health and Care Excellence website, one report submitted to Health Education England (HEE) website and one paper reporting a clinical trial deposited on clinicaltrials.gov. Following removal of duplicates, 289 articles remained and were screened (Figure 1).

Following review of the titles and abstracts, 204 articles were removed using the inclusion and exclusion criteria. The remaining 85 articles were retrieved and read to enable a more detailed evaluation of their relevance. Fourteen papers met the inclusion criteria.

Overview of included studies

The 14 included studies spanned from 1975 to 2018, with 8 of these studies being published after 2010. Most studies related to children (n=12). The included studies used a range of methodologies including case studies (n=5), cross-sectional research designs (n=3), prospective comparative studies using pre-post design (n=3), observational studies (n=1), , pilot studies (n=1) and mixed method designs (n=1). Table 2 provides an overview of the studies reviewed.

Critical review of the literature

There were no adequate or validated critical appraisal tools available to critique the different methodologies used in research involving individuals with an intellectual disability, and which could ascertain methodological standards of rigour of the reviewed literature. Therefore, a new critical appraisal tool was developed by the first author (Link to [Appendix 1. CAT-ID](#)), which is an amalgamation of critical appraisal tools from the Centre for Evidence Based Management (CEBM), the Institute of Health Economics and CASP

guidelines for case studies, case series and cohort studies respectively, Downs and Black (1998) checklist and the CAMELOT tool developed by Munthe-Kaas et al., (2019). Specific consideration was given to the definition of the sample in line with the World Health Organisation definition (WHO, 2020), public and patient involvement (PPI) in the design of the study and generalisability to other sub-populations and settings.

As with CASP and the CEBM appraisal tools, the studies were rated as “yes”, “no” or “can’t tell” for the different aspects reviewed and additional written commentary was provided as evidence to support the decision. Validity of the new tool was increased through amalgamating all aspects of the critical appraisals covered within the CASP and CEBM tools. Furthermore, a second reviewer reviewed a sample of completed appraisals and discrepancies were discussed until agreement was reached.

Study designs and methodologies

1. Aim of the research

The majority of the research papers clearly articulated a research question, aim or hypothesis, with the exception of three papers that lacked clarity and focus regarding the research question. All the studies that failed to adequately state the aim of the research were case studies or case series with the justification for the paper implied from the description of the participant prior to intervention.

2. Methodology selected.

Most studies only provided partial evidence to either justify the methodology or to select an appropriate research design for their specific research question. Two studies (Durand, 1975 and Bird et al., 2011) provided justification for the methodology in line with the hypothesis or research question. A preference for quantitative data was noted despite some researchers collecting data on individuals’ perceptions and subjective phenomena such as beliefs about their own quality of life (Fabiana Faleiros-Castro et al., 2013; Valcenti et al., 2014; McQuarrie, 2009). This is arguably better aligned to an interpretivist paradigm (Parahoo, 2014).

Further critique of the designs of the research papers included the use of cross-sectional studies (Valcenti et al., 2014; Wang et al., 2018). Cross sectional studies do not allow for the identification of directionality or causal relationships. Therefore, longitudinal studies would have been preferable although more costly in terms of resources and time. The majority of studies used retrospective data with its inherent limitations, which reduces the rigour, including collating subjective responses that rely on respondents’ memory

(Valcenti et al., 2014; McQuarrie, 2009) and incomplete records (Cocchi, 1996). The advantage of cross-sectional retrospective studies is the reduced time delay in comparison to observational studies, as illustrated by the 2-year data gathering period reported by Danford and Huber (1981).

The research design used in a number of studies was influenced by previous research conducted by the authors (Barnhill et al., 2018; Bird et al., 2011). This has the limitation that additional factors influencing the dependent variable in this specific population may have been missed. Lack of measurement of potential confounding variables known to effect sleep, due to the previous research dictating the variables assessed, reduces the rigour and the validity of the conclusions.

3. Patient and public Involvement.

None of the research papers involved potential participants or their carers or families as their advocates, in reviewing the research question or involving them in the design and implementation of the study. Fabiana et al. (2013) included feedback from individuals with intellectual disabilities during the development of the data collection tools. Evans (2015) invited professionals working with individuals with an intellectual disability to review the results to verify the themes drawn from focus groups. No other research studies reviewed involved individuals, their carers / family or professionals working directly with the researchers to verify results for credibility.

4. Sample.

Papers reviewed typically reported that individuals included in the sample had specific syndromes or used care services for people with intellectual disabilities. Only three papers specifically considered functional or developmental ability in line with the WHO and DSM-1V. Bird et al. (2011) only included functional ability in his outcome measures and not the inclusion / exclusion criteria. Good practice was presented by Valcenti et al. (2011) who used a multi-disciplinary team to assess adaptive as well as intellectual functioning.

Issues with the representativeness of the samples were noted in all the papers, mainly due to the small sample sizes (including case studies), which reduces the likelihood that the sample represents the wider population of people with an intellectual disability. Only two papers (McQuarrie, 2009; Evans, 2015) included a power calculation, however these studies did not reach power that enabled priori calculations to be reliably performed. Additional weaknesses in sampling were identified from the inclusion and exclusion criteria when stated, for example Wilhite et al., (2012) excluded people that were not independently mobile, able to consent and engage in reciprocal communication. The inclusion criteria for

the sample used would therefore exclude a large proportion of individuals with intellectual disabilities, especially those with moderate to profound disabilities.

Publication bias was evident in a number of studies due to retrospectively reporting on a case study that had positive results (researchers less likely to report no change or negative results). Secondly, self-selection bias through using samples following recruitment through websites, forums and professional services was frequently present (Bird et al., 2011; McQuarrie, 2009; Evans, 2015), and thus those not actively engaged with support are not represented. Additional factors that could have caused selection bias include transportation issues (Wilhite et al., 2012) and selection based on using a service and thus excluding those living at home or being home schooled (Searle, 1994; Wang et al., 2018).

Selection bias due to the reasons given above, is a limitation noted in several studies where data was collected at one setting only (Fabiana Faleiros-Castro et al., 2013; Danford and Huber, 1981). Further research is needed to validate conclusion and to check if conclusions are generalizable to other settings or populations.

5. Measures

Data was collected using a wide range of data collection methods such as clinical case notes, diary sheets, surveys, interviews, blood analysis and clinical symptomology.

This section will specifically consider measures of sleep and nutritional analysis that were used in the papers. The only studies that measured the nutritional content of food consumed, were Durand (1975) who recorded caloric intake, and Searle (1994) who used serology and food / drink logs to ascertain caffeine intake. Two studies completed a comprehensive measure of nutritional intake (Bird et al., 2011; Barnhill et al., 2018), which included both validated assessment tools and objective markers, including laboratory analysis using serology. The data collection methods used by Barnhill et al. (2018) included anthropometric, biochemical analysis, clinical symptoms, dietary assessment and environmental assessment in line with the ABCDE approach to nutritional assessment.

To collect data on sleep quantity and sleep efficacy the following assessment tools and methods were used: sleep diaries following hourly observation (Searle, 1994), estimates of time spent asleep (Wang et al., 2018), clinicians notes reporting that individuals have difficulty falling asleep or have night terrors (Cocchi, 1996) and parental reports obtained through evaluation tools or surveys (McQuarrie, 2009).

The majority of the studies did not use objectives measurement tools to assess sleep. Questionnaires completed by carers or family members were the most used type of assessment, followed by parent / carer reported changes measured through interviews,

focus groups or parents' report at medical consultations. These data collection methods are subjective, inherent to bias, and lack sensitivity and specificity when compared to recordings using polysomnography (Esbensen et al., 2018 and Evans, 2015). Only two studies (Durand, 1975 and Searle, 1994) completed a sleep log to evaluate changes to sleep pattern, but no study used actigraphy as a more objective marker of sleep.

Several issues arose from these data collection methods, including the lack of tools validated specifically for individuals with an intellectual disability (Fabina Faleiros-Castro et al., 2013) and subjectivity of tools given that parental reports are used (McQuarrie, 2009; Valcenti et al., 2011).

Analysis

Analysis of data varied, depending on the aim, methodology and sample size. Consideration was given to parametric assumptions prior to inferential statistics being applied (McQuarrie, 2009; Valcenti et al., 2011).

Several studies considered confounding factors such as recent introduction of new medication (Barnhill et al., 2018), age (Fabiana Faleiros-Castro, 2013; Bird et al., 2011), errors in documentation (Durand, 1975), or comorbid conditions (Valcenti et al., 2011; Wang et al., 2018). Follow-up ranged from 9 days (Durand, 1975) to one year for intervention studies (Bird et al., 2011; Pallangyo et al., 2016). A lack of follow-up after the intervention had ceased, was recognised as a limitation of some studies (Bedell, 2008; Wilhite et al., 2012).

Generalisability and transferability

Generalisability of studies was deemed low with recognition of the need for future research to consider a range of settings from which participants are recruited as well as a range of syndromes and comorbid conditions that are associated with intellectual disabilities. Larger sample sizes are preferable to ensure a greater diversity within the sample which includes individuals who are not currently engaged with social networks and professional services. To ensure generalisability, participants with a range of disabilities including those who lack the ability to provide informed consent and who are dependent on others for mobility and activities of daily living, need to be included (Mietola et al., 2017).

Themes / findings from existing literature

None of the reviewed papers specifically addressed the questions about the impact of eating specific foods, taking micronutrient(s) or following specific dietary plans on the quality or quantity of sleep in people who have an intellectual disability.

There was a lack of homogeneity between studies, making synthesis of the findings difficult. Textual descriptions of results from quantitative studies were provided to allow an integrated synthesis. Narrative synthesis was applied given that it was not possible to complete meta-analysis or meta-aggregation due to the lack of homogeneity across studies retrieved (Popay et al., 2006).

Improved sleep, dietary patterns and overall well-being

Wilhite et al., (2012) reported that improved dietary patterns increased sleep and alertness during the day which was supported by case studies (Durand, 1975 and Barnhill et al., 2018). This improvement in sleep outcomes could potentially be due to the impact of changing nutrition on physical health state. Using nutrition to improve physical health was researched by Fabiana Faleiros-Castro et al. (2013), whose primary aim was to reduce constipation, and found improvements in sleep as a secondary outcome, which will be discussed in more depth later. Further support of a good dietary intake impacting sleep comes from discourse between professionals, who expressed that when people with intellectual disabilities eat enough then sleep is better for the whole family (Evans, 2015). Therefore, it can be postulated that a varied and balanced diet may improve the sleep and over-all wellbeing of people with intellectual disabilities.

A balanced and varied dietary pattern is reduced when an individual displays food fussiness or if they are on a restrictive diets. A case study conducted by Barnhill (2018) showed that a child on a gluten-free casein free diet, followed by a restrictive specific carbohydrate diet, maintained sleep problems. Furthermore, Evans (2015) found that individuals with foetal alcohol spectrum disorder who display food fussiness or selective eating were more likely to have sleep disturbances, which suggests that a varied diet may improve sleep. This corroborates that dietary patterns are important for overall health and sleep.

Use of nutritional supplements

The literature regarding supplements is heterogenous, possibly due to the type, dose and timing of nutrient administration. Some researchers have found a positive effect on sleep (Bedell, 2008; Pallangyo et al., 2016) while others reported detrimental effects on sleep (Bird et al., 2011). Bird et al. (2011) prescribed supplements at high doses, greatly exceeding the recommended daily amounts (RDA) or prescribed supplements despite the RDA being unknown due to no conversion factors being established (e.g., for 5-methyl-TFH). In addition, the supplements were not prescribed to improve sleep but to improve phenotype style behaviours in participants, therefore this finding should be interpreted with caution.

There is a dearth of literature that demonstrate the feasibility of using nutritional supplements and making dietary changes for reducing or eliminating sleep problems. However, the use of nutritional approaches for multiple reasons showed that 22% of families and carers use nutritional complimentary or alternative medicine with individuals who have an intellectual disability (Valcenti et al., 2011). This is lower than the 65% figure reported by Tenenbaum et al. (2019), who looked at reported use of vitamins and minerals or application of dietary approaches in people with intellectual disabilities. However, MacQuarre (2009) found that parents with a child diagnosed with an Autistic Spectrum Disorder were more likely to attribute problems to nutrition, while a parent with a child with an intellectual disability was more likely to attribute issues to their child's health status. Therefore, parents may be less prone to independently contemplate dietary changes over current comorbidities if their child has an intellectual disability compared to a neurodevelopmental disability such as autism.

Thus, the use of nutritional supplements to improve sleep or other markers of health appear to be acceptable interventions for individuals with intellectual disabilities, their families or carers. Using supplements to obtain optimal micronutrient levels appears to enhance sleep. However, individuals should ensure that they do not exceed recommended doses without advice from physicians and following biochemical analysis.

Specific foods or foods containing specific chemicals

Cocchi (1996) researched four individuals with sleep problems and found no consistent preference for sweet foods or preference for broth in comparison to those without sleep problems. Evidence about other foods which could influence sleep in people with

intellectual disabilities was not present in the literature. The only evidence that reviewed chemical compounds found within foods concerned the consumption of caffeinated drinks and foods, with Searle (1994) concluding that reducing caffeine for two weeks had no effect on sleep.

Links to health comorbidities

A number of health complications which are affected by eating were alluded to in the literature. Evidence suggests that if comorbid conditions are managed through diet then this can increase sleep efficacy and sleep quantity. Examples of this include reduction in constipation (Fabiana Faleiros-Castro, 2013), treatment of anaemia (Pallagyo et al., 2016) and potentially improvements in cholesterol and blood pressure (Wilhite et al., 2012). Feeding practices aimed to manage PICA, aerophagia and hyperphagia may also reduce sleep disturbances (Danford and Huber). Some parents of children with Down's syndrome agreed that sleep problems could be attributed to another health problem (McQuarrie, 2009). The impact of nutrition on health comorbidities could therefore be a confounding variable that needs to be considered when assessing sleep.

Discussion

There is evidence that individuals with specific intellectual disabilities have poor sleep quality and quantity. Case studies suggest that individuals with intellectual disabilities, with support from their families, carers and multi-disciplinary teams, are able to make dietary changes to promote health. Sleep is one health factor that may be amenable to change following improved dietary practices in people with intellectual disabilities. However, safety and ethical dilemmas need to be considered when using nutritional interventions. Nutraceuticals should remain within the recommended daily amounts in order to reduce the risk of adverse reactions, including sleep problems (Bird et al., 2011).

The findings of this review suggest that a healthy balanced dietary pattern enhances sleep and overall well-being (Wilhite et al., 2012; Evans, 2015). Restrictive diets determined through choice or dietary approaches that are not carefully managed to ensure adequate nutrient intake may lead to health problems, such as anaemia and constipation, and sleep problems (Fabiana Faleiros-Castro, 2013; Pallagyo et al., 2016). In adults without intellectual

disabilities a recent review concluded that individuals who were depleted of micronutrients who increased intake of these micronutrients had improved sleep markers (Binks et al., 2020). Therefore, further research is required to examine if these nutrients including zinc, tryptophan, melatonin or phytochemicals may also be beneficial for individuals with intellectual disabilities.

Furthermore, management of feeding difficulties, such as aerophagia and hyperphagia, may support the management of sleep disturbances (Danford and Huber, 1981). This review considers nutritional intake, however research is emerging that chrononutrition is an important aspect of an individual's dietary regime that may impact sleep and overall well-being (Pot, 2018). Chrononutrition considers the timing that foods are eaten and may be particularly relevant to those with gastro-oesophageal reflux, dysphagia, aerophagia and other feeding difficulties.

Even though the evidence suggests a positive effect of improving dietary intake on sleep quantity and possibly also quality, it needs to be interpreted with caution. Research methods used in the studies have limitations and /or do not assess the specific impact of diet on sleep in individuals with an intellectual disability. This demonstrates the need for rigorous research studies to examine the potential relationship between nutritional interventions and sleep. The review found no studies that specifically investigated the benefits of eating specific foods to improve sleep. Therefore, further research is needed to examine the impact of specific foods, food groups and micronutrients on objective and subjective markers of sleep. Further research is required which considers specific nutrients, such as omega 3, vitamins and minerals as well as whole foods known to improve sleep and other comorbidities such as constipation.

This review includes papers published since 1975, covering a wide time span, and used multiple database and grey searches in order to get a comprehensive view of the current evidence-base. However, this review included papers that had methodological limitations which may have reduced the rigour of the findings. As a result, the findings and conclusions need to be interpreted with caution. A number of methodological challenges have been highlighted in this review, including lack of validated and rigorous data collection methods and tools, small sample sizes, and underrepresentation of certain groups of people with intellectual disabilities, which limits the generalisability of the findings to the wider population.

Further research would benefit from using combinations of data collection methods and objective and reliable measures tools, such as actigraphy, as well as qualitative measures to support interpretation of findings.

In conclusion, dietary patterns may be an important factor to improving the quality and quantity of sleep in people with intellectual disabilities. However, more rigorous research is needed to examine these relationships, the feasibility of the interventions, and the magnitude of the impact.

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Appendix 1.

Table 1. Search terms

	<p style="text-align: center;">Word in abstract, title or keyword / subject heading</p> <p style="text-align: center;">Using OR</p>	<p style="text-align: center;">Word in abstract, title or keyword / subject heading</p> <p style="text-align: center;">Using OR</p>
<p>Boolean term</p>	<p>Learning Dis*</p> <p>Intellectual* Dis*</p> <p>Mental retar*</p> <p>Down* Syndrome</p> <p>Angelman Syndrome</p> <p>Williams syndrome</p> <p>Fragile X</p> <p>Cerebral Palsy</p> <p>Global development* delay</p> <p>Foetal Alcohol spectrum / FASD</p> <p>Development* dis*</p>	<p>Sleep</p> <p>Insomnia</p> <p>Chrono* (for terms such as chronobiology /chronotype)</p> <p>Circadian</p>

CAT - ID

Reference:				
Appraisal question	Yes / robust evidence	Can't tell / partial	No / weak evidence	Evidence
Does the study address a clearly focussed question?				Consider – was the aim and research questions clearly stated
Is the research design / method appropriate for answering the research question?				Consider – would a different method / design be more suitable for the sample selected.
What was the PPI in the development of the research study and involved in checking results for credibility (accuracy and resonance)?				Consider - was people with Intellectual disabilities, families and carers involved in the development of the study, tools used for data collection and for checking accuracy of results and interpretations.
Are the participants representative with regards to the population to which the findings will be referred? Consider: were the eligibility criteria stated and appropriate? Did the study have sufficient power / reach saturation?				Consider - power calculation stated, exclusion and inclusion criteria did not exclude large portions of individuals due to behaviours, abilities or attendance at local services unless these demographics were relevant to the research question.
Is there evidence of selection / participation bias?				Consider - was the approach to recruitment of the sample appropriate? To enable a diverse range of abilities, socio-demographic groups and those with limited previous engagement in

				services to be considered. How many people declined to participate?
Has the sample been adequately defined in line with the World Health Organisation's (2010) definition of Intellectual Disability?				Consider - was functional ability considered.
Is the setting representative of that of the wider population of people with an intellectual disability?				Consider - Were the cases collected in more than one centre / setting?
Was the intervention of interest clearly described and reproducible?				Consider - Was the intervention administered as intended? Were additional intervention possible co-founders to the phenomenon of interest?
Are the methods for collecting data clearly described, accurate, validated and a reliable measure?				Consider - Are quality control measures used? Was the measurements subjective or objective? Is the current gold standard approach used / has the measurement been validated for people with an intellectual disability?
Is there researcher bias / influence due to additional roles held within the setting by the researchers?				Consider - does their role influence either the research process or findings? If the authors would have pursued the research if no difference was found.
Does the study provide plausible explanations of any variability in the data?				Consider - Are confounding factors acknowledged and minimised?

Was compliance with the intervention reported and reliable?				Consider feasibility and acceptability of the intervention.
Was the follow-up long enough? Were individuals lost to follow-up?				Consider – was wider literature on long-term success of intervention used to determine follow-up required.
Has there been a comprehensive attempt to record all adverse events that may be a consequence of the intervention?				Consider if adverse events are not reported what adverse events are reported in the wider literature?
Is the analysis rigorous?				Consider was analysis repeated by more than one researcher to ensure reliability? Was unplanned retrospective analysis completed?
Have ethical considerations been considered?				Consider consent, capacity, coercion, (self-) advocacy, beneficence
Bradford Hills criteria				Consider biological plausibility, consistency, mechanistic explanations
How are the results relevant to practice / the research question proposed?				
Are the results transferable / generalisable to other settings?				Consider home, hospital, day services, residential with and with out nursing support.

Table 2: **Summary of Findings.**

Authors and date published	Study type / methodology	Sample (n= *) and Location	Variables	Outcome / Findings related to sleep
Durand, B. (1975)	Case study.	5-year-old boy with Down's syndrome and failure to thrive fed on whole milk and instant breakfast milk. USA	Monitored sleep as well as caloric intake, height / weight and behaviour.	An increase in height, weight, sleep duration of 33 minutes per period and a more consistent period and a more consistent reduction in caloric intake re
Danford, D. and Huber, A. (1981).	Observational study.	Institutionalised individuals aged 11-88 years (n=991). USA	Surveyed for eating dysfunction, medical records used to collect data on demographics, ID, medication and sleep.	Sleep disturbance correlated with aerophagia, hyperphagia (ex
Searle, G. (1994)	Non-randomised before and after trial.	Institutionalised adults (n=14). UK	4 weeks caffeine-controlled diet and 2 weeks either side for control. Sleep log completed by nursing staff	No significant changes to sleep latency.

Cocchi, R. (1996)	Retrospective case study	Mosaic Down's syndrome (n=16). Italy	Review of case notes for food habits and sleep problems	4 individuals had sleep difficulties. These food preferences were noted. None refused food groups. One had a preference for milk. One of the children had a preference for breakfast; 2 had an increased preference for sweet foods and the other had a preference for milk. All had an unknown preference for broth.
Bedell, L. (2008)	Case study	7-year-old female from Washington, with ID and ADHD studied over 8 weeks.	Chiropractor completed torque release technique and began taking fish oil-based supplements and mother given dietary advice to take protein powder smoothies.	Mother reported sleep pattern improved from 3/10 to 5/10 from the beginning to the end of the case review.
MacQuarrie, J. (2009).	Cross sectional survey design.	Parents of children aged 5-11 years with ASD or DS who currently had difficulty getting to sleep or staying asleep (n=128). UK	The Simonds and Parraga Sleep Questionnaire, demographics and the illness perception question. Hospital Anxiety and Depression scale and demographics.	Parents of children with DS had an agreement that sleep problems were attributed to another health condition. Parents of children with ASD had an agreement that sleep problems were attributed to personality, environment, or diet of the child.

Bird, L.M.; Tan, W.H.; Bacino, C. A.; Peters, S.U.; Skinner, S.A.; Anselm, I.; Barbieri-Welge, R.; Bauer-Carlin, A.; Gentile, J.K.; Glaze, D.G.; Horowitz, L.T.; Mohan, K.N.; Nespeca, M.P.; Sahoo, T.; Sarco, D.; Waisbren, S.E.; Beaudet, A.L. (2011)

A nonrandomized open-labelled prospective clinical trial

Children aged <5 years with Angelman syndrome (n=65), 90 participants enrolled. USA

One year of supplements containing L-5-methyltetrahydrofolate, creatine, betaine, and vitamin B12.

Adverse events leading to withdrawal included seizures in 1 person, constipation in 2 people and sleep problems in 2 people. Sleep problems did not result in withdrawal from the study. Reported in 9 participants.

No change in cognitive or language skills. Modest benefit in daily living skills in caregiver report. No change in observed skills.

Wilhite, B.; Biren, G.; Spencer, L. (2012)

Pilot intervention study

Community dwelling adults with ID and caregivers (n=16; 10 people with ID). Living in New Jersey, USA.

12-week intervention exercise sessions and nutrition consultations.

Anthropometric and physiological markers, fitness assessment, interviews and written program evaluations

Self-reported better sleep patterns, alertness and overall well-being. Better.

Total cholesterol and resting heart rate significantly improved.

Faleiros-Castro, F.; de Paula, E., Dias R. (2013).	Prospective comparative study (pre, post-study design)	Individuals with cerebral palsy (n=50) aged between 1 and 21 years. 96% had complications relating to constipation e.g., flatulence, rectal bleeding, pain. 94% had low intake of fluids. Portugal.	Encouraged to eat laxative foods, increase fluids, have intestinal massage and withhold laxatives until no bowel movement for 3 days when able to give suppository to re-educate the intestine.	Complications reported by caregivers included altered sleep which decreased from 44% pre-test to 4% post-intervention. Irritability, reduced appetite and other complications related to constipation were significantly reduced. Fruits had the greatest impact on constipation followed by water, leafy vegetables, synergistic effects. 78% reported increasing water intake, 78% increased laxative fruit, 76% increased vegetables and 84% increased oils.
Valicenti-McDermott, M.; Burrows, B.; Bernstein, L.; Hottinger, K.; Lawson, K.; Seijo, R.; Schechtman, M.; Shulman, L.; Shinnar, S. (2014)	Cross sectional study	Sample consisted of 50 people with ASD and comparator group of people with intellectual disabilities who were matched for age and gender. Aged between 2-18 years. Living in New York, USA.	Structured interview and questionnaire. Parental reports on use of complimentary and alternative medicine and demographics, food allergies, gastrointestinal problems, behavioural and sleep problems.	42% of the ASD group had used supplements compared to 22% with ID. A further 26% had tried casein free diet and 10% herbal supplements. 0% and 4% in the ID group.
Evans, S. (2015)	Mixed method study	Responses from caregivers (n=74) and focus group with healthcare professionals (n=26) who	Children's Eating Behavior Questionnaire and the Child Behavior Checklist 1.5-5.	More food fussiness in individuals with sleep problems.

		had experience of supporting children with FASD. USA	Focus group discussion regarding eating behaviours of children with FASD.	Qualitative analysis revealed “the importance of nutrition of atypical eating behaviours occurring diagnosis with and medications ... sleep disturba
Pallangyo,P. ; Lyimo, F.; Nicholaus, P.; Makungu, H.; Mtolera, M.; Mawenya, I. (2016).	Case study	1 year old boy with semilobar holoprosencephaly and type 1 diabetes and iron deficiency anaemia and erratic sleep patterns. In Tanzania, East Africa.	Hemovit syrup 10 ml thrice daily, ferrous sulfate 10 mg once daily, folic acid 1 mg once daily, and multivitamin syrup 5 ml once daily. Nutritional counselling given to parents. Re-assessed at 12-month follow-up.	Healthcare professionals reported when the child was getting er sleep life was better for the v Sleep pattern was stable, imp noted in neurocognitive statu
Barnhill, K.; Devlin, M.; Moreno, H. T.; Potts, A.; Richardson,W. ; Schutte, C.; Hewitson, L. (2018).	Longitudinal case study	4-year-old boy with Fragile X, ASD and gastrointestinal problems. USA	Specific carbohydrate diet for 4 months. Child sleep history questionnaire, food diary and anthropometrics, as well as behavioural, gastrointestinal and biochemical measures.	Improvement in growth statu gastrointestinal symptoms ar Reduced daytime sleepiness increases in sleep anxiety, be resistance and sleep duration

Wang, J.; Gao, Y.; Kwok, H.H. M.;
Huang, W.Y. J.; Li, S.Li, L.2018).

Cross sectional study.

(n=524) Children (mean age 12.2 years) with ID
in Hong Kong

Parents completed questionnaire about

Physical Activity,

Eating habits

Sleep duration

Parenting practices

Sociodemographic

Finding sleep duration under
day increased the relative risk
overweight and obesity as
did increased sedentary beha
PA. Children who had higher
of meats, fish, eggs, fried foo
beverages were more vulnera
overweight / obese. Sleep ov
day used as reference (1.00)
obesity found at 2.16 (1.13-4
8 hours sleep.