Sleep and Sleep-wake rhythm
in older adults with intellectual disabilities

Ellen van de Wouw - van Dijk

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Chapter 1

General Introduction

Everyone who has experienced poor sleep knows how it affects daytime functioning and wellbeing. A good night's rest and a stable sleep-wake rhythm are therefore very important. The sleep-wake rhythm is regulated by several brain structures. People with an intellectual disability (ID) all have some form of brain dysfunction, and might therefore be at risk for sleep disturbances.[1-2] During the process of ageing, brain structures that are important in regulating the sleep-wake rhythm show functional deterioration,[3] resulting in for example waking up too early in the morning and daytime sleepiness. Also, the architecture of night sleep changes, leading to a decreased ability to initiate and maintain sleep.[4]

As a result of a combination of pre-existent brain damage and the age-related changes, older adults with ID might be extra vulnerable to develop sleep-wake rhythm disturbances. Until now no epidemiological research has been performed on this topic in this population. Because life expectancy nowadays has increased in people with ID, knowledge about night sleep and the sleep-wake rhythm is of importance for optimal care in this population. Also, for both epidemiological research and individual diagnostics of sleep problems, an objective tool to investigate sleep that is suitable for older adults with ID, is needed.

In this chapter, after some background information on intellectual disability, sleep regulation and ageing, we will introduce the Healthy Ageing and Intellectual Disabilities study and the selected method to investigate sleep and the sleep-wake rhythm in that study, followed by the aims and outline of this thesis.

INTELLECTUAL DISABILITY

Intellectual disability (ID) is characterized by significant limitations both in intellectual functioning (IQ<75) and in adaptive behaviour, which covers many everyday social and practical skills, and this disability originates before the age of 18 (definition according to the American Association on Intellectual and Developmental Disabilities). The main etiological factors involved are chromosomal or genetic disorders (e.g. Down syndrome), perinatal problems (e.g. hypoxia or prematurity), an acquired condition in early childhood (e.g. trauma or infection), or a combination of these factors.

SLEEP REGULATION AND AGEING

Sleep is a complex physiological state, which is characterized by reduced consciousness, decreased sensory activity, and inactivity of nearly all voluntary muscles.[5] Generally, sleep is considered as a period of rest and recovery.[6] Sleep and wake alternate

rhythmically. This sleep-wake rhythm is a circadian biological rhythm with a duration of around 24 hours,[7] it is regulated by the 'circadian pacemaker' that is located in the suprachiasmatic nucleus (SCN), a small group of cells in the hypothalamus of the brain. [8] This circadian pacemaker is adjusted to the local environment with external cues, so-called 'Zeitgebers'. The most important Zeitgeber is daylight, which reaches the SCN through the eyes and optical nerves. Besides regulation by the circadian pacemaker, several structures in the brainstem, hypothalamus and basal forebrain are involved in sleep and arousal.[9]

When looking at night sleep specifically, several sleep stages can be identified. This so-called sleep architecture represents the structure of night sleep, and can be categorized as rapid eye movement (REM) and non-rapid eye movement (NREM) sleep. REM sleep is characterized by rapid movements of the eye muscles, and is also called 'dream sleep'. NREM sleep can be divided in four stages (N1, N2, N3 and N4), of which N1 and N2 are referred to as 'light sleep' and stage N3 and N4 are referred to as 'deep sleep' or 'restorative sleep'.[4, 10] Usually, sleep stages follow each other in 90 to 120 minute cycles, with four to five cycles during the night [10]. In this thesis on older adults with ID, the sleep-wake rhythm and night sleep specifically are both topic of research. For the benefit of readability of this Chapter, we will use the term 'sleep-wake pattern' to cover both terms.

Ageing induces a functional deterioration of several brain systems, including the SCN.[3, 11] As a result, sleep-wake patterns often become more fragmented in older adults.[12] Also changes in night sleep architecture occur: the sleep stages representing 'light sleep' increase in duration (N1 and N2), whereas REM sleep and 'deep sleep' decrease.[13] As a result, older adults experience difficulties falling asleep, wake up easily during the night,[4] and total sleep time and sleep efficiency (ratio of time spent asleep and time spent in bed) both decrease.[13] Besides functional decline of relevant brain structures, sleep difficulties in older adults may be secondary to effects in the brain of Alzheimer dementia and Parkinson's disease, or caused by disease symptoms hampering night-rest, for example pain and dyspnea.[14-16] It is therefore not surprising that sleep difficulties are common in older adults.[17-21] The National Sleep Foundation interviewed 1506 persons aged 55 years and older, and found that 67% of the participants reported one or more symptoms of sleep difficulties (for example difficulties falling asleep, waking up too early, waking up feeling not refreshed or snoring) at least a few nights a week.[22] Several epidemiological studies have reported associations between sleep difficulties and poorer quality of life, cognitive decline, depression, dependency in basic activities of daily living and the necessity of placement in a home for the elderly.[16] On the other hand, long sleep time is also associated with negative health outcomes in older adults, like poor self-rated health and quality of life,[23] high cholesterol levels,[24] and depression and anxiety disorders.[25] Accord-

ing to a meta-analysis by Cuppoccio et al., both short and long sleep duration are significant predictors of mortality.[26]

Sleep in older adults in the general population is a frequent topic of research. In older adults with ID, only few studies that focused on dementia involved some information about sleep disturbances.[27-29] Otherwise, knowledge about sleep-wake patterns in older adults in this population is lacking. In the population with ID life expectancy has increased as a result of improved care. Ageing in those with a mild ID is now similar to that in the general population,[30] and many persons with severe ID reach the age of 50 years and higher. Compared to the general population, health problems like epilepsy, musculoskeletal disability, vision and hearing problems are frequently present from a young age in people with ID.[31] With ageing, these health problems can be accompanied by similar age-related co-morbid conditions like in the general older population. Due to the combination of changes in the sleep-wake pattern with ageing, pre-existent brain damage, and the presence of more co-morbid conditions, older adults with ID might be extra vulnerable to sleep problems. Accordingly, we wondered how often sleep problems occur, and which specific factors influence sleep and the sleep-wake rhythm in this population.

THE HEALTHY AGEING AND INTELLECTUAL DISABILITIES (HA-ID) STUDY

Information about sleep-wake patterns was collected in the 'Healthy Ageing and Intellectual Disabilities' (HA-ID) study – a large cross-sectional epidemiological study, addressing many aspects of health in older adults (50 years and older) with intellectual disabilities in the Netherlands. Subthemes were physical activity and fitness, nutrition and nutritional state, and depression and anxiety. The general aims of the HA-ID study were to perform assessments of prevalence rates and secondary health effects for each subtheme, to identify risk groups, and to select and evaluate diagnostic tools to assess health problems in this population.[32] The study on sleep-wake patterns is part of the subtheme physical activity and fitness. The study consort consists of three care provider services for people with ID (Abrona, Amarant and Ipse de Bruggen), and the department of Intellectual Disability Medicine of Erasmus Medical Center Rotterdam. For the activity and fitness theme there was a collaboration with the Center of Human Movement Sciences of Groningen University, the Netherlands. At the start of the study in 2008, the consort provided support or care for 2322 clients aged 50 years and over, which was 10% of the total Dutch client population aged 50 years and over of formal ID services.[33] In total, 1050 clients participated in the HA-ID study. Data collection was performed in 2009 and 2010. Measurements in the study involved, among other things, physical examination, laboratory assessment, fitness tests, swallowing obser-

vations, physical activity assessment using pedometers, and depression and anxiety screening. For individual participants all measurements were performed on-site in a period of two weeks. Detailed information about recruitment and design of the HA-ID study has been described by Hilgenkamp et al. (2011) (Appendix I).

SELECTING A TOOL TO INVESTIGATE SLEEP

For people with ID it is often difficult or not possible to explain their personal sleep preferences. Daily practice around sleeping and waking, e.g. helping more severely disabled clients to bed, is often based on the interpretation of the professional caregivers and their working schedule. Although professional caregivers know their clients very well, they are mostly not close to them during the night. A questionnaire survey about sleep patterns of the client, e.g. in the past week, might therefore be influenced by recall bias, and caregivers might tend to only report sleep difficulties that disturb the environment [34-35] and not difficulties that may be experienced by clients themselves. Another method used to investigate sleep in people with ID is with direct sleep observation, for example by routine checks every 30 minutes.[36-39] This is more reliable than a history questionnaire survey; however it can be hard to see if somebody is asleep, and this observation method might disturb sleep as well. The same applies for video observations, which also violate the clients' privacy. Moreover, video observations are very time consuming and may not be feasible in clinical practice or epidemiological research.

Therefore, in the HA-ID study we aimed to objectively study the sleep-wake pattern with a valid method causing minimal burden for participants and caregivers. With regard to the general aims of the HA-ID study, a tool that was suitable for large-scale epidemiological research but also for individual diagnostics of sleep problems, needed to be selected.

The gold standard to investigate sleep is polysomnography (PSG), which involves an electroencephalogram to measure brain activity.[10] PSG provides detailed information about sleep architecture, but it requires complex recording equipment. This is too burdensome for many people with ID, as well as expensive, and is therefore not suitable for large-scale epidemiological research in this population. A less complicated objective method is actigraphy. Actigraphy is increasingly used in sleep research,[40] and this method is suitable to investigate the sleep-wake pattern based on measurement of movement activity.[41] The type of actigraph that was used in the HA-ID study was the Actiwatch AW7 (Cambridge Neurotechnologies). Like the name suggests, the Actiwatch is a watch-like device that measures activity by means of a piezoelectric accelerometer that records the combination of intensity, amount and duration of move-

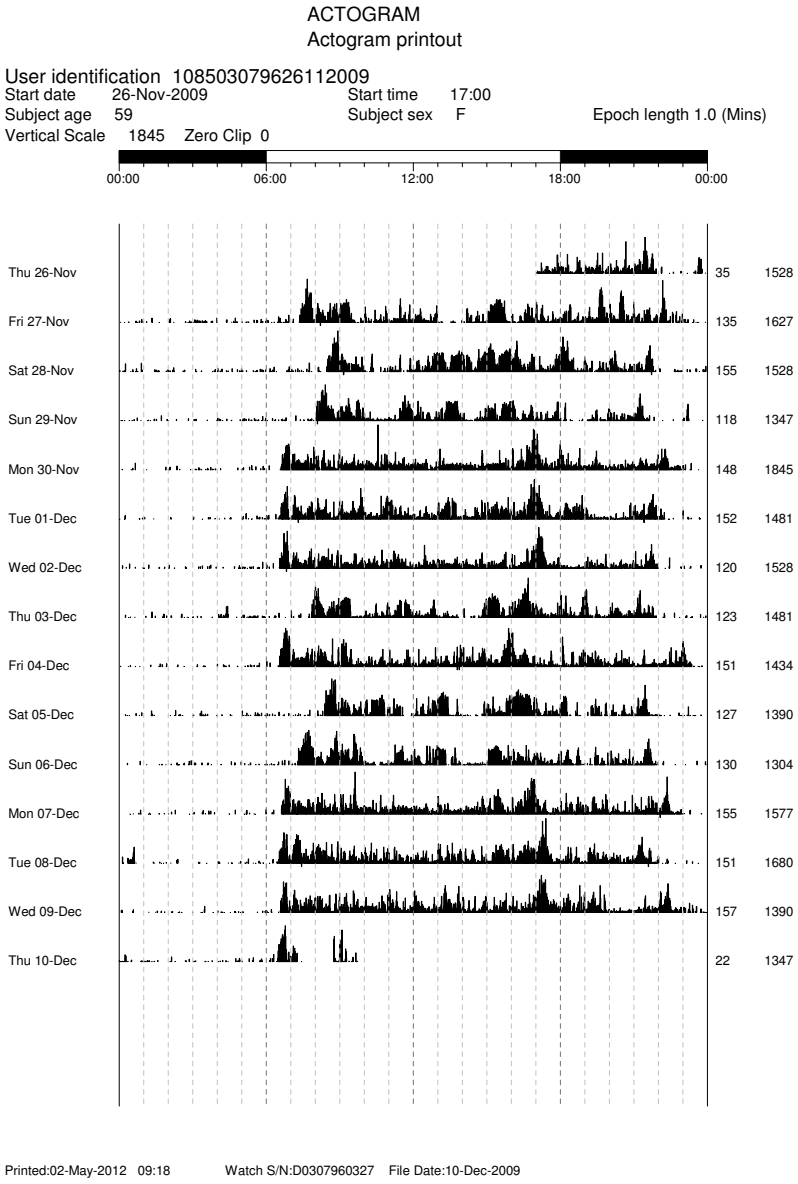

Figure 1 Actogram

The actogram is a visual display of all movement activity during day and night. This actogram shows no abnormalities during the night specifically (i.e. little movement activity) nor in the sleep-wake rhythm (i.e. activity is clustered during the day and inactivity is clustered in the night, and there is little variability between days)

ment.[42] This type was selected because of its excellent interunit reliability (i.e. when worn at the same body site) and good criterion validity,[43] and its software enables separate analysis options for sleep and sleep-wake rhythm parameters. Sleep parameters often used in sleep research are sleep onset latency (time to fall asleep), total sleep time, wake after sleep onset (wake time during the night) and sleep efficiency. Sleep-wake rhythm parameters that can be calculated with the Actiwatch software are among other things interdaily stability (measure of stability of the sleep-wake rhythm over days) and intradaily variability (measure of fragmentation of the sleep-wake rhythm). The Actiwatch has also been used in research in older adults in the general Dutch population,[44-45] enabling comparison between older adults with ID and the general population. A measurement of at least seven nights is necessary to gain reliable outcomes of both sleep parameters and sleep-wake rhythm parameters.[46-47] In order to gain sufficient data, participants were instructed to wear the Actiwatch for 14 days and nights continuously.

Besides quantitative information on these night sleep and sleep-wake rhythm parameters, an actogram is provided: a visual display of all movement activity during day and night (Figure 1). The actogram is particularly useful for the individual assessment of sleep problems and sleep-wake disturbances in clinical practice. The Actiwatch is small, it enables a multi-night measurement and can be easily applied in the home environment. These properties make the Actiwatch a suitable instrument for people with ID, both in large-scale epidemiological research and clinical practice.

STUDY AIMS AND OUTLINE OF THIS THESIS

The main aims of this study were: 1. To assess the validity of actigraphy in older adults with ID, 2. To determine the prevalence of sleep problems measured with actigraphy, and 3. To determine which factors are associated with sleep parameters and the sleep-wake rhythm in this population.

First, a systematic literature review (*Chapter 2*) was performed to provide an overview of available information on sleep problems in adults and older people with ID, and to explore which measurement methods and definitions for sleep problems have been previously used in research in this population.

Because it appeared that the Actiwatch had not been previously applied in large-scale epidemiologic research in people with ID, questions concerning its feasibility and validity are addressed in Chapters 3 to 5. In *Chapter 3* these questions are formulated, based on data collected in the first year of the HA-ID study. To establish which sensitivity setting of the Actiwatch is most valid for older adults with ID, Actiwatch outcomes

were compared to polysomnography in a small study sample. *Chapter 4* covers the data that were collected during nighttime, involving the question which sensitivity setting can be used best to detect sleep disturbance in older adults with ID. In *Chapter 5*, we describe how well the Actiwatch classifies sleep and wake during daytime.

Chapter 6 describes the circadian sleep-wake rhythm in older adults with ID, and a comparison to the sleep-wake rhythm in older adults in the general population is reported. Factors that are independently associated with the sleep-wake rhythm of older adults with ID are described.

In *Chapter 7* we focus on night sleep parameters. We outline the distribution of sleep parameters and on factors that are independently associated with these sleep parameters, and we present the prevalence of objectively measured sleep problems in older adults with ID.

For participants in the HA-ID study who were capable of self-report, their answers to questions involving sleep were compared to their Actiwatch data (*Chapter 8*). This chapter also describes information that was available on sleep problems in caregiver records, which we compared to the sleep problems that were actually found with actigraphy.

Finally, *Chapter 9* is an overview of the main findings of this thesis. Implications for further research and clinical practice are discussed.

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Chapter 2

Prevalence, associated factors and treatment of sleep problems in adults with intellectual disabilities: a systematic review

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ABSTRACT

In people with intellectual disability (ID), impaired sleep is common. Life expectancy has increased in this group, and it is known that in general population sleep deteriorates with ageing. Therefore the aims of this systematic review were to examine how sleep problems are defined in research among adults and older people with ID, and to collect information on the prevalence, associated factors and treatment for sleep problems in this population. PubMed, EMBase, PsycINFO and Web of Science were searched for studies published between January 1990 and August 2011. All empirical studies covering sleep problems in adults with ID were included, and assessed on quality (level of evidence), using a slightly modified version of the SIGN-50 methodology checklist for cohort studies. Of 50 studies that were included for systematic review, one was of high quality, 14 were well conducted, 14 were well conducted but with a high risk of bias, and 21 were non-analytical. The reported estimated prevalence rates of sleep problems in adults with ID ranged from 8.5% to 34.1%. A prevalence of 9.2% was reported for significant sleep problems. Sleep problems were associated with the following factors: challenging behaviour; respiratory disease; visual impairment; psychiatric conditions; and using psychotropic, antiepileptic and/or antidepressant medication. Little information was found on older people specifically. Two studies reported treatment effects on sleep problems in larger populations; their findings suggest that non-pharmaceutical interventions are beneficial. Research on the prevalence, associated factors and treatment of sleep problems in adults and older people with ID has mainly focused on subjectively derived data. The definitions used to describe a sleep problem are not uniform, and associations are mainly described as correlations. In order to give recommendations for clinical practice further research is needed, involving objective measurements and multivariate analysis.

INTRODUCTION

Sleep problems are common in the ageing general population. Foley et al. (1995) interviewed 9.282 community-living persons aged 65 years and over and reported that 43% experience difficulties initiating or maintaining sleep.[1] Meta-analyses of the change in sleep patterns during the lifespan demonstrate an increase in sleep latency and night waking frequency, and a decrease in total sleep time and sleep efficiency (ratio of time spent asleep to the amount of time spent in bed) with ageing.[2-3] Symptoms of insomnia can lead to poorer quality of life, cognitive decline, depression, disability in instrumental activities of daily living (ADLs) and institutionalization.[4] In contrast, a cohort study of 3.820 persons aged 60 years and over showed that self-reported long sleep duration was associated with higher mortality rates, even in those with better health status.[5]

For people with intellectual disability (ID), previous reviews on sleep problems indicate that disruptions of sleep and sleep-wake rhythms are common,[6] and the prevalence of sleep problems is higher than in the general population.[7] The estimated prevalence of sleep problems in people with ID varies from 13% to 86%, depending on the age of the studied participants, used diagnostic method and definitions used for a sleep problem.[8] Although these reviews are valuable, they were not done systematically and cover both children and adults.[7-8]

A criterion to diagnose a sleep problem is that the individual experiences his sleep quality as a burden.[9] However, for people with ID it is often hard to communicate their personal sleep experience, and professional caregivers may selectively report problems that disturb themselves or other clients.[10] This may complicate the detection and subsequent treatment of sleep problems. People with ID nowadays live longer than previously expected, and ageing in people with a mild level of ID is even similar to that in the general population.[11] Accordingly, a better insight into sleep problems in adults and older people with ID is first important for optimal care, and second important for working towards a unified and broadly accepted definition for sleep problems in this population.

Therefore, the aim of this systematic review is first to examine how sleep problems are defined in research among this population. Secondly we aim to give an overview of existing literature on sleep problems in adults and older people with ID, in order to investigate the prevalence rate, associated factors (e.g. personal characteristics, medical history) and treatment of sleep problems, taking methodological quality into account.

METHODS

Search strategy

A systematic literature search was conducted using the electronic databases Medline/PubMed, EMBase, PsycINFO and Web of Science. We selected various different search terms, in order to reduce the chance of missing important information.

Terms for intellectual disability were: mental retardation, intellectual disability, intellectually retarded, intellectually disabled, mental disability, mentally disabled, idiocy, mental deficiency, learning disability, learning disorder, learning disturbance, developmental disability, mental handicap, mentally handicap, intellectual handicap, intellectually handicap, Down syndrome, mental incapacity, intellectual incapacity and oligophrenia.

Terms for sleep problems were: sleep, sleep disorder, insomnia, dyssomnia, parasomnias, somnolence and hypersomnia. Terms for (older) adults were: adult, middle aged, aging, ageing, elderly, geriatric, old and senior.

Terms for intellectual disability, sleep problems and adults were all combined in the search.

The database-specific search codes used are shown the Appendix.

Selection criteria

We considered all empirical/observational studies with at least 10 participants, case reports and case-series published between January 1990 and August 2011 in the English or Dutch language. Case reports and case series were only included if an intervention on a sleep problem was described. Studies that were not available through medical libraries in the Netherlands were excluded.

Participants had to be adults (mentioned as adults in the paper, otherwise age 18+) with ID (mentioned as ID in the paper). In case of studies involving both children and adults, information on sleep for adult participants had to be separately reported in the text or a table/figure (at least 10 adults). The research question had to cover disrupted sleep patterns/sleep problems, or disrupted sleep patterns/sleep problems had to be reported in the results section. In addition, 'daytime sleepiness' and 'decreased need for sleep' were considered as a sleep problem. Studies that described the sleep pattern, but no association with sleep problems, were excluded.

Selection process

The selection process was carried out by the first author. After the electronic database search, title and abstract of all obtained articles were screened using the selection criteria. Of articles that could not be excluded based on title and/or abstract, the full-text was screened. Of articles that met the selection criteria, the bibliographies were

checked for studies that seemed relevant to answer one of the research questions. Of those additional studies that seemed relevant, the full-text was screened as well.

Data extraction and management

Of all studies that met the selection criteria, the following information was noted by the first author (if provided):

1. Study design, number of participants and study population (representative: participants are representative for the population of people with ID; referred: specific group or participants referred to specialized team for sleep problems; or residential: participants from residential living facility for people with ID)
2. Participant characteristics (age, sex and level of ID)
3. Method of sleep assessment, type of sleep problem or sleep characteristics
4. Factors associated with sleep problems, along with their main results
5. The definition of a sleep problem (other than a positive item score on a general questionnaire)
6. Prevalence rates of sleep problems, prevalence rates in older people (if mentioned separately)
7. Treatment of sleep problems (description of sleep problem, characteristics of intervention and follow-up)

Factors associated to sleep problems were listed. Any factor was considered associated to a sleep problem as it was investigated or mentioned in the selected studies and presented in the results in terms of numbers or statistics, indicating an association with sleep problems. The listed associated factors were categorized as 'general characteristics (age, gender and level of ID)', 'challenging behaviour', 'autism spectrum disorder (ASD)', 'dementia', 'medication use', 'caffeine intake', 'physical conditions', 'psychiatric conditions' and 'other associated factors'.

Quality assessment

The methodological quality of each included study was assessed using the SIGN-50 methodology checklist (SIGN, Scottish Intercollegiate Guidelines Network)[12] for cohort studies as a guideline for quality assessment (level of evidence, LE). The checklist was slightly modified to enable quality assessment of cross-sectional studies on sleep problems. As the SIGN criteria do not include cross-sectional studies, we followed De Winter et al. (2011), who recommended to score LE3 (non-analytical studies) for cross-sectional studies without any statistical analysis, and LE2 (case-control and cohort studies) for cross-sectional studies with statistical analysis (Table 1).[13] Each article was assessed twice: EvdW assessed all included studies; the second assessment of the studies was performed by MAE and a medical student. When consensus was

Table 1 Levels of evidence (LE) according to the SIGN criteria (SIGN, Scottish Intercollegiate Guidelines Network)

1++	High-quality meta-analyses Systematic reviews or randomised controlled trials (RCTs) or RCTs with a very low risk of bias
1+	Well-conducted meta-analyses Systematic reviews or RCTs with a low risk of bias
1-	Meta-analyses Systematic reviews or RCTs with a high risk of bias
2++	High-quality systematic reviews or case–control or cohort studies High-quality case-control or cohort studies with a very low risk of confounding or bias and a high probability that the relationship is causal High-quality cross-sectional studies with statistical analysis and very low risk of bias *
2+	Well-conducted case-control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal Well-conducted cross-sectional studies with statistical analysis and low risk of bias *
2-	Case-control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal Cross-sectional studies with statistical analysis and a high risk of bias *
3	Non-analytical studies, e.g. case reports, case series Cross-sectional studies without any statistical analysis *
4	Expert opinion

* Added by de Winter et al. (de Winter, et al., 2011)

not reached, LE was discussed per included study. If no consensus could be achieved, a fourth researcher made the final decision. In case sleep problems were a secondary topic of the included study, the quality assessment was limited to the parts of the study that were relevant to sleep problems.

Results from studies with high-quality (LE 2++) or low risk of bias (LE 2+) were valued most, whereas results from other studies were considered as background information. Studies with a high risk of bias (LE 2-) and case reports (LE 3) were included in this systematic review in order to provide a complete overview of available information on sleep problems in adults and older people with ID.

RESULTS

The initial search resulted in 1217 studies. Finally, fifty studies met the inclusion criteria.

Figure 1 shows the flow chart of data selection. Searching the bibliographies of included studies did not result in additional relevant references that met the selection criteria.

Fifty studies were included for the systematic review. Two studies described the same study population.[10, 14] In six studies a clear definition of a sleep problem in the studied population was described. Seventeen studies described a prevalence of sleep problems and 28 studies described one or more associated factors (eight studies described both a prevalence rate and associated factors). Of 13 studies that described the treatment of sleep problems, most were case-reports (one study described both a prevalence rate and the treatment of sleep problems). In 28 studies sleep problems were addressed as a primary topic and 46 studies exclusively concerned adults. All studies providing

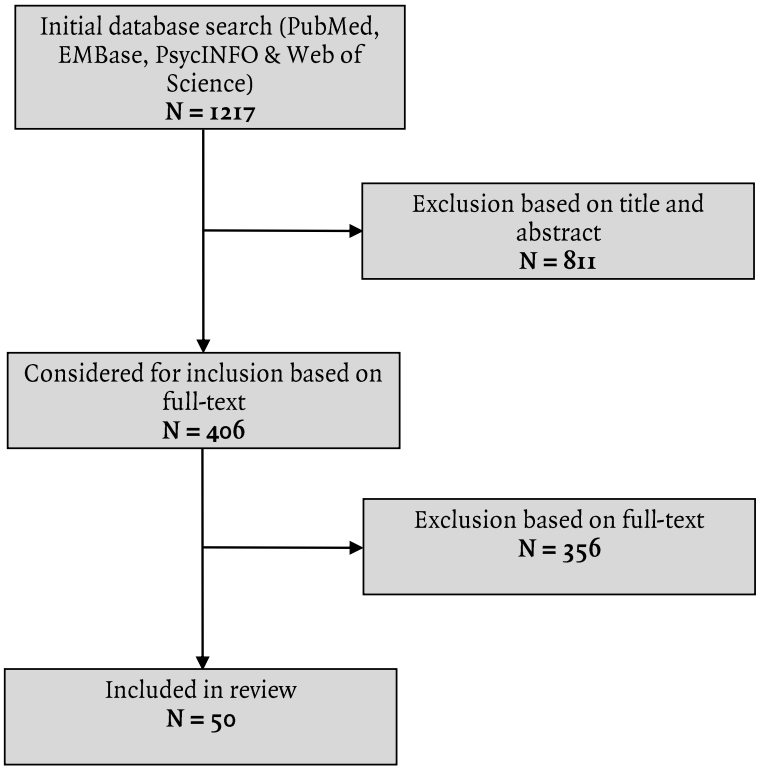

Figure 1 Flow-chart data selection

data on the prevalence and associated factors had a cross-sectional design, except for Searle (1994), which was an intervention study.[15]

Characteristics, results and LE of studies that report prevalence rates of sleep problems are displayed in Table 2, of studies reporting associated factors of sleep problems are described in Table 3, and of studies reporting treatment of sleep problems in Table 4. The tables show that, next to questionnaire surveys (n=28), the following diagnostic methods were used: polysomnography (n=2), actigraphy (n=3), sleep observations (n=9), and retrospective file review (n=5). In three case-reports, the method to examine sleep was not described. Various synonyms were used to specify a sleep problem, which are described in the column 'type of sleep problem / sleep variable' in Table 3.

Concerning level of evidence, one study was a high-quality study (LE 2++), 14 were well conducted (low risk of bias, LE 2+), 14 had a high risk of bias (LE 2-) and 21 were non-analytical (LE 3).

Definitions of sleep problems

Six of the included studies used a clear definition to define a sleep problem (other than a positive item score on a general questionnaire) of which one was of high-quality, four were well conducted and one had a high risk of bias. Although various synonyms were used, sleep problems were mainly defined as 'settling problem, night waking problem and early waking problem' (or a similar description). Boyle et al. (high quality) based their definition on the Schedules for Clinical Assessment in Neuropsychiatry (SCAN) and Psychiatric Assessment Scale for Adults with Developmental Disabilities (PAS-ADD) questionnaire,[16] and a definition for sleep problems by Gunning & Espie (low risk of bias) was based on the International Classification of Sleep Disorders.[17] Brylewski & Wiggs and Maas et al. used previously determined research criteria (low risk of bias).[14, 18] Espie & Tweedie (1991) used a sleep efficiency lower than 85% to define a sleep problem. This value was based on previous polysomnographic research in patients with insomnia (low risk of bias).[19] Harvey et al. did not mention a reference to validate their choice for the definitions used for sleep problems (high risk of bias).[20] The definitions of sleep problems are described in Table 2.

Prevalence of sleep problems

In 17 studies the prevalence of sleep problems in adults with ID was addressed. They were all cross-sectional, and all based on questionnaires that were completed by caregivers or family members. In two studies the participant was interviewed together with the caregiver, if possible.[16, 18] Characteristics of the studies and the reported prevalence rates of sleep problems are displayed in Table 2. In 11 studies (marked with an asterisk in the table), the prevalence was investigated in specific populations.[18, 21-30] Of these studies, three were well-conducted, one had a high risk of bias and six

Table 2 Prevalence of sleep problems and definitions of sleep problems

Study	N	Participant characteristics (level of ID/specific group and age)	Study population	Assessment of sleep	Prevalence of sleep problem	Definition of sleep problem (if provided)	LE
Boyle et al. (2010)	1023	All levels of ID[1] 51.8% <45 years 48.2% >45 years	Representative	Questionnaire survey (PAS-ADD[2] interview)	Overall sample 8.5% delay falling asleep 9.9% waking too early 12.0% broken sleep 9.2% significant sleep problem >45 years (n=493) 7.5% delay falling asleep 10.5% waking too early 11.6% broken sleep 8.7% significant sleep problem	Occurred at least once in the past four weeks: - initial insomnia: at least 1 h - waking too early: at least 1 h before usual get-up time (and unable to sleep again) - broken sleep: waking up for 1 h or more before falling back asleep Significant problem: at least one sleep problem which was severe, or at least two sleep problems	2++
Brylewski & Wiggs (1998) #	205	All levels of ID Mean age 46.8 years (range 21 – 83)	Representative	Questionnaire survey (developed by Simonds & Parraga)	26.8% settling problems 34.1% night waking problems 14% parasomnias 34.6% excessive daytime sleepiness		2+

Table 2 Prevalence of sleep problems and definitions of sleep problems *(continued)*

Study	N	Participant characteristics (level of ID/specific group and age)	Study population	Assessment of sleep	Prevalence of sleep problem	Definition of sleep problem (if provided)	LE
Brylewski & Wiggs (1999) #	205	All levels of ID Mean age 46.8 years (range 21 – 83)	Representative	Questionnaire survey (developed by Simonds & Parraga)	97 (47.3%) subjects with sleep problem (settling, night waking or both)	Over the previous month: Settling problem: occurrence several times per week or nightly, and the individual takes more than 1 h to settle and fall asleep Night waking problem: occurrence several times per week or nightly, and if the individual either (a) woke once, but for more than a few minutes; or (b) woke more than once, but re-settled within a few minutes	2+
Cooper * (1997b)	134	Dementia All levels of ID Mean age dementia group 76.4 years (range 69 – 94)	Representative	Questionnaire survey (Disability Assessment Schedule, PPS-LD[3])	69.0% changed sleep pattern		3
Espie & Tweedie (1991)	120	All levels of ID Mean age 35.7 years (SD 13.7)	Representative	Questionnaire survey	15.0% sleep problem		2+
Espie *et al.* * (1998)	28	Severe and profound level of ID and epilepsy Mean age 31 years (range 16 – 51)	Referred	Questionnaire survey and EEG[4] assessment	32.0% sleep problem	Sleep Efficiency < 85%	2+

Table 2 Prevalence of sleep problems and definitions of sleep problems *(continued)*

Study	N	Participant characteristics (level of ID/specific group and age)	Study population	Assessment of sleep	Prevalence of sleep problem	Definition of sleep problem (if provided)	LE
Gunning & Espie (2003)	155	Mild, moderate and severe level of ID Mean age 32 years (SD 16.5)	Representative	Questionnaire survey (using ICSD-R criteria)	17.4% difficulty getting to sleep 11.0% difficulty staying asleep 4.5% difficulty staying awake during the day	Difficulty getting to sleep: 1h Difficulty staying asleep: 2 or more awakenings a night Difficulty staying awake during the day: actual sleep episodes during the day Had to occur three or more nights a week in order to be a problem	2+
Halbach *et al.** (2008)	53	Rett syndrome Mean age 26.9 years (range 16 – 53, SD 7.85)	Referred	Questionnaire survey (OOB[5], physical and psychiatric morbidity)	77.0% nightly unrest 51.0% prolonged wakefulness and/or early morning awakening 85.0% sleepy during the day		2-
Harvey *et al.* (2003)	237	All levels of ID Mean age 42.4 years (range 18.6 – 70.3, SD 11.1)	Representative	Questionnaire survey (telephone interview)	63.0% >30 min sleep onset 43.0% >3 nighttime awakenings 36.0% >1 hr awake at night 36.0% awake early 32.0% multiple problems	Sleep problem variables: Sleep latency >30 minutes Night wake frequency >3 times Awake during the night > 1 hour Waking early (no cut-off) Multiple sleep problems: two or more of the sleep problem variables Sleep disorders: sleep has an impact on the focus person's life	2-
Hiraiwa *et al.** (2007)	165 (29 adults)	Prader-Willi syndrome Range 18 – 31 years	Referred	Questionnaire survey	51.7% hypersomnia		3

Table 2 Prevalence of sleep problems and definitions of sleep problems *(continued)*

Study	N	Participant characteristics (level of ID/specific group and age)	Study population	Assessment of sleep	Prevalence of sleep problem	Definition of sleep problem (if provided)	LE
Lindblom *et al.** (2006)	81 (54 adults)	Aspartylglucosaminuria Mean age 30 years (SD 10.0)	Referred	Questionnaire survey (Basic Nordic Sleep Questionnaire)	61.0% sleep related problem (settling problem, night waking problem, early waking problem, disturbing movements, snoring, daytime naps)		2+
Maas *et al.** (2010)	79	Prader-Willi syndrome Mean age 34.4 years (range 18 – 65, SD 11.8)	Referred	Questionnaire survey (semi-structured interview)	1.0% settling problem 13.0% night waking problem 4.0% early waking problem 15.0% current sleep problem	Settling problem - mild: falling asleep takes 30 min < 1 h, one or two times a week - severe: falling asleep takes more than 1 h, three or more times a week, and caregivers were disturbed during this time Night waking problem - mild: night waking occurs once or twice a week - severe: occurrence more than three times a week, individual remains awake for more than a few minutes and disturbs caregivers Early waking - mild: waking up before 5 a.m. once or twice a week - severe: waking up before 5 a.m. three or more nights a week Current sleep problem: at least one of the three types of sleep problems mentioned above both mild or severe	2+

Table 2 Prevalence of sleep problems and definitions of sleep problems *(continued)*

Study	N	Participant characteristics (level of ID/specific group and age)	Study population	Assessment of sleep	Prevalence of sleep problem	Definition of sleep problem (if provided)	LE
Matson *et al* *. (2008)	334	ASD[6] Mainly profound and severe level of ID Mean age 51.6 years (range 16 – 88)	Referred	Questionnaire survey (DASH-II[7] subscale on sleep disorders)	44.7% some degree of sleep problem		2+
Moog *et al.* * (2007)	20	Sanfillipo type B Range 18 to 57 years	Referred	Medical history	For 11 of 20 patients a sleep problem was reported in the medical file		3
Partsch *et al.* * (2000)	19	Prader-Willi syndrome Mean age 23 years (range 18 – 34 years)	Referred	Medical history	11 of 19 sleep apnoea		3
Virji-Babul *et al.* * (2007)	223 (59 adults)	Down syndrome Range 19 – 40	Referred	Questionnaire survey	19.0% sleep disorder (age 19 – 30 years) 23.0% sleep disorder (31 – 40 years)		3
Young *et al.* * (2007)	202 (56 adults)	Rett syndrome Age range 18 – 29 years	Referred	Questionnaire survey (sleep problems or specific sleep disturbances, two items from the RSBQ[8])	52.1% night laughing 30.1% night screaming 28.8% night seizures 57.5% night teeth grinding 1.9% sleep walking 16.4% sleep talking 9.6% night terrors 84.3% frequent daytime naps 29.6% spells of night screaming		3

* Studies addressing a specific population
# Both studies addressing the same study population
Studies with most reliable prevalence rates are marked in italic

[1] Intellectual Disability, [2]Psychiatric Assessment Scale for Adults with Developmental Disabilities, [3]Present Psychiatric State – Learning Disabilities, [4]Electroencephalogram [5] Observational Questionnaire Elderly Residents with ID (Observatielijst Ouderwordende Bewoners), [6] Autism Spectrum Disorder, [7]Diagnostic Assessment for the Severely Handicapped-Revised, [8]Rett Syndrome Behaviour Questionnaire

Table 3 Associated factors

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (n subgroup)	Results	LE
Biswas *et al.* (2001)	122 (not mentioned)	Mean 45 (range 25 – 76)	All	Representative	Medical history (Retrospective case-note analysis)	Decreased sleep Increased sleep	*Medication use & caffeine intake*	Of all treatment-emergent behavioural symptoms, decreased sleep occurred in 35% of cases, increased sleep in 7%	3
Boyle *et al.* (2010)	1023 (562)	Adults	All	Representative	Questionnaire survey (PAS-ADD[2] interview)	Delay in falling asleep Waking too early Broken sleep Significant sleep problem	*General (age, gender, level of ID)*	Multivariate analysis: No independent association for level of ID Chi-squared test: No differences between males/females and younger/older age groups for all types of sleep problems	2++
							Challenging behaviour (n=191)	Multivariate analysis: Problem behaviour independently associated with broken sleep (OR 2.06, CI 1.31 – 3.24) and significant sleep problems (OR 2.06, CI 1.27 – 3.26)	
							ASD[3] (n=77)	Chi-squared test: No difference for all sleep problems between participants with or without ASD	

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (n subgroup)	Results	LE
							Medication use (n=334 psychotropic medication, n=117 analgesics, n=272 antiepileptic medication)	Multivariate analysis: Using psychotropic medication independently associated with early morning waking (OR 1.75, CI 1.10 – 2.76) and broken sleep (OR 2.03, CI 1.32 – 3.14) Using antiepileptic drugs independently associated with broken sleep (OR 1.73, CI 1.13 – 2.66)	
							Physical conditions (n=928 physical health problem, n=481 visual impairment)	Multivariate analysis: Respiratory disease independently associated with initial insomnia (OR 1.94, CI 1.21 – 3.31), broken sleep (OR 2.12, CI 1.38 – 3.27) and significant sleep problems (OR 2.03, CI 1.27 – 3.24) Visual impairment independently associated with initial insomnia (OR 1.91, CI 1.21 – 3.04)	

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (∩ subgroup)	Results	LE
							Psychiatric conditions (n=195)	Multivariate analysis: Mental ill-health of any type (excluding problem behaviour and ASD is independently associated with initial insomnia (OR 4.81, CI 3.02 – 7.67), early morning waking (OR 3.99, CI 2.51 – 6.35), broken sleep (OR 3.75, CI 2.41 – 5.81) and significant sleep problems (OR 5.53, CI 3.52 – 8.69)	
							Other factors: Down syndrome (n=186)	Multivariate analysis: No independent association for Down syndrome and sleep problems	
Brylewski & Wiggs # (1998)	205 (125)	Mean 46.8 (range 21 – 83)	All	Representative	Questionnaire survey (Simonds & Parraga)	Settling, sleep anxiety, night waking, sleep duration, parasomnias, sleep-related breathing disorders and excessive daytime sleepiness	*General (age, gender, level of ID)*	Older people snore more (Mann-Whitney U=1387, p=.05) and suffer more excessive daytime sleepiness (Mann-Whitney U=1578, p=.005) Women have more problems preparing for bed than men (χ^2=14.5, df=1, p=.0001) and longer sleep duration (Mann-Whitney U=2665, p=.02)	2+

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (n subgroup)	Results	LE
							Medication use (n=50 antiepileptic medication, n=60 antipsychotic medication)	Use of antiepileptic medication: more likely to snore (χ^2=4.04, df=1, p=.04) and are more likely to have nocturnal incontinence (χ^2=10.38, df=1, p=.001) No association with use of antipsychotic medication	
							Caffeine intake	Drinking more than four mugs of tea or coffee after 1800h associated with a sleep delay of more than one hour (χ^2=4.4, p=.03) and a shorter sleep duration (Mann-Whitney U=1452, p=.03) No association with total caffeine intake and sleep problems	
							Physical conditions (n=50)	Epilepsy: more excessive bedtime rituals (χ^2=5.59, df=1, p=.02) and more nocturnal incontinence (χ^2=17.32, df=1, p=.00003)	

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (n subgroup)	Results	LE
							Other factors: Down syndrome (n=36)	Significantly less excessive bedtime rituals in people with Down syndrome compared to other aetiologies (χ^2=4.26, df=1, p=0.04) Also less waking at night (χ^2=3.99, df=1, p=0.04) and less nocturnal incontinence (χ^2=5.11, df=1, p=0.02)	
							Other factors: Ability to communicate	More night waking when not able to communicate (χ^2=4.29, df=1, p=.04)	
Brylewski & Wiggs # (1999)	205 (125)	Mean 46.8 (range 21 – 83)	All	Representative	Questionnaire survey (Simonds & Parraga)	Settling problems Night waking problems	*Challenging behaviour*	Significantly higher scores on irritability (t-test, t=-3.76, p<.001), stereotypy (t-test, t=-3.07, p<.01), and hyperactivity (t-test, t=-2.62, p=.01) of the Aberrant Behaviour Checklist in sleep problem group Aggression (t-test, t=-3.12, p<.01), self-injury (t-test, t=-2.83, p<.01) and screaming (t-test, t=-3.26, p=.001) were significantly more severe in the people with sleep problems	2+

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (n subgroup)	Results	LE
Chaney *et al.* (1994)	40 (27)	Mean 36 (range 18 – 66)	Moderate, severe and profound	Referred	Observation of sleep	Insomnia	*General (age, gender, level of ID)*	No significant differences between participants with and without insomnia for age, gender and level of ID	2-
							Challenging behaviour	One-tailed Fisher exact probability test: More stereotypic behaviour in insomnia (p=.01) More severity of self-injurious behaviour in participants with sleep disturbance (p=.056)	
Cooper & Collacott (1994)	42 (not mentioned)	Adults	Mild, moderate, severe	Representative	Medical history	Mid-insomnia	*Psychiatric conditions*	Significant more mid-insomnia in recurrent episode of depression (χ^2=5.39, df=1, p=.02)	2-
Cooper (1997a)	134 (67)	Dementia group: Mean 76.4 (range 69 – 94)	All	Representative	Questionnaire survey (Disability Assessment Schedule, PPS-LD[4])	Sleep disturbance	*Dementia* (n=29 dementia)	Chi-squared: Significant more sleep disturbance in participants with dementia compared to those without dementia (p=.001)	2-
Cooper & Prasher (1998)	45 (14)	Range 42 – 94	All	Representative	Questionnaire survey (PSS-LD[4], Disabilities Assessment Schedule DMR[5])	Disturbed sleep	*Dementia*	Chi-squared: More disturbed sleep in participants with Down syndrome and dementia compared to other aetiology of ID and dementia (p=.041)	2-

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (n subgroup)	Results	LE
Deb *et al.* (2007)	24 (not mentioned)	Range 48 – 72	All	Residence	Questionnaire survey (Focus group and qualitative interviews with caregivers)	Changed sleep pattern	*Dementia*	Changed sleep pattern in most clients	3
Espie & Tweedie (1991)	120 (48)	Mean 35.7 (SD 13.7)	All	Representative	Questionnaire survey	Sleep efficiency, sleep onset latency, total sleep time, waking frequency	*General (age, gender, level of ID)*	Inverse correlation between sleep onset latency and age (r=-.30, p<.001) Severe/profound level of ID more wake time than people with mild/moderate ID (t=1.97, df=49, p=.005)	2+
							Other factors: Living environment	T-test: Sleep onset latency (t=2.93, p<.005), total sleep time (t=1.85, p=.06) and waking frequency (t=2.19, p<.05) significant longer in community residents (compared to hospital) Sleep efficiency not significantly different	
Gonzales & Matson (2006)	42 (18)	Mean 53 (range 30 – 78)	Severe and profound	Residence	Questionnaire survey (parent version of Young Mania Rating Scale, Mania subscale DASH-II[6])	Decreased need for sleep	*Psychiatric conditions*	MANOVA: Significant more 'decreased need for sleep' in the bipolar group compared to other psychopathology/no psychopathology F(2,1)=5.83, p<.01)	2-

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (n subgroup)	Results	LE
Hare *et al.* (2006)	31 (21)	No ASD: Mean 38.8 (SD 10.3) ASD: Mean 28.5 (SD 9.7)	Not mentioned	Referred	Actigraphy	Sleep efficiency Sleep onset latency Actual sleep time	ASD (n=14 ASD)	T-test: No significant differences for the outcomes on sleep for participants with ASD compared to non-ASD	2+
Harper & Wadsworth (1993)	43 (20)	Mean 46.5 (range 21 – 79)	Moderate, severe and profound	Residence	Questionnaire survey (Iowa Loss Instrument Questionnaire 'knowledge about death', Survey of Grief)	Sleep difficulties	*Other factors: Grief* (n=37)	51% sleep difficulties as a response to grief	3

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (n subgroup)	Results	LE
Harvey *et al.* (2003)	237 (140)	Mean 42.4 (range 18.6 – 70.3)	All	Representative	Questionnaire survey	Hours slept, napping during the day, sleep problem	*General (age, gender, level of ID)*	ANOVA: More nights with less sleep in people with profound ID than individuals with mild levels of ID (F=3.27, p<.05) More napping in people with profound ID during the day than mild, moderate or severe ID (F=12.3, p<.05) More multiple sleep problems in profound ID compared to mild, moderate and severe (χ^2=11.6, p<.05) Logistic regression: Multiple sleep problems more likely for severe and moderate level of ID, compared to mild level of ID (OR=1:5.5 and OR = 1:16.3) (adjusted for medication effects)	2-
							Medication use (n=185)	Profound ID more likely to have sleep effects from two or more medications than mild, moderate or severe level of ID (χ^2=13.4, p<.05)	

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[x]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (n subgroup)	Results	LE
Lenjavi *et al.* (2010)	20 (0)	Mean 40 (range 19 to 58)	Mild, severe and profound	Residence	Observation of sleep	Sleep efficiency	*Challenging behaviour*	Significantly lower frequencies of maladaptive behaviour in participants with high sleep efficiency (r-.49, p=.028) No significant differences in sleep efficiency between participants with SIB compared to those with other maladaptive behaviours	2+
Luiselli *et al.* (2005)	59 (37)	Mean 42.5 (range 23 – 71)	All	Referred	Observation of sleep	Mean hrs asleep Mean hrs awake Mean hrs awake and disruptive	*General (age, gender, level of ID)*	Age, gender and level of ID did not correlate with sleep	2+
							Medication use (n=17)	Inverse relationship between hours slept and participants taking SSRI's (r=-.39, p<.01)	
Maas *et al.* (2010)	79 (34)	Mean 34.4 (range 18 – 65)	Mild and moderate	Referred	Questionnaire survey (Semi-structured interview, ESS[7], SA-SDQ[8], DBC-A[9])	Settling problems, night waking problems, early waking problems Excessive Daytime Sleepiness Sleep apnoea	*Challenging behaviour* (n=35)	No significant correlations between sleep disturbances and behavioural problems in people with Prader-Willi syndrome	2+

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (n subgroup)	Results	LE
Mahan *et al.* (2010)	80 (44)	Mean 45.2 (range 18 – 70)	All	Residence	Questionnaire survey (MEDS[10])	Changed sleep pattern	*Medication use*	Percentage with changed sleep pattern: Zero psychotropic medications: 0% One psychotropic medications: 6.6% Two or more: 30%	3
Matson *et al.* (2007)	45 (18)	Mean 53 (range 31 – 75)	Severe and profound	Residence	Questionnaire survey (parent version of Young Mania Rating Scale, Mania subscale DASH-II[6])	Decreased need for sleep	*Psychiatric conditions*	Significant correlation between a clinical diagnosis of mania and a decreased need for sleep (Spearman's Rho 0.65, p<.001)	2-
Matson *et al.* (2008)	334 (182)	Mean 51.6 (range 16 – 88)	Severe and profound (mainly)	Referred	Questionnaire survey (DASH-II[6], ASD-BPA[11])	Difficulty staying awake during the day Frequent night waking Difficulty getting to sleep Sleepwalking Wakes up crying and screaming	ASD (n=168)	Significant higher scores on DASH-II sleep items in ASD group. Sleep items: wake up frequently (t=2.10, p=.001), difficulty getting to sleep (t=5.74, p=.001), waking up crying/screaming (t=6.10, p=.001) No significant differences for sleep walking	2+

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (∩ subgroup)	Results	LE
Moss & Patel (1995)	105 (61)	50 years and over	All	Representative	Questionnaire survey (ABS[12], Assessment of dementia, PAS-ADD[3])	Sleep difficulty	*Dementia* (n=18)	Discriminant function analysis: People with dementia more likely to score positive on sleep difficulty item (function 1 coefficient 1.78), and to score negative of delayed sleep item (function 1 coefficient -1.43)	2-
Prasher & Filer (1995)	40 (17)	Non-demented mean 51.4 (SD 9.1) Demented mean 54.2 (SD 8.6)	Moderate and severe	Referred	Questionnaire survey (Psychiatric interview)	Sleep disturbance	*Dementia* (n=15)	Mann-Whitney: Significantly more sleep disturbance in group Down syndrome with dementia, compared to Down syndrome without dementia, p=.0023	2-
Rojahn *et al.* (2004)	180 (97)	Mean 50.6 (range 20 – 91)	All	Residence	Questionnaire survey (DASH-II[6], BPI[13])	Sleep disorders	*Challenging behaviour*	MANCOVA: Participants with stereotype behaviour had higher scores on the factor Sleep disorders (F=7.6, p<.001)	2-
Searle (1994)	31 (15)	Males mean 35.3 (range 27 – 50). Females mean 31.4 (range 19 o 55)	Mild, severe and profound	Residence	Observation of sleep	Sleep time Sleep latency	*Caffeine intake*	No change in sleep patterns as a result of the changes in dietary caffeine intake (statistic test not specified in text)	2+

Table 3 Associated factors *(continued)*

Study	N (male)	Age (years)	Level of ID[1]	Study population	Assessment of sleep	Type of sleep problem / sleep variable	Associated factor (n subgroup)	Results	LE
Sturmey *et al.* (2010)	693 (394)	Mean 48 years (SD 15.0)	All	Residence	Questionnaire survey (DASH-II[6])	Decreased need for sleep	*Psychiatric conditions* (n=21 manic)	T-test: Significant more decreased need for sleep in manic group compared to the whole sample and group without mania (p<.01)	2-
Symons *et al.* (2000)	60 (36)	SIB[14]: Mean 41.2 (range 30 -69) No SIB: Mean 41.4 (range 25 – 56)	Profound	Residence	Observation of sleep	Sleep time	*Challenging behaviour* (n=30)	Participants with SIB were asleep fewer hour intervals on average compared to the non-SIB group (Wilcoxon signed-rank test, z=2.31, p<.02)	2+
Urv *et al.* (2008)	251 (63)	45 and over	All	Referred	Questionnaire survey (ABS[12], Dementia Questionnaire for Mentally Retarded Persons)	Sleep problems	*Dementia* (n=90)	Participants with questionable, possible and definite dementia had significantly more sleep problems than the no dementia group (χ^2=9.10, p<.05)	2-
Valdovinos *et al.* (2005)	30 (19)	Mean 45.4 (range 31 to 75)	All	Referred	Medical history	Sleep effects	*Medication use*	In 67% cases sleep effects as potential medication side effect Number of reported sleep side effects is correlated to the number of medication changes (r=.50, p<.01)	2-

Both studies addressing the same study population
No p-values are shown for non significant results

[1] Intellectual Disability, [2]Psychiatric Assessment Scale for Adults with Developmental Disabilities, [3] Autism Spectrum Disorder [4]Present Psychiatric State – Learning Disabilities, [5]Dementia Questionnaire for Mentally Retarded Persons, [6]Diagnostic Assessment for the Severely Handicapped-Revised, [7]Epworth Sleepiness Scale, [8]Sleep Apnoea sub-scale of the Sleep Disorders Questionnaire, [9]Developmental Behaviour Checklist for Adults, [10]Matson Evaluation of Drug Side-Effects ,[11]Autism Spectrum Disorder-Behaviour Problems for Adults with intellectual disabilities, [12]Adaptive Behaviour Scale, [13]Behavior Problems Inventory, [14] Self Injurious Behaviour

Table 4 Treatment of sleep problems

Study	Study design	Participant characteristics	Description of sleep problem	Assessment of sleep	Intervention	Duration of baseline, intervention and follow-up	Outcome	LE
Belcher (1995)	Case report	41-year old man with ID[1] living in institutional setting. Level of ID and co morbidities not described.	Average 5.30 hours of sleep per night. Out of bed in 93% of days between 2 AM and 5 AM	Observation of sleep	Moving to community setting. Creation of a positive responsive social, structured environment.	Baseline: 12 months Intervention: not mentioned Follow-up: 12 months	Average sleep time improved from 5.30 hours on average to 7.78 hours on average (48% increase).	3
Bradshaw (1991)	Case report	40-year old man with Down syndrome living is a host family. Level of ID and co morbidities not described.	Recurrent nightmares	Therapist interview	Cognitive behavioural therapy (changing the end of the nightmare in a positive ending).	Baseline: not mentioned Intervention: 3 weeks Follow-up: 3 months	No recurrence of the nightmare in the three months after the intervention.	3
Didden *et al.* (2002)	Case series with multiple baseline design (one adult)	25-year old man with Down syndrome, visited day centre of residential facility. Severe level of ID, antipsychotic treatment for daytime behavioural problems and recent cardiac surgery.	Refusal to go to bed. Getting out of bed. Problems emerged after cardiac surgery.	Parent interview Observation of sleep	Extinction procedure	Baseline: ± 8 days Intervention: ± 65 days Follow-up: ± 7 days	Mean number of night-time disruptions decreased from 15.5 at baseline to 5.1 after the intervention, with no further decrease during follow-up.	3

Table 4 Treatment of sleep problems *(continued)*

Study	Study design	Participant characteristics	Description of sleep problem	Assessment of sleep	Intervention	Duration of baseline, intervention and follow-up	Outcome	LE
Dodd *et al.* (2008)	Case series with baseline-treatment design	Case 1: 43-year old women with moderate level of ID and mild CB[2] Case 2: 69-year old man with moderate ID, severe CB and ASD[3] Case 3: 47-year old man with severe ID, severe CB, ASD and epilepsy Living setting not clearly described, probably residential setting	Case 1: Settling problem (3-5 hrs to fall asleep) followed by a sleep time of 2-3 hrs. Sleeping during the day and angry when woken. Case 2: Frequent night waking during 8 years. Case 3: Broken sleep over 9 years	Actigraphy	Melatonin treatment	Baseline: 2 weeks Intervention: 1 – 4 weeks (dependent on dose of melatonin needed) Follow-up: not mentioned	In all cases, the use of melatonin did not lead to clinically significant improvements in sleep quantity or quality, as measured by actigraphy.	3

Table 4 Treatment of sleep problems *(continued)*

Study	Study design	Participant characteristics	Description of sleep problem	Assessment of sleep	Intervention	Duration of baseline, intervention and follow-up	Outcome	LE
Eshbaugh et al. (2004)	Case report with quasi-experimental design	A 32-year old man with severe ID, ASD and anxiety disorder, living in a community-based residential setting	Settling problems, frequent awakenings) and difficulty staying awake during the day	Not mentioned	Pre-medication baseline phase with behaviour intervention (interrupt daytime sleep). Evening medication regimen phase with Trazodone 50mg each evening.	Pre-medication baseline phase: 4.5 months Intervention (medication): 8 months Follow-up: not mentioned	No change in daytime sleep in pre-medication baseline phase. Reduced daytime sleep attempts and challenging behaviours after start of medication..	3

Table 4 Treatment of sleep problems *(continued)*

Study	Study design	Participant characteristics	Description of sleep problem	Assessment of sleep	Intervention	Duration of baseline, intervention and follow-up	Outcome	LE
Espie & Wilson (1993)	Case series	Case 1: 42-year old man with severe ID, stereotyped behaviour patterns Case 2: 29-year old man, with profound ID and epilepsy Case 3: 18-year old man, with moderate ID, no co morbidities mentioned Case 4: 18-year old man, with mild ID and obsession behaviour Living setting not mentioned	Case 1: difficulty falling asleep Case 2: disturbed night-time sleep, daytime napping Case 3: high awakening frequency and resettling problem Case 4: too late bedtime hour	Not mentioned	Optimal scheduling	Baseline: not mentioned Intervention: not mentioned Follow-up: not mentioned	Improved sleep variables in all cases.	3

Table 4 Treatment of sleep problems *(continued)*

Study	Study design	Participant characteristics	Description of sleep problem	Assessment of sleep	Intervention	Duration of baseline, intervention and follow-up	Outcome	LE
Gunning & Espie (2003)	Multiple case study with multiple baseline design	N = 9 completed intervention phase (6 females) Age range 20 – 47 years. Level of ID mild, moderate and severe. No co morbidities described. Recruited at adult training centre.	Delayed sleep phase syndrome Irregular sleep-wake pattern Limit-setting sleep disorder Inadequate sleep hygiene	Questionnaire survey Sleep diary	Optimal scheduling, stimulus control, sleep hygiene, behaviour management	Baseline: 1-3 weeks Intervention: 4 weeks Follow-up: 1 week	Improvement in individually targeted variables.	2+
Hylkema & Vlaskamp (2009)	Multiple case study	N = 34 adults (13 females) Age range 19 – 64 years. Level of ID moderate, severe and profound. Co morbidities: epilepsy, visual impairment and ASD.	Naps during the day, settling problems and night waking problems	Actigraphy	Activity during the day, different daily routine and sleep scheduling	Baseline: 3 weeks Intervention: 22.5 weeks on average (SD 9.3) Follow-up: 3 weeks	In 29 of 34 participants sleep efficiency percentage improved.	2+

Table 4 Treatment of sleep problems *(continued)*

Study	Study design	Participant characteristics	Description of sleep problem	Assessment of sleep	Intervention	Duration of baseline, intervention and follow-up	Outcome	LE
Ikemoto et al. (2006)	Case report	A 39-year old man with severe level of ID, cerebral palsy epilepsy and with severe behavioural disturbances, living in residential setting.	Night-time waking, behavioural problems during the night	Observation of sleep	Light therapy (sunbathing two times a day 30 minutes)	Baseline: 10 days Intervention: 7 months Follow-up: 10 days	On all of the days when both sunbathing and exercise occurred, the patient slept well and after six months the sleep-wake cycle had improved remarkably.	3
O'Reilly (1995)	Case report	A 31-year old man with severe level of ID and aggressive behaviour. Living at home and attended vocational facility 5 days each week.	Frequent sleep deprivation, with less than 5 hours of sleep each night	Observation of sleep	A multicomponent behaviour support plan.	Baseline: 3 weeks Intervention: 18 therapy sessions (not clearly mentioned) Follow-up: 7 months	Less aggression when the participant slept more than 5 hours.	3
Sforza et al. (1991)	Case report	A 20-year old man with Prader-Willi syndrome. Level of ID not mentioned, co morbidities and living facility not mentioned.	Severe daytime sleepiness and loud snoring	Polysomnography	CPAP[4]	Baseline: 1 night Intervention: 1 night Follow-up: not mentioned	CPAP normalized the respiratory pattern and the sleep structure, except for SOREM[5]	3

Table 4 Treatment of sleep problems *(continued)*

Study	Study design	Participant characteristics	Description of sleep problem	Assessment of sleep	Intervention	Duration of baseline, intervention and follow-up	Outcome	LE
Short & Carpenter (1998)	Case report	A 34-year old man with profound level of ID and visual impairment	Difficulty getting off to sleep, waking frequently during the early hours of the morning and excessive daytime sleepiness	Not mentioned	Light therapy (exposure to direct natural daylight)	Baseline: 3 months other interventions (not successful) Intervention: 2 weeks Follow-up: not mentioned	After implementing the light regime, his sleep pattern was back to normal and remained stable thereafter.	3
Vgontzas et al. (1995)	Case series	Case 1: 21-year old female with Prader-Willi syndrome and sleep apnoea. Level of ID not mentioned. Case 2:25-year old female with Prader-Willi syndrome and sleep apnoea. Level of ID not mentioned. Both living in residential setting	Sleep apnoea and excessive daytime sleepiness	Polysomnography	Weight loss	Baseline: not mentioned Intervention: not mentioned Follow-up not mentioned	Weight loss was associated with complete abolition of sleep apnoea and hypoventilation. Continued experience of excessive daytime sleepiness.	3

[1] Intellectual Disability, [2] Challenging Behaviour, [3] Autism Spectrum Disorder, [4] Continuous Positive Airway Pressure, [5] Sleep Onset Rapid Eye Movement

were non-analytical. The studies in specific populations are not taken into account for the conclusions on prevalence rates, but are mentioned in Table 2 to complete the overview of available literature.

Six studies addressed the prevalence of sleep problems in heterogeneous groups.[10, 14, 16-17, 19-20, 22] One study was of high-quality, four were well-conducted with low risk of bias, and one study had a high risk of bias. Reported prevalence rates in these studies varied from 8.5 to 63% for settling problems,[10, 16-17, 20] 11 to 43% for night waking problems,[10, 16-17, 20] 9.9% and 30% for early waking problems,[16, 20] and 4.5 and 34.6% for daytime sleepiness.[10, 17] In studies that only mentioned 'sleep problem', prevalence rates were 15 to 47.3%.[14, 19, 22] 'Significant' or 'multiple' sleep problems were investigated in two studies, with a prevalence of 9.2% for significant sleep problems[16] and 32% for multiple sleep problems.[20] Boyle et al. (2010) presented prevalence rates for people aged 45 years and older separately (Table 2).

Taking into account the level of evidence of the studies, and whether a formal and/or validated source was used to define a sleep problem, we consider the prevalence rates found by Boyle et al., Brylewski & Wiggs and Gunning & Espie most reliable (see Table 2). Based on these studies, the prevalence of sleep problems in adults with ID ranges from 8.5 to 26.8% for settling problems, and from 11 to 34.1% for night waking problems. The prevalence of significant sleep problems is 9.2%.

Associated factors

Information on studies that investigated one or more factors associated with sleep problems are displayed in Table 3. The information in table 3 has been ordered by author, as some studies describe more than one association. The results are summarized by category below.

General characteristics: age, gender, level of ID

Our search identified six studies addressing an association of age, gender and/or level of ID with sleep problems. One was a high-quality study,[16] three studies were well-conducted [10, 19, 31] and two had a high risk of bias.[20, 32]

Taking levels of evidence into account, there is no clear evidence for an association with age, gender or level of ID.

Challenging behaviour

Seven studies addressed the association between challenging behaviour and sleep problems, one of high-quality, four well-conducted, and two with a high risk of bias. Chaney et al. (high risk of bias), Lenjavi et al. and Symons et al. (low risk of bias) performed sleep observations.[32-34] Two studies described a specific population; Maas et al. (2010) investigated individuals with Prader-Willi syndrome, and Chaney et al.

(1994) investigated individuals with profound ID. Except for one study (low risk of bias),[18] in all identified studies an association for challenging behaviour and sleep problems was found.[14, 16, 26, 32-35] We conclude that challenging behaviour is associated with sleep problems.

Autism spectrum disorders (ASD)

We identified three studies with information on the association between ASD and sleep problems. One was a high-quality study and two were well conducted (low risk of bias). In one study sleep was observed using actigraphy.[36] One study [26] investigated individuals with mainly severe and profound ID. Both Boyle et al. (high-quality) and Hare et al. (low risk of bias) did not find a difference for the occurrence of sleep problems and a difference in sleep quality between people with or without ASD.[16, 36] However, Matson et al. found that participants with ASD, as compared to participants without ASD, had more sleep difficulties (low risk of bias).[26]

We conclude that there is conflicting evidence concerning the association of ASD and sleep problems in adults with ID.

Dementia

We found six studies that describe the association between dementia and sleep problems. Five were well conducted but with a high risk of bias, and one study was non-analytical. One study investigated dementia in individuals with Down's syndrome.[37] All identified studies found more sleep disturbances in persons with dementia.[37-42] However, taking into account the low level of evidence, based on these studies we can not confirm that dementia is associated with sleep problems.

Medication use

In seven studies the association between medication use and sleep problems was described. One study was of high-quality, two were well-conducted and two had a high risk of bias. Two studies were non-analytical.[43-44] Luiselli et al. and Searle et al. performed sleep observations.[15, 31] More side effects on sleep were found in profound level of ID (high risk of bias).[20] The use of psychotropic, antiepileptic and/or antidepressant medication was associated with sleep problems (high-quality, low risk of bias).[10, 16, 31, 44] We conclude that there is evidence that medication use is associated with sleep problems.

Caffeine intake

Two studies addressed the association with caffeine intake and sleep problems, both studies were well-conducted. Drinking coffee after 6 p.m. was associated with sleep problems, but no association was found for total daily caffeine intake (low risk of

bias).[10] No changes in sleep patterns were observed after caffeine withdrawal (low risk of bias).[15] We conclude that there is no clear association with sleep problems and caffeine intake.

Physical conditions

In two studies physical conditions were investigated. One was of high-quality and one was well-conducted. Respiratory disease and visual impairment are independently associated with sleep problems (high-quality).[16] Brylewski et al. (1998) described more excessive bedtime rituals and more nocturnal incontinence in people with epilepsy (low risk of bias).[10]

Psychiatric conditions

In five studies psychiatric conditions (other than dementia and ASD) were investigated. One was of high quality, four had a high risk of bias. Boyle et al. found that mental illness (other than problem behaviour and ASD) is associated with sleep problems (high quality).[16]

Decreased need for sleep was associated with bipolar disorder and mania (high risk of bias).[45-47] Matson et al (2007) and Gonzales & Matson (2006) investigated individuals with severe and profound ID. Cooper et al. found that participants with Down syndrome and recurrent depression had more mid-insomnia compared to participants with a single episode of depression (high risk of bias).[48]

We conclude that there is evidence that psychiatric conditions are associated with sleep problems.

Other associated factors

Four studies included other associations with sleep problems. Two were on Down syndrome (high-quality and low risk of bias),[10, 16] one was on ability to communicate (low risk of bias),[10] one on living environment (low risk of bias)[19] and one on grief (non-analytical).[49] We conclude that the evidence of an association with Down syndrome and sleep problems is conflicting. There is limited evidence of an association with communicative ability, living environment and grief.

Treatment of sleep problems

We identified 13 studies describing treatment effects, of which 11 were case reports or case series (non-analytical).[50-60] The other two studies, both with a low risk of bias, evaluated non-pharmaceutical interventions in larger populations.[17, 61] These interventions were mainly based on behavioural and environmental improvement. Information on study design and treatment effects is shown in Table 4. We conclude that

there is some evidence that these interventions are beneficial to treat sleep problems in adults with ID.

DISCUSSION

This is the first systematic review on the prevalence, associated factors and treatment of sleep problems in adults and older people with intellectual disability (ID). Fifty studies matched the inclusion criteria, of which one study was of high-quality, 14 were well conducted, 14 well conducted but with a high risk of bias and 21 were non-analytical. Informant-based interviews was the most frequently used research method. Sleep problems were most often named as settling problem, night waking problem and early waking problem. The estimated prevalence of sleep problems in adults with ID ranges from 8.5 to 26.8% for settling problems and from 11 to 34.1% for night waking problems. The prevalence of significant sleep problems is 9.2%. Most studies addressing associated factors had a cross-sectional design; only one of these studies was based on objective measurements (actigraphy). Sleep problems were associated with challenging behaviour; respiratory disease; visual impairment; psychiatric conditions; and using psychotropic, antiepileptic and/or antidepressant medication. No associated factors, other than dementia, were addressed specifically for older people with ID. Most studies that addressed the treatment of sleep problems were case reports and case series. In two larger non-pharmaceutical intervention studies sleep improved in most to all participants.

It is difficult to compare the prevalence of sleep problems in adults and older people with ID to the general population, because studies in people with ID are not based on self-report. Accordingly, a sleep problem might only be mentioned if it is noticed by a professional caregiver. For example clients that are awake but lie quietly in bed might not be noticed. The prevalence rate is also influenced by the type of questionnaire survey, which in the included studies varied from structured interviews to a 5-minute telephone interview. Although in some studies the clients, if possible, were interviewed as well,[16, 18] the amount of sleep problems experienced by clients themselves was not specifically described.

Although older people (50 years and over) were included in studies on prevalence rates and associated factors, only Boyle et al. reported prevalence rates for participants aged 45 years and over.[16] Unfortunately no information was provided on the range and distribution of age in this subgroup. Therefore these numbers can not easily be generalized to all older people with ID. Brylewski et al. mentioned more excessive daytime sleepiness in the 'older age groups',[10] but did not specify this. Only studies focusing on dementia specifically included people with ID aged 65 years and over.

Therefore, the specific prevalence of sleep problems and associated factors in ageing people with ID can not be derived from this review. In the general population, sleep deteriorates with age, and as the age of people with ID increases, we stress the necessity to focus more on older people with ID specifically.

Most included studies on associated factors had a cross-sectional design. As a consequence, it is difficult to draw conclusions on the causality of the associations. For example for challenging behaviour, Brylewski et al.[14] and Symons et al.[34] both argued that sleep problems can be part of the challenging behaviour, but the challenging behaviour can also be caused or aggravated by the lack of sleep. Also, the use of psychotropic and antiepileptic medication is associated with a higher risk of sleep problems. However, it is unknown whether the medication or the underling condition causes the sleep problem. Only Boyle et al. used multivariate analyses to investigate independent associations for sleep problems.[16] All other studies used correlations or calculated differences between groups, making it difficult to draw conclusions on the independent influence of investigated associated factors.

The effects of treatment on sleep problems were mostly reported as case reports and case series, which provide limited levels of evidence. In one study in which objective assessment of sleep was used, caregivers reported greater improvement in sleep than was objectively recorded, suggesting that their perception of the problem had changed as a consequence of the intervention.[53] This underscores the surplus value of objective outcome measures in intervention studies.

There are some limitations to this systematic review. First, the SIGN-50 checklist for cohort studies is originally not designed for the quality assessment of cross-sectional studies. However to our knowledge no checklist is available for quality assessment of these studies; therefore we followed de Winter et al. (2010) who used the SIGN-50 checklist for cohort studies as a guideline. An advantage of the SIGN-50 criteria is that a Level of Evidence (LE) can be applied to the studies. Although all studies were carefully rated by at least two researchers, the method to assign level of evidence is somewhat subjective. There are several reasons for this. We based our quality assessment only on the part of the study that addressed sleep problems (as explained in the methods section of our paper). For example in the study by Mahan et al. (2010) statistical analysis was performed, but not on the data that specifically addressed sleep problems. This resulted in a lower LE. Also, we slightly modified the SIGN-50 checklist to make it applicable for quality assessment of cross-sectional studies on sleep problems. Due to these adaptations, outcome of quality assessments of the same studies could be slightly different. Last, LE is attributed based on the amount of criteria of the checklist that are fulfilled. This amount is characterized as ‘most’, ‘some’ or ‘few criteria are fulfilled’ by SIGN, and is therefore susceptible for different outcomes of quality assessments. Despite these issues, we attempted to provide information on

the quality of available studies as best as possible. A second limitation is, because we wanted to provide a complete overview of available literature, studies in specific populations were not excluded. This may confound our conclusions on factors associated with sleep problems. Third, we only included studies that showed information on sleep problems for adults separately. As a consequence, studies that investigated both children and adults, but did not report results of the adult participants discretely, were excluded. Because the aetiology of sleep problems in children may be different from adults, we feel that this trade-off is justified.

Based on the information found in available literature, it is too premature to provide recommendations for clinical practice. Before we can do so, further research is needed. Until now, research on sleep problems in adults and older people with ID has mainly focused on subjectively derived data. The definitions used to describe a sleep problem are not uniform, and associations are mainly described as correlations. Future epidemiological research should involve more objective measurements, like direct observations or actigraphic measurements. This is necessary to gain information on sleep problems, which is not influenced by the experience or memory of professional caregivers. Although direct observations are not entirely objective, if performed correctly it provides more reliable information than questionnaire surveys. A uniform definition of sleep problems in this population needs to be developed as well. Because many people with ID can not clearly explain their sleep patterns and needs themselves, other factors that might indicate a sleep problem should be investigated (for example daytime sleepiness, irritability and challenging behaviour). These factors can be used to validate a definition for sleep problems. For this, research in which these factors are compared to objectively obtained sleep patterns could be beneficial. Longitudinal research is necessary to better understand the causes of sleep problems in this specific population. Analysis of measurements in future research should not only involve correlations, but also multivariate models to investigate which individual factors most contribute to sleep problems in adults and older people with intellectual disability.

APPENDIX

Search terms

PubMed

(mental retardation[mesh] OR mental retard*[tw] OR intellectual disabilit*[tw] OR intellectually retard*[tw] OR intellectually disabl*[tw] OR mental disabilit*[tw] OR mentally disabl*[tw] OR idiocy[tw] OR mental deficien*[tw] OR learning disabilit*[tw] OR learning disorder*[tw] OR learning disturb*[tw] OR developmental disabilit*[tw] OR mental handicap*[tw] OR mentally handicap*[tw] OR intellectual handicap*[tw] OR intellectually handicap*[tw] OR down's syndr*[tw] OR down syndr*[tw] OR mental incapac*[tw] OR intellectual incapac*[tw] OR oligophrenia[tw]) AND (sleep disorders[mesh] OR sleep*[tw] OR insomni*[tw] OR dyssomni*[tw] OR parasomni*[tw] OR somnolen*[tw] OR hypersomni*[tw]) AND (adult[mesh] OR middle aged[tw] OR aging[tw] OR ageing[tw] OR elder*[tw] OR geriatr*[tw] OR old*[tw] OR senior*[tw]) AND (dut[la] OR eng[la]) NOT (animals[mesh] NOT humans[mesh])

EMBase

('mental deficiency'/exp OR ((intellectual* OR learning OR development*) NEAR/2 (handicap* OR retard* OR disabilit* OR deficien* OR disturb* OR disord* OR incapac*)):ti,ab OR ((mental*) NEAR/2 (handicap* OR retard* OR disabilit* OR deficien* OR disturb* OR incapac*)):ti,ab OR idiocy:ti,ab OR ((downs OR down) NEAR/1 syndr*):ti,ab OR oligophrenia:ti,ab) AND ('sleep disorder'/exp OR sleep*:ti,ab OR insomni*:ti,ab OR dyssomni*:ti,ab OR parasomni*:ti,ab OR somnolen*:ti,ab OR hypersomni*:ti,ab) AND ([dutch]/lim OR [english]/lim) AND ([adult]/lim OR [aged]/lim) NOT [child]/lim

PsycINFO

(exp mental retardation/ OR ((intellectual* OR learning OR development*) ADJ1 (handicap* OR retard* OR disabilit* OR deficien* OR disturb* OR disord* OR incapac*)).ti,ab,de. OR ((mental*) ADJ1 (handicap* OR retard* OR disabilit* OR deficien* OR disturb* OR incapac*)).ti,ab,de. OR idiocy.ti,ab,de. OR ((downs OR down) ADJ1 syndr*).ti,ab,de. OR oligophrenia.ti,ab,de.) AND (exp sleep disorders/ OR sleep*.ti,ab,de. OR insomni*.ti,ab,de. OR dyssomni*.ti,ab,de. OR parasomni*.ti,ab,de. OR somnolen*.ti,ab,de. OR hypersomni*.ti,ab,de.)

limit x to (human and "300 adulthood <age 18 yrs and older>" and (dutch or english))

Web of Science

(((intellectual* OR learning OR development*) SAME (handicap* OR retard* OR disabilit* OR deficien* OR disturb* OR disord* OR incapac*)) OR ((mental*) SAME (handicap* OR retard* OR disabilit* OR deficien* OR disturb* OR incapac*)) OR idiocy OR down OR oligophrenia) AND (sleep* OR insomni* OR dyssomni* OR parasomni* OR somnolen* OR hypersomni*) AND (adult* OR middle-aged OR aging OR ageing OR elder* OR geriatr* OR old* OR senior*)

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Chapter 3

Exploring the use of actigraphy to investigate sleep problems in older adults with intellectual disabilities

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ABSTRACT

The aim of this study was to explore the use of actigraphy to investigate sleep problems in a convenience sample of clients of Dutch intellectual disability (ID) care providers. Based on data obtained in a large multi-centre study on healthy ageing in people with ID, research questions were: 'To what degree are actigraphic measurements successful in this population?' and 'What is the influence of different sensitivity settings of the Actiwatch Sleep Analysis software on the distribution of sleep variables in this group?'

Data were collected in a cross-sectional descriptive study design. We included 563 participants, aged 50 years or older, with borderline to profound intellectual disabilities. Sleep-wake data were measured continuously during 14 days and nights using the Actiwatch AW7. A complete measurement of at least seven days and nights, including at least one weekend day, was considered successful. Objective variables of sleep were analysed using different sensitivity settings of the Actiwatch AW7 Sleep Analysis software.

In 200 participants (35.5%), a successful measurement was obtained. Unsuccessful measurements were caused primarily by problems with wearing the device and incomplete information on bedtime and get-up time. Of 382 participants who started wearing the Actiwatch, 354 (92.3%) wore it for at least seven days. Application of different sensitivity settings of the Sleep Analysis software resulted in clear differences of all sleep parameters.

Further research is needed into the validity of objective sleep parameters, as measured with the Actiwatch, for screening and epidemiological research in older people with ID. It needs to be investigated which sensitivity setting of the Actiwatch gives most valid results in this specific group, whereas reference data on sleep parameters and cut-off values are to be obtained.

INTRODUCTION

Sleep deprivation has a negative impact on general well-being and quality of life.[1] It is associated with poor cognitive function, negative effects on health and depression.[1-3]

In the process of ageing, the sleep-wake cycle changes, which can contribute to sleep problems.[3] In a survey of the National Sleep Foundation in the United States involving 1.506 persons aged 55 years and older, 46% to 50% reported one or more symptoms of insomnia.[4] In older people with intellectual disability (ID), besides the process of ageing, their neurological pathology may also contribute to issues involving a good night's rest.[2] For people with ID, prevalence numbers of sleep problems vary from 13 to 86%.[5] This wide range depends on the subjects' ages, used measures and definitions of disordered sleep in different studies.[5] Recently, Boyle et al investigated sleep in 1.042 adults with ID using questionnaires, and found a prevalence rate of significant sleep problems of 9.2%.[6] The particular prevalence of sleep problems in older people with ID still remains unknown.

Although previous studies on sleep problems in people with ID give useful information, they are mostly based on questionnaire surveys or direct observations. Questionnaires about sleep patterns are often completed by personal caregivers and possibly influenced by recall bias.[7-8] Some studies used observations at night, by visual inspection every 20 or 30 minutes.[9-11] This may be more accurate in comparison to questionnaire surveys, but it is still hard to see whether someone is asleep or not, and additionally, observation may even disturb sleep. However, information about sleep problems based on personal caregivers' view and documentation in the medical record is frequently the only information available.

The gold standard for investigating sleep is polysomnography (PSG). Albeit very accurate, it requires an overnight sleep in a sleep laboratory and sophisticated recording equipment, which may disrupt the usual sleep pattern.[12-14] Because of its complexity and costs, this method may not be suitable for large-scale research neither for health screening in people with ID.

A perhaps more applicable method to investigate sleep in this group is actigraphy, a method which is increasingly used in sleep research.[15] An actigraph is a small watch-like device designed to measure sleep and wakefulness patterns based on motor activity[16]. It is non-invasive and can produce recordings for several days in a row in the home environment.[13-14, 17] A validation study by Kushida et al (2001), involving 100 sleep disordered patients, showed that the Actiwatch (a type of actigraph) had a 92% to 96% sensitivity and an overall agreement rate of 77% to predict sleep compared with PSG.[18] Yet, actigraphy in general has a lower capacity to detect periods of being awake, because individuals are not necessarily moving when they are awake.[17-19]

A measurement with the Actiwatch provides an actogram, a visual display of rest-activity patterns over the entire length of the measurement.[20] Objective sleep parameters, as often utilized in sleep research, can also be calculated with specific Sleep Analysis computer software.[20] The Actiwatch was previously used in a few studies in people with ID. Hare et al (2006) used it to compare sleep patterns of 31 individuals with ID, with and without autism spectrum disorders.[21] It was also used to evaluate effects of melatonin treatment in 13 children with fragile X syndrome and autism[22] and in three individuals with moderate or severe ID.[23] Hylkema and Vlaskamp (2009) evaluated the effect of non-pharmaceutical interventions for sleep problems in 41 adults with ID using repeated measures with the Actiwatch.[24] To our knowledge, no epidemiological studies using the Actiwatch in individuals with ID, young or old have been published.

We wanted to explore to what degree Actiwatch measurements are successful in a large group of participants. Further, calculations of objective sleep parameters can be performed using different sensitivity settings for movement: if a low sensitivity has been set, more movement is required to consider a person awake than with a higher sensitivity setting. Therefore, we also wanted to explore to what extent different sensitivity settings lead to different outcomes of objective sleep parameters.

In this perspective, we formulated the following research questions:

1. For how many older people with ID are Actiwatch measurements completed successfully?
2. What is the influence of different sensitivity settings of the Actiwatch sleep analysis software on the distribution of sleep variables in this group?

MATERIALS AND METHODS

Study design

Data were collected in a cross-sectional descriptive study design.

Population

The collection of Actiwatch data is part of a large multi-centre study on healthy ageing in older people with intellectual disability (ID) in the Netherlands. Inclusion and participation, and measurement measures of the Healthy Ageing study has been published elsewhere.[25] All clients (n= 2150) aged 50 years and older of three large Dutch care providers for people with intellectual disabilities (Abrona, Amarant and Ipse de Bruggen), were asked to participate in the study. Clients who were capable to give informed consent were asked themselves. If clients were unable to give informed consent, their representatives decided about participation. Informed consent was

obtained for 1052 participants. Data collection is in progress since February 2009. The data of a convenience sample consisting of all participants included during the first year of the study (n=563) were analysed in this paper. This study was approved by the Medical Ethics Committee of the Erasmus Medical Center (no. 2008-234) and the ethical committees of the care organizations.

Data collection

Demographic and medical data

General information on gender, age and aetiology of ID was collected from medical records. Level of ID was obtained from behavioural therapists and psychologists' records, who determined level of ID on available IQ tests, Vineland scores and social emotional development. Level of ID was categorized as borderline (IQ 70-85), mild (IQ 55-70), moderate (IQ 35-55), severe (IQ 25-35) or profound (IQ<25).

Actigraphy

The Actiwatch AW7 (manufactured by Cambridge Neurotechnology Ltd, Cambridge, United Kingdom) is an actigraph measuring activity by means of a piezo-electric accelerometer that records the combination of intensity, amount and duration of movement, and the corresponding voltage produced is converted and stored as an activity count.[20] Activity counts were summed over one-minute intervals, called epochs.

In the Healthy Ageing study, a range of physical variables were assessed at one day. Participants received the Actiwatch at the end of all measurements. It had to be worn for 14 days and nights continuously. Instead of collecting information in a sleep diary, the event marker button on top of the Actiwatch had to be pressed at bedtime and get-up time. No selection of participants was made regarding presence of sleep problems. Although it is recommended to wear the Actiwatch on the non-dominant wrist,[16] for many participants hand dominancy was undifferentiated or unknown. In those cases the participants or their personal caregivers could decide on which wrist the Actiwatch would be would be worn. Personal caregivers and their clients received verbal instructions and an information brochure about the use of the Actiwatch.

To get the most reliable outcomes, a measurement of at least seven nights is necessary.[26] We also considered potential differences in nights on weekdays and nights at weekends.[16] Therefore, an Actiwatch measurement was called successful in case it met all the following criteria:

1. The Actiwatch was worn for at least seven nights
2. The event marker button was pressed at bedtime and get-up time for at least seven nights, of which at least one weekend night

3. The maximum amount of nights at weekends was at most half of the total nights involved in the measurement

Analysis

Data files were analysed using the Actiwatch Sleep Analysis 7 software (CamNtech Ltd version 7.27, Cambridge Neurotechnology Ltd, Cambridge, United Kingdom).

Determination of sleep and wakefulness by the software relies on an algorithm that looks at each data point and calculates a total score, based on the activity counts from each epoch and those surrounding it.[20] The software provides four sensitivity settings to analyse the data files: low sensitivity= 80 counts per epoch, medium sensitivity=40 counts per epoch, high sensitivity=20 counts per epoch and auto sensitivity=variable counts per epoch (based on individual amount of physical activity). At the low sensitivity setting (80 counts per epoch) more movement is necessary to score an epoch as awake, than at the high sensitivity setting (20 counts per epoch). A one minute epoch is scored as 'sleep' if total activity counts are less than the chosen sensitivity setting.

Variables of interest were Sleep Onset Latency (SOL): the interval between bedtime and sleep start, Time in Bed (TIB): time between bedtime and get-up time, Total Sleep Time (TST): total time scored as asleep between bedtime and get-up time, Wake After Sleep Onset (WASO): total time scored as awake between sleep start and sleep end, and Sleep Efficiency (SE): percentage of total time asleep during the total time in bed.

Normal distribution of all variables was tested using the one-sample Kolmogorov-Smirnov test (SPSS 15.0 for Windows). To investigate the influence of the sensitivity setting on the range of sleep variables, distributions of SOL, TIB, TST, WASO and SE were calculated using the highest (20) and lowest (80) sensitivity setting for all selected data.

RESULTS

Successful measurement

A successful measurement was obtained in 200 of 563 participants (35.5%). Participation and exclusion are presented in Figure 1.

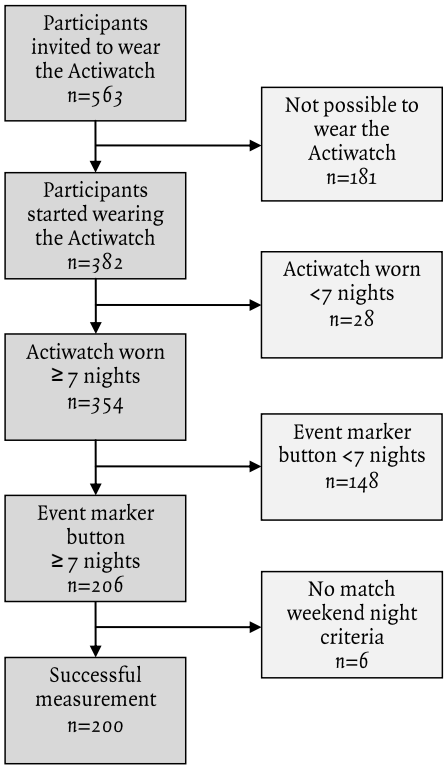

Figure 1 Flow-chart data file selection

Reasons for not wearing the Actiwatch (181 participants) were primarily loss or breakage of the device, as expected by personal caregivers, and further fear, resistance or refusal by participants.

The sample of 200 participants with a successful Actiwatch measurement consisted of 86 men and 114 women, aged 50 to 93 years (mean 62.6, SD 9.0 years). Demographic data are displayed in Table 1.

Table 1 Demographic data

Total number of participants (n=200)		
	N	%
Male	86	43.0
Female	114	57.0
Age		
50-59 years	87	43.5
60-69 years	66	33.0
70-79 years	37	18.5
>80 years	10	5.0
Level of ID*		
borderline (IQ 70-85)	8	4.0
mild (IQ 55-70)	42	21.0
moderate (IQ 35-55)	89	44.5
severe (IQ 25-35)	18	9.0
profound (IQ <25)	10	5.0
unknown	33	16.5
Aetiology of ID*		
Down syndrome	17	8.5
Fragile X syndrome	2	1.0
Angelman syndrome	1	0.5
No specific syndrome	140	70
Unknown	40	20

*ID = intellectual disability

Table 2 Distribution of sleep parameters for the low (80) and high (20) sensitivity setting

	TIB# (min)	**SOL# (min)**	**TST (min)**		**WASO (min)**		**SE (%)**	
	Low(80)/ High(20)	*Low(80)/ High(20)*	*Low(80)*	*High(20)*	*Low(80)*	*High(20)*	*Low(80)*	*High(20)*
Normally distributed	No	No	Yes		No		No	
Mean			506.84	446.26				
SD			102.11	105.58				
Median	638.94	33.35	509.68	443.01	45.06	103.87	82.11	71.73
Minimum	248.23	1.85	164.47	124.88	1.73	6.92	23.11	15.00
Maximum	833.78	338	788.33	754.27	325.78	371.88	98.82	98.00

TIB= Time in Bed, SOL= Sleep Onset Latency, TST= Total Sleep Time, WASO= Wake After Sleep Onset, SE(%)= Sleep Efficiency percentage

Independent of sensitivity setting

Influence sensitivity setting on objective sleep variables

Normal distribution of sleep variables was tested using Kolmogorov-Smirnov test. Only Total Sleep Time (TST) was normally distributed in this population. As a consequence, the mean was calculated for TST and the median was calculated for Time in Bed (TIB), Sleep Onset Latency (SOL), Wake After Sleep Onset (WASO) and Sleep Efficiency (SE). Standard deviation was calculated for TST. Minimum and maximum values of TIB, SOL, WASO, TST and SE were determined for the high and low sensitivity setting (Table 2).

The Sleep Analysis software determines sleep start by searching for a period of at least 10 minutes of consecutively recorded immobile data following bedtime. Because the software searches for complete immobility, it is independent of the sensitivity setting. Therefore, both median TIB and SOL are equal for both sensitivity settings. Between the high and the low sensitivity setting, mean TST differed 60.58 minutes and median WASO differed 58.81 minutes. Median SE differed 10.4% between the high and the low sensitivity setting.

CONCLUSION AND DISCUSSION

This is the first study to explore the applicability of the Actiwatch as a method for screening of objective sleep parameters in 563 people with ID aged 50 years and over. A successful measurement was obtained in 200 participants (35.5%). Resistance or advice against wearing the Actiwatch (n=181), as well as not correctly pressing the button marking bedtime and get-up time (n=148), were the mean reasons for an unsuccessful measurement. Of 382 participants who started wearing the Actiwatch, 354 (92.3%) wore it for at least seven days. Application of the low and high sensitivity setting of the Sleep Analysis software resulted in clear differences in outcome values of objective sleep parameters: average Total Sleep Time (TST) was 446.26 minutes with the high and 506.84 minutes with the low sensitivity setting, average Wake After Sleep Onset (WASO) was 103.87 and 45.06 minutes with the high and low sensitivity setting, respectively, and average Sleep Efficiency (SE) was 71.73% with the high and 82.11% with the low sensitivity setting.

Because the current study is part of a large-scale study on aspects of healthy ageing, demanding much involvement of the participants and their caregivers, it is understandable that participants or their personal caregivers may have shown non-optimal commitment to the Actiwatch measurement and forgot to press the event marker button every morning and evening. The multiple measurements of the healthy ageing study might have influenced the number of participants who refused to wear the

Actiwatch as well. Nevertheless, most participants (92.3%) who started wearing the Actiwatch wore it for at least seven days, indicating that an accurate measurement is principally feasible for a majority of older people with ID. Fear and refusal may be overcome if the Actiwatch is introduced under careful individual guidance.

A limitation of this study is the large number of participants with 'no specific syndrome' (n=140). Several decades ago, knowledge on syndromes and diagnostic testing for specific aetiology was not as common as it is today. As a consequence, information on specific aetiology of ID is unfortunately lacking for part of our study population. Diagnostic testing for specific aetiology was beyond the scope of the Healthy Ageing study.

The results of this study give cause for further research. The wide range between the high and low sensitivity setting for outcomes of objective sleep parameters hampers valid interpretation. Therefore, in order to draw conclusions from data collected with the Actiwatch, a validated choice of sensitivity setting is essential. Several authors have investigated the agreement of Actiwatch outcomes with polysomnography (PSG) using different sensitivity settings. At the low and auto sensitivity setting, TST en SE did not appear significantly different from PSG in 45 children with sleep disordered breathing,[13] whereas WASO, TST en SE did not appear significantly different from PSG in 12 healthy adults with normal intelligence.[14] In contrast, Kushida et al found best overall accuracy and specificity (ability to detect wake) for actigraphy compared to PSG at the high sensitivity setting.[18] At the medium sensitivity setting, most sleep parameters differed significantly from PSG measurement in these studies.[13-14, 18] This information is contradictory and therefore does not support an evidence-based choice of the right sensitivity setting to investigate sleep in older people with ID. Therefore our further research should firstly involve a combined PSG and Actiwatch measurement in older people with ID, to investigate which sensitivity setting leads to valid outcomes. Secondly, if we want to distinguish sleep problems objectively, we need to define which sleep parameters and cut-off values are most valid. Although a cut-off value of SE<85% is generally used to define sleep problems, this value was only based on one study with PSG in 18 good sleepers and 18 insomniacs in the general population .[27] Therefore it is questionable if this value is applicable in older people with ID. Moreover, maybe another variable besides the commonly used SE will provide more valid information in this specific population.

The Actiwatch enables a multi-day and night measurement in the home environment and is non-invasive. Also, the software provides an actogram, which provides a display of day and night activity even if the event marker button is not pressed correctly. Although interpretation of the actogram is subjective, it may give more understanding of the sleep pattern to personal caregivers and physicians. Sleep problems are multifaceted and very difficult to clarify in objective figures. Sleep problems also

depend on personal experience of sleep and can not only be defined by a cut-off value. [28] However for people with ID, evaluating their personal sleep experience may be difficult. Therefore in clinical practice, additional objective evaluation with the Actiwatch may be useful; both by inspection of the actogram and by objective sleep parameters.

In conclusion, a validated choice for sensitivity setting, used objective sleep parameters and reference values are important to provide more precise information about distribution of sleep parameters, prevalence of sleep problems and possible risk factors for sleep problems (e.g. gender, level of ID, age, co-morbidity and medication use) in older people with ID. We expect that in clinical practice the Actiwatch may provide useful additional diagnostic information in case of (suspected) sleep problems in older people with ID. In such situations, with motivated clients and personal caregivers, the measurement seems more likely to succeed. However, further research is needed into the validity of objective sleep parameters of the Actiwatch for the purpose of screening and epidemiological research.

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Chapter 4

Comparison of two types of Actiwatch with polysomnography in older adults with intellectual disabilities: a pilot study

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ABSTRACT

The Actiwatch is increasingly used to investigate sleep. The study aim was to investigate which sensitivity setting of the Actiwatch is most suitable to detect sleep disturbance in older adults with intellectual disability (ID).

Two Actiwatch types were compared to polysomnography in ten older adults with mild ID, using a 1-minute epoch-to-epoch comparison. Outcome measures were sleep detection percentage, wake detection percentage and overall accuracy of both Actiwatches, and several sleep parameters.

The high sensitivity setting of the Actiwatch appeared most suitable to detect sleep disturbance in older adults with ID (wake detection percentage 54.6%, sleep detection percentage 89.7%). Sleep parameters calculated using the high sensitivity setting, correspond well to polysomnography outcomes. Outcomes were similar for both Actiwatches.

We recommend using the high sensitivity setting of the Actiwatch for clinical evaluation of sleep, and for epidemiological research in older adults with ID.

INTRODUCTION

In people with intellectual disability (ID), sleep problems are common: the estimated prevalence ranges from 13% to 86% in children and adults,[1] and from 8.5% to 34.1% in adults specifically.[2] In most studies in this population, data were collected by questionnaire surveys and informant interviews.[2] Although this information can be informative, the outcomes may not be reliable because of communication limitations between clients and caregivers. Nighttime observation might be more reliable than questionnaire surveys, but it may be hard to see whether someone is asleep or not and it might disturb sleep as well. More objective assessments of sleep in this population are therefore desirable.

Polysomnography (PSG) is the gold standard for objective assessment of sleep in clinical practice and sleep research. As a whole, it involves an electroencephalogram (EEG), electrooculogram (EOG) and submental electromyogram (EMG) to assess sleep architecture, and measurement of airflow, oxygen saturation, electrocardiogram (ECG) and EMG of the legs to investigate the presence of sleep apnoea and restless legs syndrome.[3] Although PSG provides detailed information on sleep architecture, it requires complex recording equipment which is expensive, and it may be too burdensome for people with ID. An alternative for PSG is actigraphy, a technique to measure sleep-wake patterns based on body movement. Because actigraphy is non-invasive and easy to use, it is increasingly applied to assess sleep and sleep-wake patterns.[4] Actigraphy seems a suitable method for people with ID in particular, because it involves a small device that can be applied in the home environment.

In the Dutch Healthy Ageing and Intellectual Disability study (HA-ID), the Actiwatch (a type of actigraph) was used to investigate sleep problems.[5] The Actiwatch is a watch-like device with a motion sensor, and based on the amount of movement several parameters of sleep can be calculated. These sleep parameters can be obtained for different sensitivity settings (low, medium, high and auto). The sensitivity setting relates to the amount of movement that is needed to score a one-minute epoch as awake. So, for the low sensitivity setting more movement is required to consider an epoch awake than for a higher sensitivity setting.

We evaluated the Actiwatch data collected in the first year of the HA-ID study, investigating the influence of different sensitivity settings on sleep parameters, and found considerable differences for these parameters between the low and the high sensitivity setting. For example, sleep efficiency (the amount of time slept of the time spent in bed) ranged from 71.73% (high sensitivity) to 82.11% (low sensitivity).[6] In healthy individuals with good sleep quality in the general population, actigraphy has satisfactory validity compared to PSG. However, agreement with PSG is more questionable in special populations, for example older people or people with poor sleep quality.

[7] Because the Actiwatch measures movement, lower agreement is mainly caused by the fact that persons who lie awake without moving are incorrectly classified as being asleep.[4, 7-10]

Sleep architecture changes with ageing.[11-12] For example, phases of 'light sleep' increase with age and Rapid Eye Movement (REM) sleep (or 'dream sleep') decreases.[13] Moreover, sleep becomes more fragmented with ageing, manifesting as more arousals and awakenings.[14] Colling et al. (2000) investigated which sensitivity setting of the Actiwatch is suitable for older adults in the general population. In this study, sleep detection of the Actiwatch was compared to PSG in eight elderly subjects, and the best agreement rate was found for the high sensitivity setting.[15] For people with ID there is some evidence that suggests a correlation between the amount of REM sleep and level of ID, where less REM sleep is observed in people with a more severe level of ID.[16-17] Also in people with autism and ID, sleep architecture abnormalities are found. [18] Therefore, agreement between the Actiwatch and PSG may be different in older adults with ID. The aim of this pilot study was to compare two Actiwatch models (the model used in the HA-ID study and a new model) with PSG in order to answer the following research questions: 1. Which sensitivity setting of the Actiwatch is most valid to identify sleep disturbance in older adults with ID? 2. What is the agreement between the Actiwatch and PSG for frequently used sleep parameters based on the most valid sensitivity setting? and 3. Does the new Actiwatch model provide similar information as the previous model?

METHODS

Setting

Participants were ten older adults (45 years and over) with ID. Because polysomnography (PSG) can be stressful for people with intellectual disability (ID), only people who were capable of understanding the procedure of the study and who could provide informed consent themselves were invited to participate. Participants were recruited at a care facility in the south of the Netherlands. Clients from two community-based homes were informed about the study with an information poster and by their caregivers. If interested, clients were invited to an information session. During this information session, one of the researchers explained about the study using a real portable PSG recorder and photos of the measurement procedure. Professional caregivers and a behavioural therapist attended the information session as well in order to judge whether each client understood the study aims and procedures. Clients who wanted to participate received an informed consent form.

This study was approved by the ethical committee of Erasmus Medical Center Rotterdam (MEC 2011-234) and the board of the care facility.

Participants

Around 25 people visited the information session, of whom 10 provided informed consent to participate (8 males, 2 females). Three participants were excluded at the first evening of the measurements, several hours after applying the equipment. Two of these participants declined further participation themselves because they experienced the EEG electrodes as uncomfortable. For one participant the personal caregiver advized to stop the measurement because of unrest at bedtime. Because insufficient data were collected for these participants, they were excluded from the analysis.

Of the 7 remaining participants, 1 was female and 6 were male. Mean age was 65.3 years (range 48 – 77, SD 8.75). All participants had a mild (IQ 50-70) level of intellectual disability (ID). Two participants had been diagnosed with sleep apnoea syndrome prior to the beginning of the study and used a continuous positive airway pressure (CPAP) machine during the night.

Instruments

Actiwatches

Measurements were performed with two actigraphic devices. The first was the Actiwatch AW7 (manufactured by Cambridge Neurotechnology Ltd.), which was previously used in the Dutch Healthy Ageing with Intellectual Disability study (HA-ID).[6] The Actiwatch is a watch-like device that measures activity by means of a piezoelectric accelerometer that records the combination of intensity, amount and duration of movement. The corresponding voltage produced is converted and stored as an activity count.[19] The second device was the Actiwatch 2 (manufactured by Respironics, Inc.), which is currently available in the Netherlands as a substitute for the discontinued Actiwatch AW7. Both Actiwatches measure activity with a piezo-electric accelometer and were set to record activity counts in 1-minute epochs. In total, ten Actiwatch AW7s and five Actiwatch 2s were available for this study.

Polysomnography

To minimize burden for the participants, only recordings needed to measure sleep architecture were assessed during this study: electroencephalogram (EEG), electrooculogram (EOG) and chin electromyogram (EMG). PSG measurements were performed using portable recorders of the type Porti™s (Twente Medical Systems International).

Procedure

All measurements were performed in the participants' living facilities during two consecutive nights. EEG (Fo-Co, F3-C3, P3-O1, C4-A1, O2-A2), EOG (horizontal and vertical) and chin EMG electrodes were attached on-site by a neurophysiologic laboratory assistant in the afternoon before the first night of the measurement. The electrodes were connected to the portable recorder, which was placed on the waist by two belts (waist and shoulder). The Actiwatch AW7 and Actiwatch 2 were placed on the same wrist (the participant was allowed to choose which wrist). In order to enable an epoch-to-epoch comparison, Actiwatches and PSG recorder were synchronized by pressing the event marker button on the Actiwatches, and registering the time on the display of the Porti™s simultaneously. For the registration of bedtimes and get-up times, participants and their caregivers were instructed to press the event marker button of at least one Actiwatch at bedtime and get-up time. Although in general the portable PSG recorder is put behind the pillow when sleeping, for safety reasons the PSG recorder was placed on the abdomen of the participants with the waist belt during the night. The researcher (EvdW) and the participants' caregivers ensured that the participants were comfortable in their beds. During daytime (between the two nights of the measurement) PSG recordings were continued, so that application of the equipment not needed to be redone for the second night. Swimming, showering and bathing were not permitted to protect the recording equipment. Otherwise, participants followed their normal daily routines.

Analysis

Actiwatch data

Actiwatch AW7 data were analysed with Actiwatch Sleep Analysis 7 software (CamNtech Ltd version 7.27; Cambridge Neurotechnology Ltd.). Data were analysed for the low (80 activity counts per epoch), medium (40 activity counts per epoch), high (20 activity counts per epoch) and auto sensitivity setting for sleep. When the auto sensitivity setting is selected, the software sets an individual amount of counts above which an epoch is scored as wake based on the participant's activity level.[19] Actiwatch 2 data were analysed with Actiware software (Respironics, Inc.). This software provides the same sensitivity settings with the same amount of activity counts as a cut-off value, but uses the term 'high' for 80 activity counts and the term 'low' for 20 activity counts. In order to simplify comparison of both Actiwatches we equalized the terms of 'high' and 'low' according to the sensitivity to detect wake. This means that the term 'low' was used for 80 activity counts, and the term 'high' for 20 activity counts. For both types of Actiwatch, each 1-minute epoch was scored as 'sleep' or 'wake' by the computer software, consistent with the sensitivity settings.

Polysomnography data

PSG data were analysed at an expertise centre for epilepsy and sleep disorders (Kempenhaeghe, Heeze, the Netherlands) by a neurophysiologic laboratory assistant who was blind to the results of the Actiwatch measurements. PSG data were scored per 30-second epochs as wake, sleep stage N1, N2, N3 or REM-sleep, using BrainRT computer software. For epoch-to-epoch comparison with the Actiwatches, PSG data were converted to 1-minute epochs and binary form (0=any sleep state, 1=wake). If both 'wake' and 'N1, N2, N3 or REM' occurred in one minute (two 30-second epochs), the whole minute was scored as 'sleep', assuming that presence of a sleep stage implicates a restful condition.

Comparison of polysomnography and Actiwatch data

A one-minute epoch-to-epoch comparison between PSG data and Actiwatch data was performed for the low, medium, high and auto sensitivity settings of both Actiwatches.

The sleep detection percentage, the wake detection percentage and the overall accuracy of the Actiwatches against PSG outcomes were calculated for all data collected during nighttime (all minutes of all participants combined). Data between bedtime and get-up time (according to the time the event marker button was pressed) were considered as 'nighttime data'. In case the participant forgot to press the event marker button, bedtime and get-up time were determined using the graphical display of movement activity registered by the Actiwatch. A decrease of movement activity from daytime level to zero within 15 minutes in the evening was defined as bedtime; an increase of movement activity from zero to daytime level within 15 minutes in the morning was defined as get-up time.

Calculations were based on the amount of one-minute epochs scored as 'sleep' or 'wake' by both actigraphy and PSG, as previously performed by Hyde et al. (2007) and Kushida et al. (2001).[20-21] The 'sleep detection percentage' is defined as the percentage of minutes that was correctly detected as 'sleep' by the Actiwatch, of all minutes that were scored as 'sleep' by PSG. The 'wake detection percentage' is defined as the percentage of minutes that was correctly detected as 'wake' by the Actiwatch, of all minutes that were scored as 'wake' by PSG. The 'overall accuracy' is defined as the sum of minutes that were correctly detected as 'sleep' and 'wake' by the Actiwatch, divided by all minutes that were recorded (x100%). We defined that the most valid sensitivity setting was the setting with the best wake detection percentage, which was considered important to detect sleep disturbance, combined with an acceptable sleep detection percentage.

Subsequently, sleep parameters were calculated for each night of each participant separately, using the sensitivity setting that had been identified as most valid. Calculations of sleep parameters were performed for the PSG data and Actiwatch data, within

the same time window (between bedtime and get-up time). For the Actiwatch, sleep parameters were calculated using the computer software. For the PSG data, sleep parameters were calculated manually, using the same algorithms for sleep parameters as the Actiwatch software. For the Actiwatch, sleep start and sleep end were based on the first 10 minutes immobility after bedtime, and last 10 minutes immobility before get-up time by the computer software.[22] For PSG, sleep start and sleep end were based on the presence of the first sleep stage after bedtime and the last sleep stage before get-up time. Sleep parameters of interest were sleep onset latency (SOL), the interval between bedtime and sleep start; total sleep time (TST), total time scored as asleep between sleep start and sleep end; wake after sleep onset (WASO), total time scored as awake between sleep start and sleep end; and sleep efficiency (SE), percentage of total time asleep between bedtime and get-up time. To assess agreement between the Actiwatch and PSG, the sleep parameters were compared using Bland-Altman plots.[23]

RESULTS

Available polysomnography (PSG) and Actiwatch data

Table 1 shows the number of nights for which successful measurements were obtained with each instrument. Totally, 11 nights were available for comparison of the Actiwatch AW7 and PSG, and 5 nights were available or comparison of the Actiwatch 2 and PSG.

Comparison of PSG and Actiwatch AW7 data

Epoch-to-epoch comparison

In total 5.739 minutes of nighttime data (out of 11 nights) were available for Actiwatch AW7 to PSG comparison. Sleep detection percentage, wake detection percentage and overall accuracy of the Actiwatch AW7 are displayed in Table 2.

The high sensitivity setting (20 activity counts) of the Actiwatch AW7 provided the best wake detection percentage (54.6%, CI 51.6-57.6), combined with an acceptable sleep detection percentage (89.7%, CI 88.2-90.6).

Sleep parameters

Mean values of sleep onset latency (SOL), total sleep time (TST), wake after sleep onset (WASO) and sleep efficiency (SE) were calculated for the 11 available nights of the Actiwatch AW7 using the high sensitivity setting (20 activity counts) and compared to corresponding nights measured with PSG (Table 3).

Table 1 Available polysomnography and Actiwatch data

Participant	Gender (M/F)	Age	Nights PSG	Nights AW7/ Ac2[#]	Reasons for missing data
1	M	66	2	2/0	Technical problem Actiwatch 2, no data recorded
2	M	68	1	1/1	In the second night, the wake detection percentage largely differed between the Actiwatch 2 and Actiwatch AW7 (>35%). Visual comparison of graphical activity displayed excessive differences in recorded activity between both Actiwatches. Therefore this night was excluded.
3	F	77	1	2/2	Due to a technical problem of the PSG recorder, no data were recorded for the second night
4	M	65	2	2/2	
5	M	48	1	1/1	The participant wanted to quit the measurement the evening before the second night, because of headache and irritation of the PSG electrodes.
6	M	69	2	2/0	The participant did not wear the Actiwatch 2 (only 5 Actiwatch 2 available)
7	M	64	2	2/0	The participant did not wear the Actiwatch 2 (only 5 Actiwatch 2 available)
Total successful measurements *Available for comparison*			11	12 /6 11/5	

[#] AW7= Actiwatch AW7, Ac2 = Actiwatch 2

Table 2 Epoch-to-epoch comparison Actiwatch AW7 and polysomnography

Actiwatch AW7 sensitivity setting	Sleep detection percentage % (CI)	Wake detection percentage % (CI)	Overall accuracy % (CI)
Low (80)	96.5 (95.9-97.0)	39.2 (36.2-42.1)	85.6 (84.7-86.6)
Medium (40)	93.0 (92.3-93.8)	47.7 (44.7-50.7)	84.5 (83.5-85.4)
High (20)	89.7 (88.2-90.6)	54.6 (51.6-57.6)	83.1 (82.1-84.0)
Auto (variable)	96.4 (95.9-96.9)	33.6 (30.8-36.4)	84.6 (83.6-85.5)

CI = confidence interval

Table 3 Mean values for sleep parameters measured with the Actiwatch AW7 and PSG

	SOL[*] (minutes)	TST[$] (minutes)	WASO[#] (minutes)	SE[^] (%)
Actiwatch AW7 High (20 counts)	7.3	422.4	72.8	81.3
PSG	11.8	407.2	66.0	78.5

[*] Sleep onset latency, [$] Total sleep time, [#] Wake after sleep onset, [^] Sleep efficiency

On average, values of sleep parameters calculated with the high sensitivity setting of the Actiwatch AW7 approximate the values of sleep parameters measured with PSG. SOL was underestimated with 4.5 minutes on average by the Actiwatch AW7. On average, TST was overestimated with 15.2 minutes, WASO was overestimated with 6.8 minutes and SE was overestimated with 2.8% by the Actiwatch AW7. Bland-Altman plots of SOL, TST, WASO and SE are displayed in Figure 1.

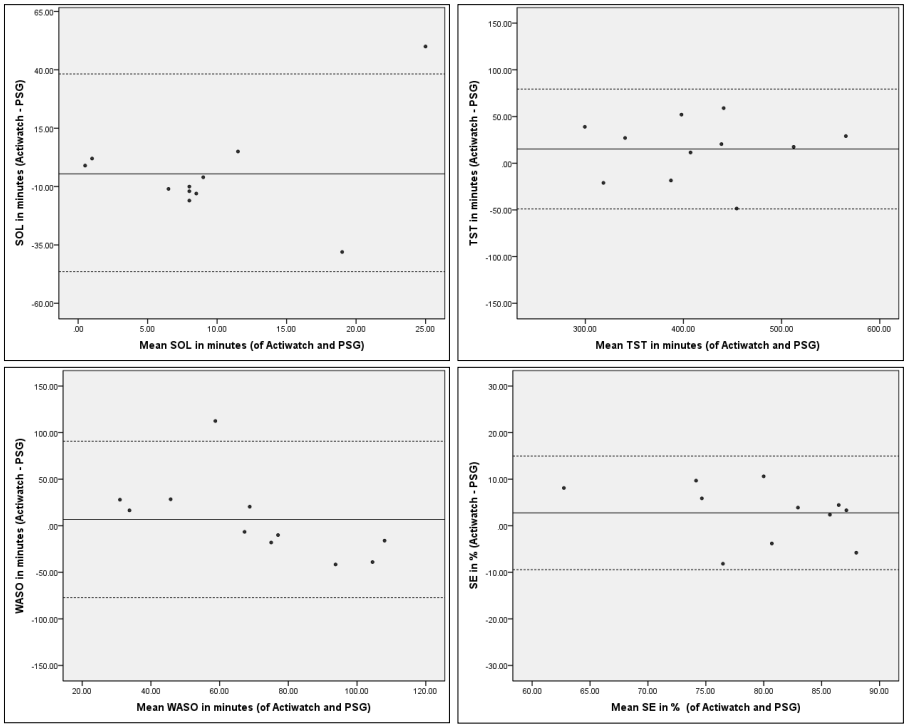

Figure 1 Bland-Altman plots for sleep onset latency (SOL), total sleep time (TST), wake after sleep onset (WASO) and sleep efficiency (SE).
Plots reflect comparison of Actiwatch AW 7 (high sensitivity setting) with PSG.
——— Mean difference between Actiwatch and PSG sleep parameters
····· Mean difference +/- 2 SD (standard deviations)

In the Bland-Altman plot for SOL, one data point was >2SD (standard deviations) from the mean SOL difference. For WASO, in the Bland-Altman plot also one data point was >2SD (standard deviations) from the mean difference. Review of these data points revealed that these points belonged to two different nights in two different participants.

Comparison of PSG and Actiwatch 2 data

Epoch-to-epoch comparison

For the Actiwatch 2, 2.838 minutes of nighttime data (out of 5 nights) were available for comparison to PSG. Sleep detection percentage, wake detection percentage and overall accuracy of the Actiwatch 2 are displayed in Table 4.

Sleep parameters

Mean values of the sleep parameters SOL, TST, WASO and SE were calculated for the available nights of the Actiwatch 2 (5 nights) using the high sensitivity setting, and compared to corresponding nights measured with PSG (Table 5).

Table 4 Epoch-to-epoch comparison Actiwatch 2 and polysomnography

Actiwatch 2 sensitivity setting	Sleep detection percentage % (CI)	Wake detection percentage % (CI)	Overall accuracy % (CI)
Low (80)	97.9 (97.8) CI: 97.3-98.5	61.4 (56.5) CI: 57.3-65.5	91.0 (90.0) CI: 90.0-92.1
Medium (40)	95.4 (95.3) CI: 94.6-96.3	69.6 (67.7) CI: 65.7-73.5	90.6 (90.1) CI: 89.5-91.6
High (20)	92.4 (92.6) CI: 91.4-93.5	77.4 (75.2) CI: 73.9-81.0	89.6 (89.3) CI: 88.5-90.7
Auto (variable)	99.3 (98.5) CI: 98.9-99.6	41.0 (44.2) CI: 36.9-45.2	88.3 (88.3) CI:87.1-89.5

CI = confidence interval
Data for corresponding nights of the Actiwatch AW7 are displayed in parentheses. Confidence intervals are provided for the Actiwatch 2.

Table 5 Mean values for sleep parameters measured with Actiwatch 2 and PSG

	SOL* minutes	TST$ minutes	WASO# minutes	SE^ %
Actiwatch 2 *High, 20 counts*	5.6 (5.0)	439.6 (452.6)	58.0 (72.4)	78.3 (80.4)
PSG	17.4	446.8	51.2	80.0

* Sleep onset latency, $ Total sleep time, # Wake after sleep onset, ^ Sleep efficiency
Data for corresponding nights of the Actiwatch AW7 are displayed in parentheses.

On average, values of sleep parameters calculated for the high sensitivity setting of the Actiwatch 2 also approximate the values of sleep parameters measured with PSG. On average, SOL was underestimated with 11,8 minutes, TST was underestimated with 7,2 minutes and SE was underestimated with 1,7% by the Actiwatch 2. WASO was on average overestimated with 6.8 minutes by the Actiwatch 2.

Comparison of Actiwatch AW7 and Actiwatch 2

The Actiwatch 2 data were compared to the corresponding nighttime data (5 nights, 2.838 minutes) measured with the Actiwatch AW7, in order to enable a comparison between the two actigraphy devices. Sleep detection percentage, wake detection percentage and overall accuracy of the Actiwatch AW7 in comparison to the Actiwatch 2 (same one-minute epochs) are displayed in parentheses in Table 4. The wake detection percentage of the Actiwatch 2 was slightly better for the low, medium and high sensitivity setting. Overall, sleep detection percentage and overall accuracy of the Actiwatch 2 approximated that of the Actiwatch AW7.

For the sleep parameters, data for corresponding nights of the Actiwatch AW7 are displayed in parentheses in Table 5. SOL was underestimated by both Actiwatch devices. TST was overestimated by the Actiwatch AW7, but was underestimated by the Actiwatch 2. WASO was overestimated by both devices, but this overestimation was larger by the Actiwatch AW7.

DISCUSSION

This is the first pilot study into the validity of two Actiwatch devices against polysomnography (PSG) in older adults with intellectual disability (ID). Measurements were performed in the home environment. The high sensitivity setting (20 activity counts) of the Actiwatch provides the best validity to identify nighttime waking (or sleep disturbance) in this population. On average, mean values of sleep parameters calculated using the high sensitivity setting of the Actiwatch approximate the values of sleep parameters measured with polysomnography (PSG). The sleep detection percentage, the wake detection percentage and the overall accuracy of the newer Actiwatch 2 are similar to that of the Actiwatch AW7.

In prior research on the validity of the Actiwatch compared to PSG, 'sensitivity' and 'specificity' are often used to describe sleep and wake detection percentage.[7] However, in epidemiological research, the term sensitivity indicates the percentage of people with a disease who are correctly identified as having the condition, and specificity indicates the percentage of healthy people who are correctly identified as not having the condition. Therefore we found application of these terms to epoch-to-

epoch comparison of PSG and the Actiwatch confusing, the more so because the term 'sensitivity' is already used in the 'sensitivity setting' of the Actiwatch. Accordingly, we chose to use the terms 'sleep detection percentage' and 'wake detection percentage'.

Although the wake detection percentage was best using the high sensitivity setting, it is still only 54.6% (CI 51.6-57.6). This indicates that around 45% of the time that is indicated as 'sleep' by the Actiwatch, is actually 'wake' according to the gold standard PSG. This is in accordance with the finding that detection of wake may be difficult in older people.[7] Our findings correspond to that of Kushida et al. (2001), who compared a similar type of Actiwatch with PSG in 100 people with normal intelligence and a sleep disorder. In that study population the sleep detection percentage ranged from 92% to 98%, but the wake detection percentage ranged from 28% to 48%.[21] We conclude that also in older adults with ID, the Actiwatch is more sensitive to detect sleep than to detect wake.

Differences in mean values of sleep parameters between the Actiwatch and PSG are smaller than one might expect based on the relatively low wake detection percentage. Based on this finding, using the high sensitivity setting of the Actiwatch provides a relatively reliable estimate of the sleep parameters in older adults with ID. The Bland-Altman plots (Figure 1) show that almost all data points are between the 2SD (standard deviation) lines, which indicates fairly good agreement for both instruments. However when interpreting these plots, one has to take into account that standard deviations of the mean differences are large, probably as a result of the small sample size and differences in sleep patterns between individuals. Also, sleep start and sleep end had to be defined differently for PSG and Actiwatch data: for PSG, sleep start was defined when sleep stages appear, whereas for the Actiwatch, sleep start is defined after the first 10 minutes in immobility. One can imagine that because of this, sleep start and sleep end times can differ between both methods. This probably caused the outliers in the Bland-Altman plots, but could have influenced the agreement between the Actiwatch and PSG in other nights as well.

When comparing both Actiwatch devices, the wake detection percentage of the Actiwatch 2 seems slightly better. Both software systems use equal algorithms to define sleep and wake, so the slight differences in sleep detection percentage, wake detection percentage and overall accuracy between both Actiwatches are probably explained by differences in material of which the Actiwatches are made of, slightly different positions of the Actiwatches on the wrist, or differences in tightness of the straps on the wrist. Larger differences between both Actiwatch devices were found for the sleep parameters. Apparently, the differences in sleep and wake detection percentage between both Actiwatches become more clear when calculating sleep parameters.

One could expect that agreement of the Actiwatch and PSG would have been good for the auto sensitivity setting, because this setting relies on individual movement patterns. However, the wake detection percentage was lowest for the auto setting, combined with a very high sleep detection percentage. This indicates that the auto sensitivity setting tends to favour scoring epochs as sleep, making this setting inadequate to investigate sleep disturbance in older adults with ID. The overall accuracy of the Actiwatch was 83.1% to 85.6% in our study. However, our results also indicate that a high overall accuracy can mask a low wake detection percentage. The overall accuracy should therefore be interpreted with care.

Previously, to our knowledge, only in a few studies with PSG in people with ID in the home environment were performed.[16, 24-25] For people with ID, ambulant PSG might be preferred over a sleep laboratory, to overcome sleep disturbance due to the laboratory setting. Home PSG can be more comfortable, and might provide more reliable information, because the client sleeps in a 'safe' and familiar environment. Yet, in our study in three participants the measurement did not succeed for at least one night. Although participants and caregivers were carefully instructed, unfamiliarity with PSG measurements at home was an important cause of missing data in our pilot. When performing home PSG measurements for diagnosing sleep disorders or for research, more extensive instruction of caregivers and anticipating possible practical problems are very important to avoid stress of caregivers.

There are some limitations to this study. First, conclusions are based on a small sample with mild level of ID. Because of the small study sample, individual sleep quality (for example much or little movement during sleep) can influence the data selectively. On the other hand, many one-minute epochs of nighttime data were collected to compare the Actiwatch to PSG. Second, participants slept with the PSG recorder on the abdomen. As a result, participants might have tended to move less in their beds, which can result in more false sleep (scoring of sleep by the Actiwatch but actually being awake). However, moving less or more carefully can be inherent to PSG research because people tend to be careful with the measurement equipment. The results that were found in our study (e.g. relatively low wake detection percentage of the Actiwatch) might be better in a 'natural' sleep situation. Third, results are based on a sample of participants with mild ID. Although correspondence between PSG and actigraphy might be different in people with more severe brain damage (severe and profound ID), performing a PSG study in people with severe and profound ID might be too much of a burden. Based on practical experience, we hypothesize that movement activity during the night in this group is similar or even less (due to more severe neurological pathology and movement disorders) than movement activity in more able subgroups. Based on this, the high sensitivity setting might also be applicable for people with a more severe level of ID. However, to strengthen our findings,

this study could be replicated in a larger study sample. When doing so, people with a more severe level of ID could be included if possible. Also, people with and without sleep difficulties could be compared, as well as people with different mobility levels. In future research attention could be paid to how the PSG recorder is placed in the bed, in a way that is both safe and hampers the participants as little as possible.

The Actiwatch is easy to use, enables a multi-night measurement and is generally minimally burdensome. Therefore in clinical practice, the Actiwatch can be a valuable instrument to evaluate sleep disturbance in older adults with ID. We recommend using the high sensitivity setting of the Actiwatch to investigate sleep in both clinical practice and in epidemiological research in this population.

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Chapter 5

Comparison of the Actiwatch with polysomnography in older adults with intellectual disabilities: brief report on daytime data

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Submitted

Chapter 6

Circadian sleep-wake rhythm in older adults with intellectual disabilities

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ABSTRACT

The circadian sleep-wake rhythm changes with ageing, resulting in a more fragmented sleep-wake pattern. In individuals with intellectual disabilities (ID), brain structures regulating the sleep-wake rhythm might be affected. The aims of this study were to compare the sleep-wake rhythm of older adults with ID to that of older adults in the general population, and to investigate which factors are associated with the sleep-wake rhythm in older adults with ID.

This study is part of the 'Healthy Ageing and Intellectual Disabilities' study (HA-ID). We applied actigraphy in 551 persons with ID and 58 persons in the general population, aged 50 years and over. Outcome measures were stability (interdaily stability), fragmentation (intradaily variability) and amplitude (relative amplitude) of the sleep-wake rhythm.

Compared to older adults in the general population, the sleep-wake rhythm of older adults with ID was significantly less stable ($p=.03$), more fragmented ($p<.001$) and had a lower relative amplitude ($p<.001$). Multivariate regression analysis revealed that higher age, dementia, depression, visual impairment, severe hearing impairment, epilepsy and spasticity are independently associated with a more disturbed sleep-wake rhythm in this group. The sleep-wake rhythm is more stable in females and those living at a setting for more intensive care. Higher physical activity levels are strongly associated with both a less fragmented ($p<.001$) and a more stable ($p<.001$) sleep-wake rhythm. Higher age, dementia and depression are also associated with the sleep-wake rhythm in the general population. Neurological and sensory impairments that were associated with the sleep-wake rhythm in older adults with ID, are frequent known conditions in the ID population. Further research should focus on which factors specifically influence the sleep-wake rhythm in older adults with ID, and on the effects of more physical daytime activity on the sleep-wake rhythm in this population.

INTRODUCTION

The sleep-wake rhythm is a biological rhythm with duration of around 24 hours.[1] This circadian sleep-wake rhythm is controlled by the 'circadian pacemaker', a small group of cells located in the hypothalamus, called the suprachiasmatic nucleus (SCN).[2] Because the normal intrinsic circadian rhythm duration is slightly longer than 24 hours,[3] precise synchronization to a 24-hour day mainly depends on exposure to environmental time signals, the so-called 'Zeitgebers', of which light is the most important one. A disrupted sleep-wake rhythm can lead to diminished quality of life, performance and health.[2]

The SCN degenerates in the process of ageing.[4] As a result, older adults wake up earlier than younger adults, and their sleep becomes often more fragmented.[5] In patients with Alzheimer's disease, alterations of the sleep-wake rhythm might also be explained by decreased SCN function.[6] Besides SCN function, environmental factors and physical activity can affect the sleep-wake rhythm in older adults as well. Van Someren et al. (1997) observed that three months of fitness training led to a less fragmented rhythm in 10 healthy older men.[7] Meadows et al. (2010) studied the influence of residential status on the sleep-wake rhythm in 122 non-demented care-home residents and 52 community-dwelling poor sleepers. They observed that the care home residents had a more fragmented sleep-wake pattern than community-dwelling older adults, which could have been caused by ambient noise and light at night.[8] In older adults in the general population, depression is also associated with sleep-wake rhythm disturbances.[9]

Because individuals with ID have some form of brain dysfunction, the circadian pacemaker in the SCN or pathways involved in the sleep-wake rhythm might be affected as well, besides the process of ageing. Additionally, people with ID often live in groups with other clients, which might disturb the sleep-wake rhythm. As a result, the circadian sleep-wake rhythm in older adults with ID might be more affected than the sleep-wake rhythm of older adults in the general population.

To our knowledge, no studies have been published on the circadian sleep-wake rhythm of older adults with intellectual disability (ID). Therefore, the aims of this study were to compare the sleep-wake rhythm of this population with that of older adults in the general population, and to investigate factors related to the circadian sleep-wake rhythm in older adults with intellectual disabilities.

METHODS

Study design and participants

Older adults with intellectual disabilities

This study was part of the large cross-sectional study 'Healthy Ageing and Intellectual Disabilities' (HA-ID) in 1050 clients aged 50 years and over, who receive support or care from three intellectual disability (ID) care provider services in the Netherlands. Details about design, recruitment and diagnostic methods have been presented elsewhere.[10] Ethical approval was provided by the Medical Ethical Committee of the Erasmus Medical Center (MEC 2008-234) and by the ethical committees of the participating care provider services. Written informed consent was obtained from all participants or their legal representatives. The study adheres to the Declaration of Helsinki for research involving human subjects.

Comparison group

The comparison group consisted of community-dwelling adults aged 50 years and over in the general population, who were family members, friends or colleagues of the researchers. Informed consent was obtained from all participants. Exclusion criteria were immobility of the arms, shift work or a flight over more than two time zones within one week before or during measurement, as well as known circadian rhythm disorders or neurodegenerative disorders.

Materials

Participant characteristics

For the older adults with ID, general information on age, gender and residential status was collected through the care providers. Residential status was categorized as central setting (care), community-based setting (support) and living independently with ambulatory support. Level of ID was obtained from behavioural therapists' and psychologists' records (borderline, mild, moderate, severe or profound). Information on physical or mental co-morbidities (autism, dementia, epilepsy, visual impairment, hearing impairment, spasticity, Down syndrome) and medication use (anti-epileptics, benzodiazepines, antidepressants and antipsychotics) was acquired from medical and behavioural therapists' records. Depression symptoms were assessed using self-report (Inventory of Depressive Symptomatology Self Report, IDS-SR) and informant-report (Dutch informant-report Signalizing Depression List for people with Intellectual Disabilities, SDL-ID) screening instruments. Severe depression symptoms were defined as a score above the cut-off of at least one of these screening instruments.[11] Informa-

tion on dementia was available in both the medical and behavioural therapist record. Because dementia is difficult to diagnose in older adults with ID, only cases with consensus between the medical and behavioural therapist record (diagnosis in both records, one suspicion and one diagnosis, or both suspicion) were used for further analysis.

For the comparison group, general information on age, gender and exclusion criteria was obtained using a short questionnaire.

Sleep-wake rhythm assessment

The circadian sleep-wake rhythm (from here called 'sleep-wake rhythm') was assessed using actigraphy. Actigraphy is a valid method to measure the circadian rhythm[12-14] and it is applicable in adults with ID.[15] The actigraphy device used in the HA-ID study is the Actiwatch AW7 (Cambridge Neurotechnology, UK). This is a watch-like device measuring movement activity by means of a piezo-electric accelerometer that records the combination of intensity, amount and duration of movement.[16] Based on the distribution of movement activity, rest-activity parameters are calculated by the computer software.[17] Statements on the sleep-wake rhythm were based on these rest-activity parameters. The assessed parameters were Interdaily Stability (IS), Intradaily Variability (IV) and Relative Amplitude (RA). IS is a measure of the stability of the rhythm, or the strength of coupling of the rhythm to environmental Zeitgebers. It ranges from 0 to 1, where 1 represents the perfect coupling. A decrease of IS indicates a higher day-to-day variation. IV indicates the fragmentation of the rhythm. It ranges from 0 to 2. A higher value is indicative of a more disrupted sleep-wake rhythm, for example by the occurrence of daytime napping and/or night-time arousals. RA expresses the ratio between the most active 10h span and the least active 5h span in an average 24 h pattern. It ranges from 0 to 1. A higher value indicates a better sleep-wake rhythm. To our knowledge, there are no cut-off points available for the parameters of stability and fragmentation, to distinguish a normal or a disturbed sleep-wake rhythm.

Participants wore the Actiwatch for 10-14 days and nights consecutively. Although it was recommended to wear the Actiwatch on the non-dominant wrist,[18] the hand dominance of many of the participants with ID was unknown. In those cases the participants or their personal caregivers decided on which wrist the Actiwatch could be worn. In case of hemiparesis, the Actiwatch was placed on the functional wrist. A measurement was deemed to be successful if the Actiwatch had been worn for a minimum of 7 days and nights continuously, without gaps of more than 4 hours during a 24-hour period.[19] In case of a gap of 4 hours or more, the software calculations were performed for the days and nights before or after the gap (if at least 7 days remained for analysis).

Daytime activity assessment in older adults with ID

Measures of daytime activity were the number of day-care sessions during the week and M10. The number of day-care sessions was obtained by personal caregivers of the participants. M10 was measured with the Actiwatch, and is the sum of all activity counts within the 10-hour span with the highest activity level. Although both daytime activity (M10) and measures of stability and fragmentation of the sleep-wake rhythm (IS and IV) are derived from actigraphic measurements, these variables are not intrinsically dependent on each other and also do not have mathematical dependence.[20] IS and IV are based on relative changes in physical activity at random times during the day or in a scheduled way, independent of the absolute amount of physical activity.[20]

Analysis

Actiwatch data were analysed using the Actiwatch Sleep Analysis 7 Software (Non-Parametric Circadian Rhythm Analysis).[16] SPSS 17.0 for Windows was used for statistical analyses.

Chi-square tests and T-tests were used to test representativeness of the sample older adults with ID compared to the total HA-ID population, and to test for differences in age and gender between older adults with ID and the comparison group. Independent samples T-tests or Oneway Analyses of Variance (ANOVA) were used to test whether there were differences for IS, IV and RA between levels of ID, age groups, gender, residential status, co-morbid conditions and used medications (univariate analysis). In the ANOVA, either Bonferroni (equal variances of over subgroups) or Tamhane (unequal variances over subgroups) post-hoc tests were used. To explore which factors were independently related with the sleep-wake rhythm, linear regression analysis was performed (multivariate analysis). The following factors were added to the model: age, gender, level of ID, residential status, measures of daytime activity (M10 and number of day-care sessions) and all factors with significant results in the univariate analysis. Because M10 is used to calculate RA, M10 was only included in the regression models of IS and IV, whereas number of sessions of day-care per week was used as an indicator for daytime activity in the regression model of RA. To correct for the effects of the use of any medication (anti-epileptics, benzodiazepines, antidepressants and/or antipsychotics) on the sleep-wake rhythm, an additional variable was computed (medication use yes/no). The regression analyses of IS, IV and RA were also performed including the variable 'medication use yes/no' (other medication variables were excluded in these models).

All factors were checked for multicollinearity; a Variance Inflation Factor (VIF) above 10 was considered unacceptable.[21] All variables were added simultaneously to the model using the forced entry (or 'Enter') method. To study differences in mean IS, IV,

RA and M10 scores between participants with ID and participants in the comparison group, an independent samples T-test was used.

RESULTS

Participant characteristics

Older adults with ID

Of the 1050 participants who initially enrolled into the HA-ID study, 551 wore the Actiwatch. Excluded from the study were participants who refused to wear the device and those who were known to easily lose or break things. In 50 cases, the Actiwatch was not worn for at least 7 consecutive days, so 501 participants were included in the analyses. Characteristics of the participants are displayed in Table 1. Mean age was 62.0 years (SD = 8.0; range = 50-92 years), and mean number of sessions of day-care per week was 6.3 (SD = 3.0; range = 0 to 10 sessions).

The group of participants that wore the Actiwatch included fewer people with severe or profound ID (χ^2 (4) = 85.1 (p <0.001)) and more people living in the community (χ^2 (2) = 85.1; p <0.001), compared to the total HA-ID study population.

Table 1 Participant characteristics

	Number (%)	
	Participants with ID (N=501)	Comparison group (N=56)
Gender		
Male	252 (50.3)	26 (46.4)
Female	249 (49.7)	30 (53.6)
Age		
50-59	222 (44.3)	28 (50.0)
60-69	180 (35.9)	20 (35.7)
70 +	99 (19.8)	8 (14.3)
Level of ID		
Borderline	25 (5.0)	
Mild	127 (25.3)	
Moderate	266 (53.1)	
Severe	48 (9.6)	
Profound	26 (5.2)	
Unknown	9 (1.8)	

Table 1 Participant characteristics *(continued)*

	Number (%)	
	Participants with ID (N=501)	Comparison group (N=56)
Residential Status		
Central Setting	202 (40.3)	
Community-based	259 (51.7)	
Independent	35 (7.0)	
Unknown	5 (1.0)	
Co-morbidities		
Down syndrome	48 (9.6)	
Autism	63 (12.6)	
Depression (severe symptoms)	71 (14.2)	
Dementia (suspicion + diagnosis)	22 (4.4)	
Epilepsy	84 (16.8)	
Visual impairment	82 (16.4)	
Mild hearing impairment	50 (10.0)	
Moderate hearing impairment	73 (14.6)	
Severe hearing impairment	39 (7.8)	
Spasticity	50 (10.0)	
Medication use		
Antiepileptics	90 (18.0)	
Benzodiazepines	68 (13.6)	
Antidepressants	48 (9.6)	
Antipsychotics	107 (21.4)	
Use of at least one of these medications	219 (41.9)	

Comparison group

The comparison group consisted of 58 participants. Actiwatch data of two participants were incomplete, which left data of 56 participants for the analyses. Demographic characteristics of the comparison group are also presented in Table 1. Mean age was 61.3 years (SD = 8.4, range = 50-89 years). Participants with ID and the comparison group did not differ significantly in mean age ($t = 0.64$; $p = 0.52$) and gender ($\chi^2(1) = 0.30$; $p=0.58$).

Comparison of older adults with ID to the comparison group

Mean IS, IV and RA of the comparison group and older adults with ID are presented in Table 2. Older adults with ID had a lower IS (less stability of the rhythm), a significantly higher IV and a significantly lower RA (both implying more fragmentation of the rhythm) than the comparison group. Mean M10 (activity count) of the comparison group was significantly higher than mean M10 of adults with ID (19852 against 13742) ($t = -5.27$; $p<0.001$).

Table 2 Differences in Interdaily Stability (IS), Intradaily Variability (IV) and Relative Amplitude (RA) between older adults with ID and the comparison group

		Older adults with ID	Comparison group	p*
IS	Mean (SD)	0.53 (0.15)	0.57 (0.10)	0.03
	Confidence Interval 95 %	0.52 – 0.55	0.54 – 0.59	
IV	Mean (SD)	0.97 (0.32)	0.81 (0.17)	< 0.001
	Confidence Interval 95 %	0.94 – 1.00	0.76 – 0.86	
RA	Mean (SD)	0.82 (0.14)	0.92 (0.04)	< 0.001
	Confidence Interval 95 %	0.80 – 0.83	0.91 – 0.93	

* T-test

Distribution and associated factors of the sleep-wake rhythm in older adults with ID

Mean IS, IV and RA of participants with ID are presented in Table 2. Mean values of IS, IV and RA in subgroups, as well as significant differences between groups, are presented for all variables in Table 3.

Variables that were added to one or more of the models for IS, IV and RA were: age, level of ID, residential setting, gender, M10 (for IV and IS) or number of sessions of day-care per week (for RA), epilepsy, depression, dementia, visual impairment, hearing impairment, spasticity, antiepileptic medication use and benzodiazepine use (Table 3). Not all variables could be obtained in all participants, therefore the number of participants included in the regression models were n=363 for IS, n=380 for IV and n=352 for RA, depending on which variables were added to each model.

For IS, seven significant variables accounted for 32.9% of the variance. A lower IS (or less stable sleep-wake rhythm) was independently associated with diagnosis of dementia, visual impairment, severe hearing impairment and spasticity. Female gender, living at a residential setting and more daytime activity (M10) were independently associated with a higher IS (or more stable sleep-wake rhythm).

For IV, three significant variables accounted for 42.0% of the variance. The IV was higher (or more fragmented rhythm) with higher age and dementia. A lower IV (or more stable rhythm) was independently associated with more daily physical activity (M10).

Table 3 Univariate relationships with interdaily stability, intradaily variability and relative amplitude

		IS	IV	RA
Gender	Male	0.53	0.96	0.81
	Female	0.54	0.98	0.83
Age	50-59	0.53	0.89 ***	0.82 **
	60-69	0.55	0.97 ***	0.83 **
	70+ *(ref)*	0.51	1.14	0.77
Level of ID	Borderline	0.57	0.93	0.83
	Mild	0.54	0.91	0.81
	Moderate	0.54	0.97	0.83
	Severe	0.51	1.00	0.79
	Profound *(ref)*	0.47	1.13	0.78
Residential Status	Independent *(ref)*	0.52	0.82	0.84
	Community Based	0.54	0.95 *	0.83 ^
	Central Setting	0.53	1.02 ***	0.79
Down syndrome	no	0.53	0.99	0.82
	yes	0.52	0.98	0.77
Autism	no	0.53	0.98	0.81
	yes	0.54	0.90	0.84
Depression	no	0.54	0.95	0.82
	Severe symptoms	0.49 *	1.06*	0.76 **
Dementia	no	0.54	0.97	0.82
	Diagnosis + suspect	0.45 **	1.19 **	0.66 **
Epilepsy	no	0.54	0.96	0.82
	yes	0.49 **	1.09 **	0.79
Visual Impairment	no	0.54	0.98	0.83
	yes	0.49 *	1.02	0.77 **
Hearing impairment	no *(ref)*	0.55	0.96	0.83
	Mild	0.50	1.04	0.80
	Moderate	0.53	0.99	0.82
	Severe	0.48 *	1.07	0.73***#
Spasticity	no	0.54	0.97	0.82
	yes	0.45 **	1.13 ***	0.75 *
Antiepileptic use	no	0.54	0.95	0.82
	yes	0.49 **	1.10 **	0.79
Benzodiazepine use	no	0.54	0.97	0.82
	yes	0.49 *	1.02	0.80
Antidepressant use	no	0.53	0.98	0.81
	yes	0.53	0.97	0.82
Antipsychotic use	no	0.53	0.99	0.82
	yes	0.53	0.97	0.81

IS=interdaily stability, IV=intradaily variability, RA=relative amplitude
ref = reference category
* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$; (significant values compared to reference category)
# in relation to mild hearing impairment $p \leq 0.05$;
^ in relation to community-based $p \leq 0.05$

Table 4 Multivariate, independent relationships with interdaily stability, intradaily variability and relative amplitude

	Interdaily Stability		Intradaily Variability		Relative Amplitude	
Independent variable	B (SE)	Beta	B (SE)	Beta	B (SE)	Beta
(constant)	.379 (.067)		.695 (.135)		.980 (.082)	
Female gender	.037 (.013)	.130 **	-.041 (.026)	-.064	.020 (.014)	.074
Age	.001 (.001)	.041	.008 (.002)	.207 ***	-.003 (.001)	-.153 **
Mild ID [a]	-.053 (.032)	-.160	.040 (.065)	.055	.023 (.033)	.069
Moderate ID	-.035 (.031)	-.123	.054 (.063)	.085	.035 (.032)	.128
Severe ID	-.034 (.036)	-.077	-.003 (.073)	-.002	.020 (.037)	.096
Profound ID	-.032 (.042)	-.054	.027 (.084)	.021	.017 (.043)	.029
Central setting living [b]	.078 (.030)	.271 *	.006 (.060)	.009	-.035 (.033)	-.124
Community-based living	.028 (.028)	.100	.036 (.057)	.056	-.034 (.031)	-.123
M10 (physical activity)	8.6E-006 (.000)	.485 ***	-2.1E-005 (.000)	-.547 ***	-	
Number of sessions day-care	-		-		.004 (.003)	.084
Epilepsy	-.072 (.033)	-.204 *	.060 (.065)	.082	-	
Depression (severe symptoms)	-.034 (.020)	-.086	-.032 (.039)	-.035	-.049 (.021)	-.127 *
Dementia (diagnosis + suspect)	-.036 (.033)	-.054	.151 (.060)	.109 *	-.132 (.036)	-.204 ***
Visual impairment	-.039 (.017)	-.109 *	-		-.057 (.018)	-.160 **
Mild hearing impairment [c]	-.010 (.021)	-.023	-		.005 (.022)	.013
Moderate hearing impairment	-.001 (.018)	-.002	-		.000 (.019)	.001
Severe hearing impairment	-.052 (.024)	-.109 *	-		-.046 (.025)	-.101
Spasticity	-.050 (.022)	-.112 *	.040 (.043)	.042	-.078 (.023)	-.180 **
Anti-epileptic use	.061 (.035)	.176	.014 (.065)	.011	-	
Benzodiazepine use	-.023 (.019)	-.057	-		-	

IS (n=363): $R^2 = 0.329$; IV (n=380): $R^2 = 0.420$; RA (n=352): $R^2 = 0.225$

* p≤ 0.05; ** p≤ 0.01; *** p≤ 0.001

B = regression coefficient; SE = standard error; beta = standardized regression coefficient.

[A] Level of ID dummy coded; with 'borderline ID as reference group

[B] Living facility dummy coded; with 'independent living' as reference group

[C] Hearing impairment dummy coded; with 'no hearing impairment' as reference group

(All variables shown in the table were entered simultaneously in the regression model)

For RA, five significant variables accounted for 22.5% of the variance. A low RA (more fragmentation of the rhythm) was associated with higher age, depression, diagnosis of dementia, visual impairment and spasticity.

No independent association was found for the variable 'medication use yes/no' (anti-epileptics, benzodiazepines, antidepressants and/or antipsychotics). When correcting for this variable, the models showed the same independent associations as in the first model, except for the variable 'epilepsy'. Epilepsy did not significantly contribute to the stability (IS) of the rhythm (p=.172), but did significantly contribute to its fragmentation (IV) (p=.012) in this second model. In these regression models with the variable 'medication use yes/no', the explained variance was 32.0% for IS, 42.4% for IV and 22.6% for RA.

The multicollinearity check revealed VIF values lower than 10 for all variables. All regression models are shown in Table 4.

DISCUSSION

This is the first study on the sleep-wake rhythm in a large group of adults with intellectual disabilities (ID), aged 50 years and over. The sleep-wake rhythm in this population is less stable and more fragmented than in older adults with normal cognitive function. As in the general population, higher age,[5, 22] dementia[6, 23] and depression[9] are independently associated with disturbances of the sleep-wake rhythm in older adults with ID. Visual impairment, severe hearing impairment, epilepsy and spasticity are independently associated with a less stable or more fragmented sleep-wake rhythm in older adults with ID specifically. On the other hand, in this population, a more stable sleep-wake rhythm was found in females and in those living at a central living setting (as opposed to living in the community). Higher physical activity levels are strongly associated with both a less fragmented and a more stable rhythm in older adults with ID.

The risk of visual impairment,[24] epilepsy[25] and spasticity is strongly increased in people with intellectual disabilities. These conditions have a cerebral origin, including cerebral visual impairment,[26-27] and may reflect more severe and childhood brain damage. The sleep-wake rhythm was more stable in older adults with ID living at a central setting where more intensive care is provided. This might be caused by regular bedtimes and get-up times, often adjusted to the shift schedules of care workers.[28] In this group, daily activities may be based on more fixed time schedules too. The number of day-care sessions during a week, in contrast to the amount of daily movement activity as measured by actigraphy, was not independently associated with the quality of the sleep-wake rhythm in older adults with ID, possibly because many day-care activities involve sedentary activities like handicrafts. We explored the effects of the main medication types that could influence the sleep-wake rhythm because of their sedative effects, but no independent association was found. Because many people with intellectual disabilities use medication with a sedative effect (41.9%) in the study group, excluding those participants from the analysis would probably provide a selected population. It would be difficult to make statements about the influence of for example epilepsy on the sleep-wake rhythm, if participants using anti-epileptics would be excluded. The specific effects of medication use on the sleep-wake rhythm of older adults with ID can be a topic for further research.

Strength of this study is that we studied a large population of older adults with ID, using objective measurements. Data were compared to older adults in the general

population who did not significantly differ in age and gender from the participants with ID.

There are also some limitations. The first is that older adults with a severe or profound ID were relatively underrepresented because of non-participation in the Actiwatch measurements. Univariate analyses showed a trend towards a less stable and more fragmented sleep-wake rhythm in case of a more severe level of ID, but this did not reach significance. Because people with a more severe ID are at higher risk of visual impairment,[24] spasticity and epilepsy, the sleep-wake rhythm might be less stable and more fragmented in this group than was found in this study. Another limitation is that the comparison group was small and probably had a higher education than the total older population. Also, participants in the comparison group all lived independently in their own homes. Therefore the comparison group is not representative for the general older population. Because of the explorative character of this study, no information on co-morbid conditions was available for this group. To our knowledge, no clear norm values are available for the sleep-wake rhythm parameters to distinguish abnormalities; therefore this study could only focus on associated factors and not provide prevalence rates of a disturbed sleep-wake rhythm.

As in the general population,[7] the results of this study also indicate the importance of daytime activity for the sleep-wake rhythm. Previous research by Hilgenkamp et al. showed that physical activity levels in older adults with ID are very low.[29] For health reasons, in daily practice daytime movement activity should be encouraged in people with ID, and this is endorsed by the findings in this study.

Some of the factors that were independently associated with the sleep-wake rhythm of this group are also associated with a disturbed sleep-wake rhythm in the general population (higher age, dementia, depression). The other factors that were independently associated with the sleep-wake rhythm are more specific conditions for the ID population (neurological and sensory impairments). Further research should focus on which factors do specifically influence the sleep-wake rhythm of older adults with ID. This could be achieved by comparing the sleep-wake rhythm of older adults with that of younger people in the ID population. Although this study implies that the sleep-wake rhythm is more fragmented in older adults with ID than the general population, further research should involve a comparison with a retirement home and nursing home population, because of more similarities with the older ID population (presence of co-morbid conditions, living in a group-home situation) than the current control group. Finally, further research should focus on outcomes of a disturbed sleep-wake rhythm on health and wellbeing, and on effects of increasing daytime activity on the sleep-wake rhythm in older adults with intellectual disability.

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Chapter 7

Objective assessment of sleep and sleep problems in older adults with intellectual disabilities

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Submitted

ABSTRACT

Little is known about sleep parameters and sleep problems in older adults with ID. The aim of this study was to investigate sleep and its associated factors in this population, using actigraphy. We investigated the distribution and inter-correlations of objective sleep parameters and which factors are independently associated with these sleep parameters, and estimated the prevalence of sleep problems in older adults with ID.

This study was part of the Healthy Ageing and Intellectual Disabilities (HA-ID) study. Sleep was assessed using actigraphy (Actiwatch AW7, Cambridge Neurotechnology), which is a watch-like device that measures sleep and wakefulness based on the amount of movement activity. Participants (n=551) were instructed to wear the Actiwatch for fourteen days and nights continuously, and a correct measurement of at least 7 nights was required for further analysis. Variables of interest were the sleep parameters time in bed (TIB), sleep onset latency (SOL), total sleep time (TST), wake after sleep onset (WASO), sleep efficiency (SE) and get-up time latency (GTL). Multivariate analyses were used to investigate the associations of several parameters (demographic, co-morbid conditions and medication use) with the sleep parameters. To estimate the prevalence of sleep problems, provisional definitions of sleep problems based on sleep parameters were drafted.

TIB was very long (mean 630 minutes). Longer TIB was independently associated with female gender, higher age, more severe level of ID, living at a central facility, wheelchair dependence and depressive symptoms. SOL was associated with Down syndrome and higher body-mass index. TST was longer in female, and WASO was longer with higher age and in participants with visual impairment. The prevalence of sleep problems was: 23.9% settling problem, 63.1% night waking problem, 20.9% short sleep time, 9.3% early waking problem. 72% of the participants had at least one problem, and 12.3% had three or more sleep problems.

Older adults with ID lie in bed very long, and the prevalence of sleep problems is high. Further research should focus on causality of the relationships found in this study, and effects of having sleep problems on health and well-being in older adults with ID.

INTRODUCTION

Sleep deprivation has a negative impact on general well-being,[1] and short sleep duration and insomnia symptoms are associated with lower health related quality of life.[2-3] In people with intellectual disabilities, sleep problems are common,[4] with estimated prevalences of sleep problems in adults of 8.5% to 34%.[5] Because people with ID are often not capable of communicating their sleep problems, previous research in this population was mainly based on caregiver interviews and questionnaire surveys.[5] Such information is possibly influenced by recall and observation bias, or caregivers may selectively report problems that are disturbing for the environment.[6] This might lead to an underestimation of sleep problems. Further, previous research has mainly focused on children and adults. Only few studies that focused on dementia in older adults with ID, involved some information about sleep disturbances.[7-9] Otherwise very little is known about sleep and sleep problems in older adults in this population.

In older adults in the general population, sleep complaints are highly prevalent.[10-15] The circadian sleep-wake rhythm changes with ageing because of degeneration of the suprachiasmatic nucleus, which is the circadian pacemaker in the brain,[16-17] resulting in disrupted sleep-wake patterns.[14, 17] Apart from age-related changes, sleep disturbances in older adults may be secondary to medical and psychiatric co-morbid conditions, [18-20] like chronic pain, cardiovascular disease, pulmonary disease and gastrointestinal disorders, and medication use.[21] Environmental factors influence sleep quality as well. For example, in elderly people living in a nursing home, disrupted sleep and poor sleep quality frequently occur due to nighttime noise and light exposure.[12]

In adults with ID, reported factors that are associated with sleep problems are challenging behaviour (for example aggression and self-injurious behaviour), respiratory disease, visual impairment, psychiatric conditions, and the use of psychotropic, antiepileptic and/or antidepressant medication.[5] Also, sleep-wake schedules for people with ID are often adapted to the work schedules of professional caregivers,[22] which can contribute to sleep difficulties. As sleep is regulated in the brain, the neurological pathology in people with ID may also contribute to sleep problems in this population.[23]

Life expectancy has increased for people with ID, and ageing in those with a mild ID is similar to that in the general population.[24] However, health problems like epilepsy, musculoskeletal disability, visual and hearing problems occur more frequently in people with ID compared to the general population.[25] Sleep architecture changes as a result of ageing, and combined with more co-morbidity, pre-existent brain damage and dependency on caregivers, older adults with ID might be extra vulnerable to sleep problems. Because caregivers are not always close to their clients at night, objective

assessment of sleep patterns is desirable. Polysomnography is the gold standard to study sleep patterns, but this method is expensive and can be stressful for people with ID. A more suitable method to investigate sleep in this population is actigraphy, which is a method that is increasingly used in sleep research.[26] An actigraph is a device designed to measure sleep parameters and sleep-wake patterns based on motor activity.[27] Actigraphy is non-invasive, does not hamper normal activities and enables continuous measurement in the home environment during a longer time.[28-30]

Because little is known about the distribution of objective sleep parameters and factors specifically influencing these sleep parameters in older adults with ID, the aim of this study was to investigate sleep and its associated factors in this population, using actigraphy. Research questions were 1. How is the distribution and inter-correlation of objective sleep parameters in older adults with ID? 2. Which factors (demographic, co-morbid conditions and medication use) are independently associated with these sleep parameters? and 3. What is the estimated prevalence of sleep problems in older adults with ID?

METHODS

Study design and participants

This study was part a cross-sectional descriptive study, titled 'Healthy Ageing and Intellectual Disabilities' (HA-ID). HA-ID is addressing health in 1050 older adults (aged 50 years and older) with intellectual disabilities (IQ<85) in The Netherlands. Details about design and recruitment of the sample, as well as diagnostic methods, have been presented elsewhere.[31] Informed consent was acquired from all participants (if able to give informed consent themselves) or from their legal representatives. Participants who refused to wear the measurement instrument themselves, or were known by their professional caregivers to easily lose or break things were excluded from the study.

The study was approved by the Medical Ethical Committee of the Erasmus Medical Center (MEC 2008-234) and by the ethical committees of the participating care-providers. The study adheres to the Declaration of Helsinki for research involving human subjects.

Materials

Variables of interest

Variables of interest were factors that might influence sleep in this population that had been measured in the HA-ID study, and had a prevalence of ≥ 5% (for sufficient statistical power). They concerned demographic information (gender, age, level of ID

and residential status), co-morbid conditions (autism spectrum disorder, depression, anxiety, psychosis, behavioural disorders, dementia, epilepsy, visual impairment, hearing impairment, respiratory disorder, gastro-oesophageal reflux disease, chronic constipation, scoliosis, spasticity, hypothyroidism and cardiovascular disease), use of medication with sedative effects (anti-epileptics, benzodiazepines, antidepressants, antipsychotics and melatonin), body mass index (BMI), mobility and day-care occupation.

Participant characteristics

General information on gender, age and residential status was collected through the care providers. Residential status was categorized as 'central setting' (care), 'community-based' (support) and 'living independently with ambulatory support or with relatives'. Level of ID was obtained from behavioural therapists and psychologists' records, and was classified as borderline (IQ 70–85), mild (IQ 55–70), moderate (IQ 35–55), severe (IQ 25–35) or profound (IQ <25). Aetiology of ID and information on physical or mental co-morbidities was obtained from medical records and behavioural therapists' records. Information on mobility was obtained from professional caregivers, and was categorized as 'walks independently', 'walks with a moving aid', or 'wheelchair dependent'. BMI was calculated as weight divided by square height (for non-ambulant people, knee height was measured and Chumlea's formula was used to calculate body height[32]).

Depression symptoms were assessed using self-report (Inventory of Depressive Symptomatology Self Report, IDS-SR) and informant-report (Dutch informant-report Signalizing Depression List for people with Intellectual Disabilities, SDL-ID) screening instruments. Severe depression symptoms were defined as a score above the cut-off of at least one of these screening instruments.[33] Anxiety symptoms were assessed using self-report (Glasgow Anxiety Scale for people with an Intellectual Disability, GAS-ID), and the Anxiety subscale of the Hospital Anxiety and Depression Scale, HADS-A) and informant report (General anxiety subscale of the Anxiety, Depression, And Mood Scale, ADAMS) for all participants. Severe anxiety symptoms were defined as a score above the cut-off of at least one of these screening instruments.[33]

Information on dementia was available in both the medical and behavioural therapist records. Because dementia is difficult to diagnose in older adults with ID, only cases with consensus between the physician and behavioural therapist (diagnosis in both records, one suspicion and one diagnosis, or both suspicion) were used for further analysis.

Objective sleep measurement

Sleep was measured using the Actiwatch AW7 (Cambridge Neurotechnology, UK), a watch-like actigraphy device designed to measure sleep and wakefulness based on the amount of movement activity.[27] Actigraphy has a high reliability to detect sleep, but wake time during the night may be underestimated as older individuals are not necessarily moving when they are awake.[26, 34] The Actiwatch measures movement activity with a piezo-electric accelerometer that records a combination of intensity, amount and duration of movement. The voltage produced by the accelometer is converted and stored as an activity count.[35] The Actiwatch was set to sum activity counts for 1-minute epochs.

Actiwatch data files were analysed with Sleep Analysis software (CamNtech Ltd version 7.27; Cambridge Neurotechnology Ltd). With this software several parameters of sleep can be calculated. Sleep parameters of interest were: the time that participants spent in bed (time in bed, TIB), the interval between bedtime and sleep start (sleep onset latency, SOL), the total sleep time (TST), the time awake between sleep start and sleep end (WASO), the percentage of time asleep during the total time in bed (sleep efficiency, SE) and the interval between sleep end and get-up time (get-up time latency, GTL). GTL can not be calculated by the Sleep Analysis software and was therefore computed manually by using the formula GTL=TIB – (SOL + WASO + TST). The software uses an algorithm to determine sleep and wakefulness. This algorithm calculates a total score of activity counts, based on the activity counts for each 1-minute epoch, taking into account the amount of activity in the epochs surrounding it [35]. A 1-minute epoch is scored as 'awake' if the calculated amount of activity counts exceeds a certain threshold. Sleep analysis can be performed for four different thresholds, called sensitivity settings: low sensitivity (80 counts per epoch), medium sensitivity (40 counts per epoch), high sensitivity (20 counts per epoch) and auto-sensitivity (variable counts per epoch, based on individual movement activity). So, for the low sensitivity setting, more movement activity is necessary to score an epoch as 'wake' than for the high sensitivity setting. In order to investigate sleep quality, it is important to detect wake periods during the night, because this can be an indication for sleep disturbance. Previous studies in the general population that compared actigraphy with polysomnography (PSG the gold standard) showed best ability to detect wake for the high sensitivity setting.[28, 36] Furthermore, we first compared the Actiwatch to PSG in ten older adults with ID [37], and results confirmed best ability to detect wake (54.6% correctly detected) during the night for the high sensitivity setting, accompanied with a good ability to detect sleep (89.7%). Also, values of sleep parameters calculated using the high sensitivity setting best approximated the values of sleep parameters measured with PSG. Therefore, data were analysed using the high sensitivity setting (20 counts per epoch).

A measurement of at least seven nights is necessary to gain reliable outcomes of sleep parameters.[38] Also, potential differences in week and weekend nights have to be taken into account. Therefore in this study, sleep parameters were only calculated for Actiwatch data that met the following criteria:[39] the Actiwatch was worn for at least 7 nights; the event marker button was pressed at bedtime and get-up time for at least 7 nights, of which at least one weekend night; and the maximum amount of nights at weekends was at most half of the total nights involved in the measurement. For each participant, the mean value of each sleep parameter obtained during the measurement was used for statistical analysis.

Definition of sleep problems

For the majority of participants, no self-report information on sleep quality and sleep difficulties was available. The prevalence of sleep problems was therefore estimated based on criteria applied in previous research on sleep problems both in adults with ID and in the older general population: settling problem: SOL ≥ 60 minutes,[6, 40-42] night-waking problem: WASO ≥ 90 minutes [43-44] and short sleep: TST ≤ 6 hours.[2, 18, 45] We added early waking problem: GLT ≥ 60 minutes.

Procedure

All participants of the HA-ID study were instructed to wear the Actiwatch for 14 days and nights continuously. It is recommended to wear the Actiwatch on the non-dominant wrist.[27] However, for many people with ID hand dominancy is unknown or undifferentiated. In those cases, the participants and their caregivers were free to decide on which wrist the Actiwatch would be worn. In case of hemiparesis the Actiwatch was placed on the functional wrist. Participants and their caregivers were instructed to press the event marker button on top of the Actiwatch at bedtime every evening and at get-up time every morning, as these markings are necessary for sleep analysis. Personal caregivers and the participants received verbal instructions and an information brochure.

Statistical analysis

Statistical analyses were performed using SPSS for Windows.

To check representativeness, a comparison was made between the group who met the inclusion criteria for sleep analysis and the total HA-ID study population (for gender, age, living facility and level of ID), using t-tests or Chi-square tests.

Means, SD and ranges were calculated for all sleep parameters. Mutual Pearson correlation coefficients were calculated for SOL, TIB, TST, WASO, SE and GTL.

Descriptive statistics were calculated for all variables of interest. For univariate analyses of demographic and medical data, t-test (dichotomous variables) or one-way

ANOVA (variables with more than two categories) were performed. In the ANOVA, either Bonferroni (equal variances of over subgroups) or Tamhane (unequal variances over subgroups) post-hoc tests were used. To investigate which factors were independently associated with the sleep parameters, linear regression analyses were performed. Variables added to these models were gender, age, level of ID, living facility, and variables with significant outcomes in the univariate analyses. Additionally, point-biserial correlations were calculated for all variables of interest, and variables with a significant ($p<.05$) correlation were added to the model as well. All variables were added to the model using the forced entry (or 'Enter') method. To correct for the effects of the use of any medication (anti-epileptics, benzodiazepines, antidepressants and/or antipsychotics) on the sleep parameters, an additional variable was computed (medication use yes/no). All regression analyses were also performed including the variable 'medication use yes/no' (other medication variables were excluded in these models).

All factors were checked for multicollinearity; a Variance Inflation Factor (VIF) above 10 was deemed unacceptable.[46] Post-hoc, representativeness was checked for variables that appeared significant in the regression model (other than gender, age, living facility and level of ID), using t-tests or Chi-square tests.

The prevalence of sleep problems was calculated by counting the amount of participants that satisfied at least one of the definitions for sleep problems. Additionally we counted the amount of participants with one, two or more than three sleep problems.

RESULTS

General characteristics

Of the 1050 participants of the HA-ID study, 551 started the Actiwatch measurement. Participants who did not participate refused to wear the instrument themselves, or were known by their professional caregivers to easily lose or break things. For 301 out of 551 participants, the Actiwatch data satisfied the selection criteria. The main reason for missing data was lack of pressing the event marker button for at least 7 nights correctly.

In the group that satisfied the selection criteria, participants with a severe or profound ID ($\chi^2(4) = 9.51$; $p=0.05$) and people who lived at a central setting ($\chi^2(2) = 6.69$; $p=0.04$) were underrepresented compared to the total HA-ID population ($n=1050$). There were no differences for age ($t = -1.49$; $p = 0.14$) and gender ($\chi^2(1) = 0.04$; $p=0.84$). We conclude that the final sample was a functionally more able group. Mean age of the 301 participants was 62.13 years (SD 8.45, range 50-92). Demographic characteristics and information on co-morbid conditions are displayed in Table 1.

Table 1 Participant characteristics (n=301)

	N	%
Gender		
male	153	50.8
female	148	49.2
Level of ID		
borderline	13	4.3
mild	66	21.9
moderate	159	52.8
severe	37	12.3
profound	22	7.3
unknown	4	1.3
Aetiology of ID		
no specific diagnosis	196	65.1
Down syndrome	33	11.0
Fragile X syndrome	3	1.0
other syndrome	13	3.7
unknown	56	18.6
Residential status		
central setting	141	46.8
community-based	144	47.8
living independently	13	4.3
with relatives	3	1.0
Mobility		
walks independently	212	70.4
walks with support	38	12.8
wheelchair	47	15.6
Number of day-care sessions		
0-2 times a week	31	10.3
3-6 times a week	94	31.2
7-10 times a week	164	54.4
unknown	12	4.0
Body-mass Index		
<25	79	26.2
25-30	121	40.2
>30	77	25.6
Psychiatric and physical co- morbidities		
Autism spectrum disorder	38	12.6
Depressive symptoms (above cut-off)	52	17.6
Anxiety symptoms (above cut-off)	55	18.5
Psychosis		
current or in the past	30	10.0
Dementia (diagnosis or suspicion)	17	5.6

Table 1 Participant characteristics (n=301) *(continued)*

	N	%
Behavioural disorder		
SIB*	8	2.7
aggression	22	7.3
SIB and aggression	9	3.0
other	24	8.0
Other psychiatric conditions	32	10.6
Epilepsy	60	19.9
Visual impairment		
impairment	53	17.6
blindness	5	1.7
Hearing impairment		
mild	35	11.6
moderate	41	13.6
severe	26	8.6
Respiratory disorder	28	9.3
Gastro-oesophageal reflux disease	44	14.6
Constipation	95	31.6
Hypothyroidism	37	12.3
Cardiovascular disease	98	32.6
Scoliosis	23	7.6
Spasticity	19	6.3
Cerebrovascular accident	18	6.0
Central nervous system medication use		
Anti-epileptics	64	21.3
Benzodiazepine		
total	44	14.6
Temazepam	4	1.3
Antidepressants	28	9.3
Antipsychotics	64	21.3
Melatonin	2	0.7
Use of at least one of these medications	134	44.5

*Self-Injurious Behaviour

Table 2 Distribution of sleep parameters

Sleep parameter	N	%	Descriptive statistics
Time in bed (minutes/hours)			
<480 (<8h)	14	4.7	Mean: 630.26 (minutes)
480-540 (8-9h)	19	6.3	SD: 82.93
540-600 (9-10h)	61	20.3	Range: 248.23 – 833.78
600-660 (10-11h)	93	30.9	
660-720 (11-12h)	76	25.2	
>720 (>12h)	38	12.6	
Sleep Onset Latency (minutes)			
<30	139	46.2	Mean: 43.49 (minutes)
30-60	90	29.9	SD: 39.12
60-90	41	13.6	Range: 1.85 – 338.00
>90	31	10.3	
Total Sleep Time (minutes/hours)			
<360 (6h)	63	20.9	Mean: 443.58 (minutes)
360-420 (6-7h)	61	20.3	SD: 103.50
420-480 (7-8h)	77	25.6	Range: 124.88 – 754.27
>480 (>8h)	100	33.2	
Wake After Sleep Onset (minutes)			
<60	37	12.3	Mean: 119.05 (minutes)
60-90	74	24.6	SD: 105.12
90-120	71	23.6	Range: 6.92 – 378.33
120-180	75	24.9	
>180	44	14.6	
Sleep Efficiency (%)			
<60	61	20.3	Mean: 70.30 (%)
60-70	74	24.6	SD: 13.10
70-80	90	29.9	Range: 15.00 – 98.00
80-90	61	20.3	
>90	14	4.7	
Get-up Time Latency (minutes)			
<15	136	45.2	Mean: 24.14 (minutes)
15-30	81	26.9	SD: 22.56
30-60	56	18.6	Range: 0.08 – 140.37
>60	28	9.3	

Distribution and inter-correlations of sleep parameters

Table 2 shows subgroups, mean, SD and ranges of the sleep parameters for all participants (n=301).

Table 3 shows the correlations between the sleep parameters measured with the Actiwatch.

Table 3 Correlations between sleep parameters

	TIB	SOL	TST	WASO	SE	GTL
TIB						
SOL	.189*					
TST	.537*	-.472*				
WASO	.298*	.326*	-.522*			
SE	-.042	-.673*	.813*	-.814*		
GTL	.061	.222*	-.349*	.159*	-.467*	

* p<.01
TIB = Time in Bed, SOL = Sleep Onset Latency, TST = Total Sleep Time, WASO = Wake After Sleep Onset, SE = Sleep Efficiency, GTL = Get-up Time Latency

Independently associated factors

Table 4 shows the associations between participant characteristics, co-morbid conditions, medication use and the sleep parameters. Variables with significant associations were added to linear regression models (with each sleep parameter as dependent variable).

Based on the outcomes of the point-biserial correlation calculations, the variable BMI was also added to the regression model of SOL and TST. Anti-epileptic use was removed from the regression analyses of TIB, TST and GTL because of multicollinearity.

Table 5 shows the variables that are significantly and independently associated with the sleep parameters. Factors that were added to the model based on the univariate analysis, but showed no significant independent association are described in the bottom row of the table.

Table 4 Mean values of sleep parameters for participant characteristics, co-morbid conditions and medication use, and significance levels of t-tests or Oneway ANOVA tests

	TIB (min)	SOL (min)	TST (min)	WASO (min)	SE (%)	GTL (min)
Gender						
male	616.0	42.3	418.9	124.6	68.7	26.1
female	645.0**	44.7	464.9***	113.3	71.9*	22.1
Level of intellectual disability						
borderline/mild *(ref)*	584.7	41.1	412.3	112.3	70.6	19.1
moderate	637.9***	44.2	449.0*	116.7	70.2	28.3**
severe	666.3***	52.4	451.4	138.9	67.8	23.6
profound	703.6***#	37.9	515.2*	135.2	72.6	15.3
Down syndrome						
yes	652.6	80.6**	424.7	119.5	65.7	27.8
no	641.6	39.8	456.6	121.9	71.0*	23.3
Residential status						
central setting *(ref)*	669.0	43.3	474.8	128.0	70.8	22.9
community-based	605.7***	44.8	421.8***	113.5	69.7	25.6
living independent /with relatives	509.7***	33.0	364.3***	91.0	71.6	21.3
Mobility						
walks independently	609.7***	42.9	428.7*	112.1	70.2	26.0*
walks with support	641.7***	34.5	459.2	124.4	71.3	23.5
wheelchair *(ref)*	707.1	54.9	494.2	141.4	69.7	16.5
BMI						
<25 (ref)	641.8	48.8	430.2	131.3	67.0	31.5
25-30	616.9	41.9	436.2	115.2	70.7	23.6
>30	616.8	36.4	459.3	101.1**	73.8**	19.5**
Autism spectrum disorder						
yes	627.7	38.1	456.0	109.3	72.1	24.3
no	631.7	44.4	443.2	120.4	70.1	23.7
Depression symptoms						
yes	674.4***	49.0	476.6*	125.2	70.6	23.6
no	619.5	42.6	435.9	117.0	70.3	24.0
Anxiety symptoms						
yes	640.3	49.6	436.7	127.0	68.4	27.1
no	626.7	42.4	444.4	116.3	70.8	23.5
Psychosis						
current or in the past	635.0	35.6	476.0	101.4	74.8*	22.0
no	631.1	44.6	439.9	122.0	69.6	24.7
Dementia						
yes / suspicion	689.7**	88.9*	428.9	150.2	62.8*	21.6
no	637.3	42.1	450.9	120.0	70.6	24.2
Behavioural disorder						
yes	643.9	43.1	455.9	118.4	70.4	26.5
no	625.6	44.4	437.9	119.5	70.0	23.8
Other psychiatric conditions						
yes	639.1	46.3	459.8	114.8	71.5	18.2*
no	631.5	43.8	441.7	210.8	69.9	25.3

Table 4 Mean values of sleep parameters for participant characteristics, co-morbid conditions and medication use, and significance levels of t-tests or Oneway ANOVA tests *(continued)*

	TIB (min)	SOL (min)	TST (min)	WASO (min)	SE (%)	GTL (min)
Epilepsy						
yes	668.4**	43.9	491.4**	116.0	73.6	17.1*
no	635.0	44.5	441.9	123.0	69.5	25.7
Visual impairment						
impairment / blind	668.8**	51.4	443.5	149.2**	66.2*	24.7
no	634.4	40.8	457.7	112.8	72.0	23.1
Respiratory disorder						
asthma / COPD	661.0	50.3	448.3	141.7	67.5	20.6
no	640.7	43.5	454.7	118.5	70.9	23.9
Gastro-oesophageal reflux disease						
yes	673.7**	42.1	470.7	137.3	69.5	23.6
no	636.8	44.8	450.7	117.6	70.7	23.7
Constipation						
yes	681.7***	39.7	493.2***	126.0	72.0	22.8
no	619.9	47.1	430.5	118.1	69.6	24.2
Hypothyroidism						
yes	652.9	58.5	434.7	138.7	66.9	21.0
no	640.9	42.0	456.5	118.3	71.0	24.2
Scoliosis						
yes	687.9**	47.8	452.4	162.8*	65.4	24.8
no	637.9	43.9	453.7	117.3	71.0	22.9
Spasticity						
yes	681.8***	43.4	475.2	143.9	69.4	19.3
no	635.2	44.4	449.2	117.7	70.6	23.9
Cardiovascular disease						
yes	644.3	43.7	464.9	116.2	71.8	19.5
no	642.0	44.6	447.2	124.1	69.7	26.1*
Anti-epileptics						
yes	677.0***	42.2	501.1***	117.8	73.8*	15.9***
no	630.5	45.6	436.8	121.9	69.2	26.1
Benzodiazepines						
yes	660.8	53.0	468.9	121.7	71.2	17.3***
no	638.1	43.1	449.4	120.8	70.2	24.9
Antidepressants						
yes	648.7	46.9	458.3	124.9	70.7	18.7
no	641.4	44.8	451.1	121.2	70.2	24.3
Antipsychotics						
yes	656.7	39.4	482.8**	113.2	73.6*	21.3
no	636.5	46.4	442.5	123.2	69.4	24.3

p<.05, ** p<.01, *** p<.001

Profound vs. moderate

TIB = Time in Bed, SOL = Sleep Onset Latency, TST = Total Sleep Time, WASO = Wake After Sleep Onset, SE = Sleep Efficiency, GTL = Get-up Time Latency

Table 5 Standardized regression coefficients and model fit indices of multivariate analyses with sleep parameters as outcome variables

	Beta	p	Adjusted R^2	F change	Sig F change
Time in bed (n=224)					
female gender	.129	.020	0.358	8.302	<.001
age	.186	.003			
moderate ID[A]	.140	.048			
severe ID	.186	.008			
profound ID	.184	.007			
community living[B]	-.130	.049			
ambulant living	-.180	.003			
wheelchair dependence	.031	.031			
depressive symptoms	.161	.011			
Sleep onset latency (n=208)					
Down syndrome	.215	.006	.048	2.035	.032
BMI	-.155	.044			
Total sleep time (n=208)					
female gender	.153	.031	.153	3.492	<.001
epilepsy	.149	.034			
antipsychotic use	.190	.016			
Wake after sleep onset (n=221)					
age	.146	.039	.102	2.914	.001
visual impairment	.010	.010			
BMI	-.211	.004			
Sleep efficiency (n=195)					
visual impairment	-.217	.003	.123	2.940	<.001
epilepsy	.193	.009			
BMI	.165	.035			
antipsychotic use	.176	.024			
Get-up time latency (n=226)					
moderate ID	.241	.004	.068	2.376	.007
epilepsy	-.145	.047			

[A] Level of ID dummy coded; with 'borderline ID as reference group

[B] Living facility dummy coded; with 'independent living' as reference group

Added to the regression models but no significant independent association:
Time In Bed: dementia, reflux disease, chronic constipation, epilepsy, scoliosis, spasticity and visual impairment
Sleep Onset Latency: gender, age, level of ID, living facility and dementia
Total Sleep Time: age, level of ID, living facility, mobility, depression symptoms, psychosis, chronic constipation and BMI
Wake After Sleep Onset: gender, level of ID, living facility, mobility, scoliosis and spasticity
Sleep Efficiency: gender, age, level of ID, living facility, psychosis, dementia and Down syndrome
Get-up Time Latency: gender, age, living facility, mobility, BMI and benzodiazepine use

TIB is longer in females and in participants with a higher age, a more severe ID, living at a central facility, wheelchair dependence or severe depressive symptoms. SOL is longer in participant with Down syndrome and shorter in participants with a higher BMI. TST is longer in females, in participants with epilepsy, and in participants using antipsychotics. WASO is longer at a higher age, in participants with visual impairment and with a lower BMI. SE is lower in participants with visual impairment, but higher in participants with epilepsy, higher BMI and antipsychotic use. A longer GTL is independently associated with a moderate ID; GTL is shorter in participants with epilepsy.

Post-hoc analysis for representativeness (compared to the HA-ID study population) of the variables that contributed significantly to the regression models showed that in the study sample (n=301), participants in a wheelchair were overrepresented (χ^2 (2) = 11.90, p=.003), and BMI was higher (27.7 vs. 27.0 kg, t = -2.04; p = 0.04) compared to the total HA-ID population. There were no differences for depressive symptoms (χ^2 (1) = 0.194, p=0.71), Down syndrome (χ^2 (1) = 3.12, p=0.09), epilepsy (χ^2 (1) = 0.96, p=0.32, visual impairment (χ^2 (1) = 0.39, p=0.55) and antipsychotic use (χ^2 (1) = 3.58, p=0.06). As previously mentioned, participants with a severe or profound ID and people who lived at a central setting were underrepresented compared to the total HA-ID population, whereas there were no differences for age and gender.

After the variable 'any medication use yes/no' had been added to the models of the sleep parameters, no changes appeared in the models of TIB, SOL and WASO. For TST, 'any medication use' was independently associated with a longer TST (adjusted R^2=0.15), whereas female gender and epilepsy were no longer significant. This effect also appeared in the model of SE, were 'any medication use' was independently associated with a higher SE (adjusted R^2=0.12), whereas epilepsy and BMI were no longer significant. For GTL, 'any medication use' was independently associated with a shorter GTL (adjusted R^2=0.10), and epilepsy was no longer significant.

Prevalence of sleep problems

The estimated prevalence of sleep problems as well as the occurrence of one or more of these problems are displayed in Table 6.

Of the participants with two sleep problems, 32.2% had both a WASO>90 min and a TST<6h. Of the participants with three or more sleep problems, this combination occurred in 86.5%. In total, 72.1% of the participants had at least one sleep problem.

Table 6 Prevalence of sleep problems in older adults with intellectual disability

Problem	N	Prevalence (CI)
Settling problem (SOL >1h)	72	23.9% (19.1-28.7)
Night waking problem (WASO >90 min)	190	63.1% (57.7-68.6)
Short sleep time (TST <6h)	63	20.9% (16.3-25.5)
Early waking problem (GTL >1h)	28	9.3% (6.0-12.6)
1 problem	121	40.2% (34.7-45.7)
2 problems	59	19.5% (15.0-24.0)
≥3 problems	37	12.3% (8.6-16.0)
At least 1 problem	217	72.1% (67.0-77.2)

DISCUSSION

This study provides first insights into sleep parameters and sleep problems in older adults with ID. The study was performed in a large sample of older adults with intellectual disabilities (ID) using objective measurements. We found that older adults with ID lie in bed very long, of whom 37.9% more than eleven hours on average. A longer time in bed (TIB) was independently associated with female gender, higher age, more severe ID, living at a central facility, wheelchair dependence and depressive symptoms. The use of central nervous system (CNS) medication with a sedative effect (anti-epileptics, benzodiazepines, antidepressants and/or antipsychotics) was independently associated with a longer total sleep time (TST) and higher sleep efficiency (SE). Sleep problems were found to be highly prevalent (72% at least one problem). 12.3% of the population had three or more sleep problems, mostly including a high amount of wake time during the night, resulting in a short TST.

Long TIB was previously described by Didden et al. and Espie et al.; both groups investigated sleep patterns in individuals (n=19 and n=28) with severe and profound ID.[47-48] In our study population too, TIB seems to be longer in people with high care needs (higher age, more severe ID, wheelchair dependence and living at a central facility). Sleep-wake schedules for people with ID are often adapted to the work schedules of professional caregivers,[22] and this might especially be true for people who are more dependent on their caregivers for bedtimes and get-up times. Another point is that daytime sleepiness – probably caused by nightly unrest or as a side effect of medi-

cation use – might be incorrectly interpreted as a need for more sleep by caregivers, leading to early bedtimes. This might especially apply for people with a more severe ID, who are less capable to communicate. In older adults in the general population, extended TIB is associated with more physical function decline than in shorter TIB.[49] In older adults with ID, a longer TIB was further independently associated with depressive symptoms. In older adults in the general population, both a short and a long sleep time are associated with depression.[45] In our study population TST was significantly longer in participants with depressive symptoms, but in the multivariate analysis this did not appear to be an independent association. The direction of the association between depression and long time in bed merits further attention.

In our study population, a higher age was associated with a longer wake after sleep onset (WASO), which is similar to the general population.[50] In previous research in adults with ID, no association between age and sleep parameters or sleep problems was found.[5]

We found that people with Down syndrome and people with dementia both had significantly longer sleep onset latency (SOL). In the multivariate analysis, dementia appeared not to be significant, indicating that SOL is longer in participants with Down syndrome who have dementia. An association between sleep difficulties and dementia in this group was also described by Cooper & Prasher (1998), who found more disturbed sleep in people with Down syndrome and dementia, compared to people with dementia and other aetiology of ID.[8]

Females spent more time in bed and also had a longer TST. Long sleep duration in adult women with ID was previously described by Brylewski et al. (1998).[6] In a large actigraphy study in 965 older adults in the Dutch general population, TST was longer in women too, whereas women themselves reported shorter sleep times and more sleep difficulties.[51] This means that longer sleep time in older women with ID does not necessarily mean there could be no sleep problem.

We found that visual impairment was independently associated with a longer WASO and lower sleep efficiency (SE). This is somewhat in accordance with Boyle et al., who found that visual impairment was independently associated with initial insomnia in adults with ID.[40] In people with ID visual impairment often includes cerebral visual impairment.[52-53] This association, together with the association with severe ID and wheelchair dependency, probably reflects effects of more severe brain damage. In older adults in the general population, it is suggested that visual impairment can contribute to physical inactivity and inadequate outdoor light exposure, which in turn can contribute to a disrupted sleep-wake pattern.[19]

A higher body-mass index (BMI) was independently associated with shorter SOL and WASO, and higher SE. We suppose that high BMI can lead to fatigue, resulting in

a higher SE. In older adults in the general population, both short sleep duration and long sleep duration are associated with higher BMI.[54-55]

In our study population the use of central nervous system (CNS) medication with a sedative effect was associated with longer TST and higher SE. In contrast, Boyle et al. studied sleep in 1023 adults with ID and found early morning waking and broken sleep in participants psychotropic medication.[40] In people with ID, CNS medication is often administered at several moments during the day. Sedative medications like antidepressants or long-acting benzodiazepines are also often prescribed in the general older population, and when taken early in the day they may cause excessive daytime sleepiness and interfere with night sleep.[21]

The prevalence rates of sleep problems that were found in this study are based on tentative actigraphy criteria, and therefore difficult to compare with research based on caregiver reports in people with ID and personal reports in the general population. Van den Berg et al (2008) studied actigraphy-based sleep parameters in 969 older adults (57-97 years) in the general Dutch population; they found a mean TST of 6.5 hours, a mean SOL of 21 minutes, and mean SE of 78.4%.[56] Compared to our results, both SOL (43 minutes) and TST (7.4 hours) were longer in older adults with ID, whereas mean SE (70.3%) was lower in our population. Because SE is a ratio of TIB and TST, the lower SE can possibly be explained by the long TIB of older adults with ID, and may not indicate a sleep problem.

A major strength of this study is that we studied sleep using objective measurements. Also, the study sample was large, which enabled reliable investigation of multivariate associations. Bias is avoided by collecting data in three different care providers. There are also limitations. First is that of all participants involved in the HA-ID study, only half started to wear the Actiwatch as a result of resistance or risk of loss or damage to the device. Additionally, many data could not be used for analysis due to lack of pressing the event marker button correctly for at least seven nights. Although participants and caregivers were carefully instructed, the total HA-ID study demanded much involvement of the participants and their caregivers, so it is understandable that this was forgotten regularly.[39] Second is that because data were collected in a cross-sectional study design, we could not investigate the causality of the associations that were found. Third, people with a more severe level of ID and living at a central facility were underrepresented in the study sample, so results of this study can not be generalized to the whole population of older adults with ID. Participants with wheelchair dependence were overrepresented in the study sample. The independent association of wheelchair dependence and a longer TIB might therefore be different in the whole population older adults with ID.

Some general remarks can be made about investigating sleep using actigraphy. The Actiwatch measures movement instead of sleep architecture, so one has to take into

account that mobility impairments might have influenced the outcomes. Also, sleep parameters (especially TIB) are partly dependent on the times the event marker button was pressed at bedtime and get-up time. Pressing the event marker button too early in the evening and too late in the morning might result in an overestimation of TIB. However, participants and caregivers were carefully instructed about the use of the Actiwatch. Because mean values for each sleep parameter were used for the analysis, an occasional error in pressing the button would not influence the data strongly.

Several factors were found to be independently associated with sleep parameters in older adults with ID. However, the explained variances for the majority of the regression models were low. Further research should focus on other factors that might influence sleep in older adults with ID, for example the amount of daily physical activity. Physical exercise positively influences sleep quality in older adults in the general population.[57] In the HA-ID study physical activity was measured using pedometers, but only in a selected population.[58] To investigate the influence of physical activity on sleep parameters, activity could be measured using a more sensitive pedometer or a detailed questionnaire on daytime activity. Of the variables that were associated with sleep parameters in older adults with ID, only dementia (in people with Down syndrome) seems age specific. It would be interesting to compare the sleep parameters of older adults with ID with a younger ID population, to investigate whether factors like visual impairment and medication use have similar associations in younger people with ID, or whether the influence on sleep parameters changes with increasing age. Longitudinal research is needed to investigate causality of the relationships and effects of sleep deprivation on physical and mental health, and well-being of older adults with ID.

The long time spent in bed could be an important cause for the high prevalence of sleep problems identified in this population, and is associated with increased depression symptoms. If sleep problems would be truly caused by long TIB, this has implications for clinical practice. Hylkema & Vlaskamp already indicated that improving bedtime scheduling and educating caregivers, results in better sleep efficiency in adults with ID.[22, 59] Ideally, bedtimes and get-up times should be more in accordance with individual sleep-wake patterns. It would be useful to develop consensus about how to define sleep problems in older adults with ID in both clinical practice and epidemiological research. The definition of sleep problems provided in this study could be used as a starting point.

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Chapter 8

Subjective and objective assessment of sleep in older adults with intellectual disabilities

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Submitted

Chapter 9

General Discussion

This is the first study that focused on sleep and the sleep-wake rhythm in older adults with intellectual disabilities (ID). Not only did we study a large sample, data were obtained using objective measurements. An important first step was made into validating this objective tool – the Actiwatch – for older adults with ID, which is very useful for improving the application of this instrument in both epidemiological research and clinical practice. After an overview of the main results, the strengths of this study and methodological issues are discussed. Thereafter, recommendations for future research and clinical practice will be presented.

MAIN RESULTS

In order to provide an overview of available literature on sleep problems in adults with ID, covering how sleep was previously studied in this population and with what instruments and definitions, we performed a systematic review. With this review we showed that in the majority of prior studies on sleep in people with ID, data were collected using caregiver interviews. Also, different definitions for sleep problems were used, and statistical analyses of factors associated with sleep problems were mostly univariate. Separate information on older adults was available only in a few studies, in which the main research focus of the study did not involve sleep.

As also became clear from literature research, the Actiwatch had not previously been used in a large sample of people with ID, raising questions about its validity in this population. We therefore compared the Actiwatch to polysomnography in a sample of older adults with mild ID, and found that to obtain valid results, Actiwatch data should be analyzed using the high sensitivity setting (i.e. less movement necessary to score a minute as awake). We found that during daytime the Actiwatch scored much time incorrectly as 'sleep', making it not a valid method to investigate daytime sleepiness.

There was no knowledge available on the sleep-wake rhythm of older adults with ID. For that reason we compared the sleep-wake rhythm of this population with that of older adults in the general population, and explored which factors are associated with the quality of the sleep-wake rhythm in older adults with ID. We concluded that the sleep-wake rhythm of this population was less stable and more fragmented than that of community-dwelling older adults in the general population. More movement activity during the most active hours of the days was strongly associated with a more stable and less fragmented sleep-wake rhythm in older adults with ID. Except for higher age and dementia, most factors that were associated with a lower quality of the sleep-wake rhythm involved cerebral pathology.

Additionally, our research focused on which factors contribute to night sleep specifically, and on the prevalence of sleep problems. The prevalence of sleep problems

in older adults with ID is high: 72% has at least one sleep problem (settling problem, night waking problem, short sleep time and/or early morning waking). The time spent in bed was very long, and this was associated with factors related to more intensive care (e.g. living at a central facility and wheelchair dependence). Apart from that, longer time in bed was associated with increased depression symptoms.

Last, we investigated how many sleep problems found in the Healthy Ageing and Intellectual Disabilities (HA-ID) study were known by professional caregivers. Also, we were interested in the concordance between objectively measured sleep parameters and client self-report. Therefore we compared our objective Actiwatch data to professional caregiver information regarding sleep problems, and to self-reported sleep parameters by participants with mild ID. Sleep problems that were found using our HA-ID definition were hardly known by the professional caregiver, and agreement between self-report and Actiwatch data was poor.

STRENGTHS OF THIS STUDY

A major strength of this study is that sleep and sleep-wake rhythms were investigated in 551 older adults with ID, which was not performed previously. Moreover, this is the first study that used actigraphy in such a large sample of people with ID. Data were obtained directly from the participants and not through proxy interviews. All measurements were carried out at the living facilities of the participants, so natural sleep circumstances were disturbed as little as possible. This study has added to the knowledge about sleep and the sleep-wake rhythm as well as applicability of the Actiwatch in this population. Both are of importance to improve care for older adults with ID.

Generally, in the 'Healthy Ageing and Intellectual Disabilities' (HA-ID) study much effort was made into careful preparations, including communication plans for clients, legal representatives and professional caregivers. Also, all measurements were performed in consultation with these professional caregivers. As a result, widespread cooperation during the study was achieved (appendix I).

METHODOLOGICAL ISSUES

In the HA-ID study, 1050 clients participated. Yet, only 551 measurements were suitable for sleep-wake rhythm analysis and 301 measurements for sleep analysis. The two main reasons for these missing data were: 1. refusal by the participant, or advice against by the caregiver to participate in the Actiwatch measurement, and 2. the lack of precise information on bedtimes and get-up times (pressing the event marker button

on the Actiwatch). These numbers suggest that the Actiwatch might be insufficiently feasible for older adults with ID. However, participants who started the measurement wore the Actiwatch for at least 14 days in the majority of cases. In clinical practice, it is conceivable that when there is a clinical question regarding the sleep pattern of a client, caregivers might be more motivated to correctly apply actigraphy, compared to a research setting.

Because of the cross-sectional design of the study, no statements could be made about of the nature of the associations that were found regarding sleep and the sleep-wake rhythm.

We performed a first step into validating the Actiwatch for older adults with ID. The conclusions about the sensitivity setting were based on a small study sample. Although many minutes were available for comparison, there may not have been much diversity (e.g. different activity levels, co-morbid conditions, sleep patterns, more severe ID, etc.).

We used the Actiwatch measure M10 (amount of movement activity during the ten most active hours of the day) as a measure of daytime activity in older adults with ID to evaluate the influence of physical activity on the sleep-wake rhythm. Although this measure is accepted for analysis involving stability and fragmentation of the sleep-wake rhythm,[1] it is not a valid method to investigate physical activity. A better method to assess physical activity is pedometry.[2] However, including only participants with both complete Actiwatch and pedometer measurements into the analysis would have led to a selected functionally more able study sample.[3]

A diagnosis of sleep problems was based on actigraphy measurements, but did not take into account individual sleep experience and daytime functioning. Our definition for sleep problems in older adults with ID was a first attempt to estimate the prevalence of sleep problems based on objective data, rather than by caregiver information. Because subjectively experienced burden and daytime functioning are important to define a sleep problem, this topic merits attention in individual assessment of sleep problems.

There are many different actigraphy devices available, often with different software programs. Results of this study are based on measurements with the Actiwatch AW7,[4] and comparison with studies using a different device should be made with care.

RECOMMENDATIONS FOR FURTHER RESEARCH

Based on previous research in older adults in the general population and in adults with ID, findings in the current study, and based on clinical practice, we built a hypothetical

model on factors related to sleep and the sleep-wake rhythm in older adults with ID (Figure 1).

At the left, the factor 'neurological effects' first contains dysfunction of brain areas regulating sleep, which is connected with conditions reflecting more severe brain damage. Second, in addition to pre-existent brain dysfunction, sleep and the sleep-wake rhythm of adults with ID will be affected by age-related changes and age-related brain conditions. Besides neurological effects, several co-morbid conditions, external factors and lifestyle factors can influence sleep and the sleep-wake rhythm of this group. At the right of the figure possible outcomes of sleep-wake disturbances are shown. This hypothetical model provides an overview of current knowledge, and can be used as a basis for further research.

Genetic research

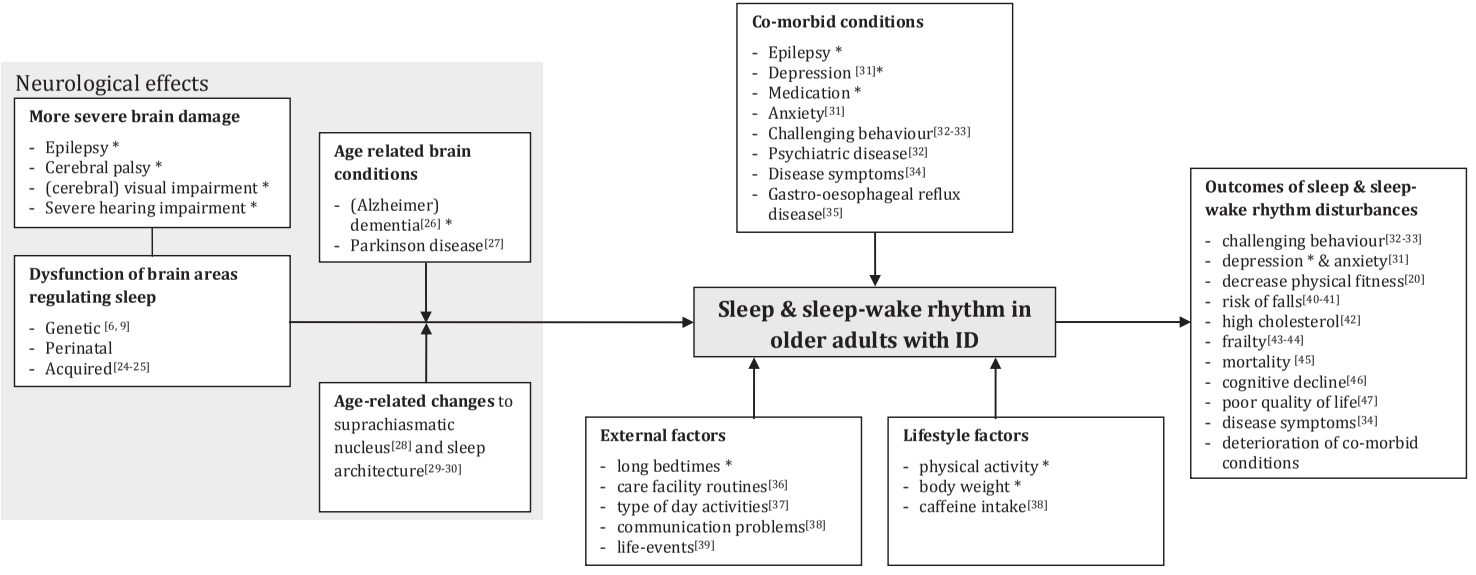
Because both sleep and the sleep-wake rhythm are regulated by various structures and pathways in the brain,[5] we hypothesize that brain dysfunction causing cognitive dysfunctioning can be an important factor in the origin of sleep and sleep-wake rhythm disturbances in people with ID. Such a link has already been found in some specific syndromes. For example the genetic disorder that causes Smith-Magenis syndrome also induces severe circadian sleep-wake rhythm disorders, because the affected gene (17p11.2 deletion) also acts in the regulation of the circadian clock.[6] In Prader-Willi syndrome, abnormal sleep architecture involving sleep onset rapid eye movements has been described.[7] Normal hypothalamic development is hampered in people with Prader-Willi syndrome,[8] and malformation of the suprachiasmatic nucleus has been described.[9] In high-income countries, severe forms of ID are now mainly caused by genetic defects.[10] Today, knowledge about genes that regulate the circadian sleep-wake rhythm has increased,[11-13] and as a result of improved gene sequencing techniques more knowledge is available on genetic disorders in people with ID.[14-15] With this information, for future research we recommended to further explore genetic causes of sleep problems and sleep-wake disturbances in people with ID. This can be beneficial for ID care, because a known high risk of sleep-wake problems can be target for interventions from an early age onwards.

Next to genetic defects, perinatal problems and acquired conditions at a young age can be cause of ID and might affect sleep regulation as well. Brain dysfunction caused by such factors is very heterogeneous, so studying how these conditions might affect brain areas regulating sleep and wake might have a low efficacy.

Epidemiological research

Besides additional knowledge on genetic factors influencing sleep-wake patterns, further epidemiological research is needed. This research should have three differ-

Figure 1 Hypothetical model of factors influencing sleep & the sleep-wake rhythm, and outcomes of sleep & sleep-wake rhythm disturbances in older adults with intellectual disabilities



* Result Healthy Ageing and Intellectual Disabilities study

ent focuses: cohort research, intervention studies and comparison with the general population.

Cohort research is needed to study the causality of the relationships shown in the model (Figure 1), for the benefit of prevention and improvement of care.

Intervention studies can provide additional information regarding the causality of relationships. All factors that might influence the sleep-wake pattern and can be acted upon in care can be a focus for an intervention study.

To study which factors specifically contribute to sleep and the sleep-wake rhythm in older adults with ID, this population could be compared to older adults in the general population who live in a retirement home or nursing home. Because people in a nursing home also have many co-morbid conditions and live in a group setting this population better resembles the older ID population than the community-dwelling comparison group in our study.

For further epidemiological research using actigraphy in older adults with ID, development of consensus how to define sleep problems is required, in order to better compare outcomes in different study populations. Also attention should be paid to careful instructions of participants and caregivers prior to the measurement, involving the importance of registering bedtimes and get-up times.

Validation of the Actiwatch

Besides further genetic and epidemiological research, further validation of the Actiwatch is needed to strengthen our findings. This should be done in a larger sample, and if possible in more diverse subgroups (including different activity levels, reported sleep problems, more severe ID, etc.). In people with severe and profound ID, more abnormalities are found in sleep architecture,[16-17] and agreement between the Actiwatch and polysomnography might therefore be different in this group. Because polysomnography measurements in people with severe ID might be too much of a burden, feasibility is a point of attention. Agreement between the Actiwatch and polysomnography might be different between older adults with ID who sleep well and those who have a sleep problem, between age groups, or different amounts of physical activity. Different sensitivity settings might be necessary for subgroups.

Daytime physical activity assessment

To further evaluate the influence of physical activity on sleep and the sleep-wake rhythm, an accelometer sensitive to walking speeds below 3.2 km/h (the Stepwatch) can be used. We recently found a good validity of this instrument in older adults with ID (van Schijndel et al., submitted).

RECOMMENDATIONS FOR CLINICAL PRACTICE

Based on this study we can provide first recommendations for clinical practice.

Actigraphy as diagnostic tool

Our opinion is that actigraphy should become part of the diagnostic routine of physicians and behavioral therapists working with people with ID. Especially in case of suspicion of a sleep problem, actigraphy can be useful, because all day and night activity can be displayed in a graph, the actogram. This visual display may provide a clear insight into nightly activity, but also visualizes the sleep-wake rhythm. Two examples of an abnormal actogram are shown in Figure 2 and 3 (a normal actogram has been shown in Chapter 1).

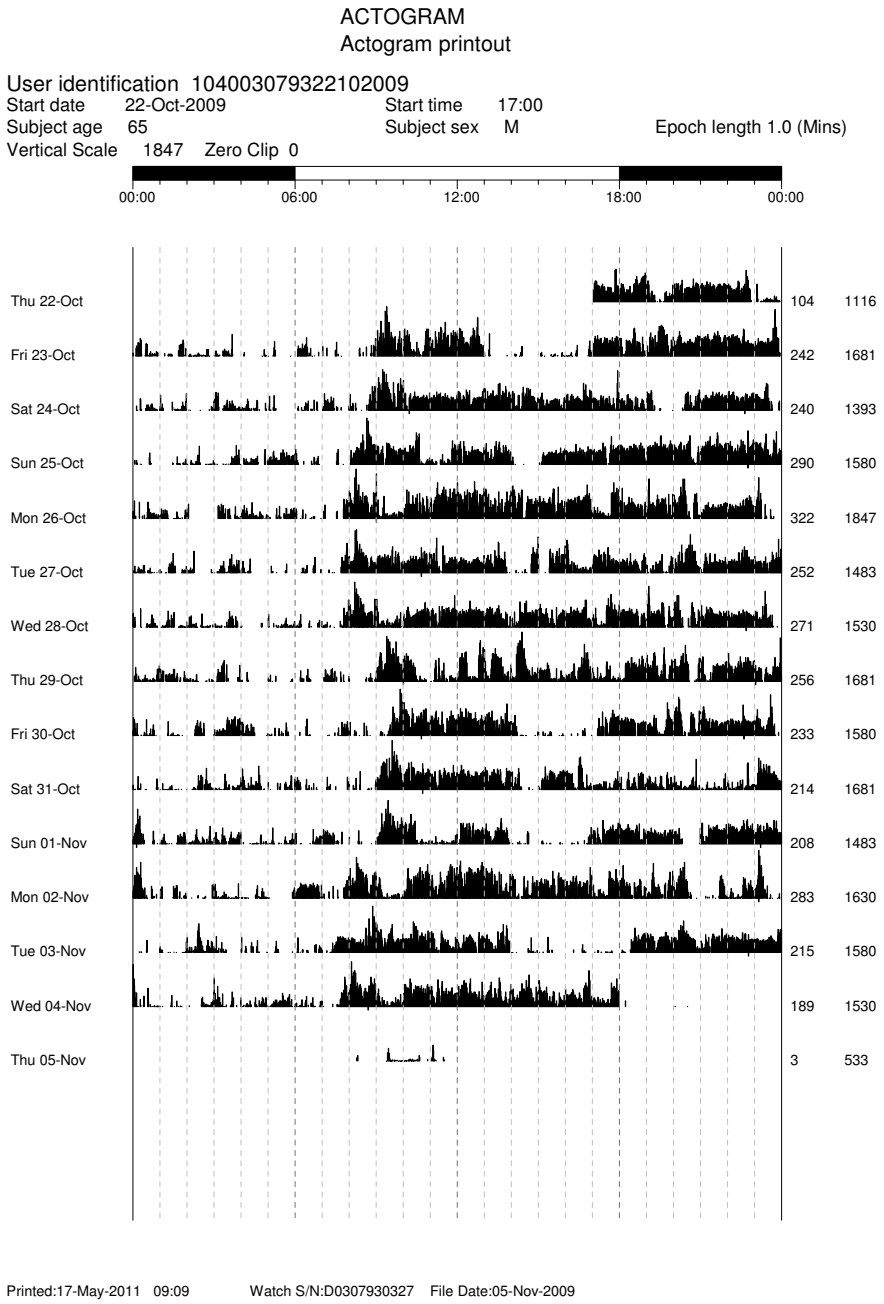
Although the actogram often provides useful information, it should always be judged together with the history of the client, self-report and observed nighttime and daytime behavior. When taking the history of the client, possible factors influencing sleep-wake patterns (Figure 1) should also be taken into account. For the purpose of our epidemiological research, provisional cut-off values for sleep parameters were made to define sleep problems. Nevertheless, we do not recommend diagnosing sleep problems based on cut-off values in clinical practice. For example, high sleep efficiency does not exclude that someone is awake during the night but lies in bed motionless. For individual diagnosis of sleep and sleep-wake problems, actigraphy, client and caregiver information needs to be combined.

Our hypothetical model (Figure 1) can function as a guideline for the differential diagnosis and possible targets of interventions (improving co-morbid conditions, influencing external factors or lifestyle factors). If actigraphy is used in clinical practice, we recommend monitoring of treatment effects on sleep parameters and the sleep-wake rhythm. Adequate monitoring of the effects of interventions can be useful to provide guidelines on effective treatment of sleep problems in older adults with ID.

Sleep and sleep-wake rhythm as part of healthy lifestyle

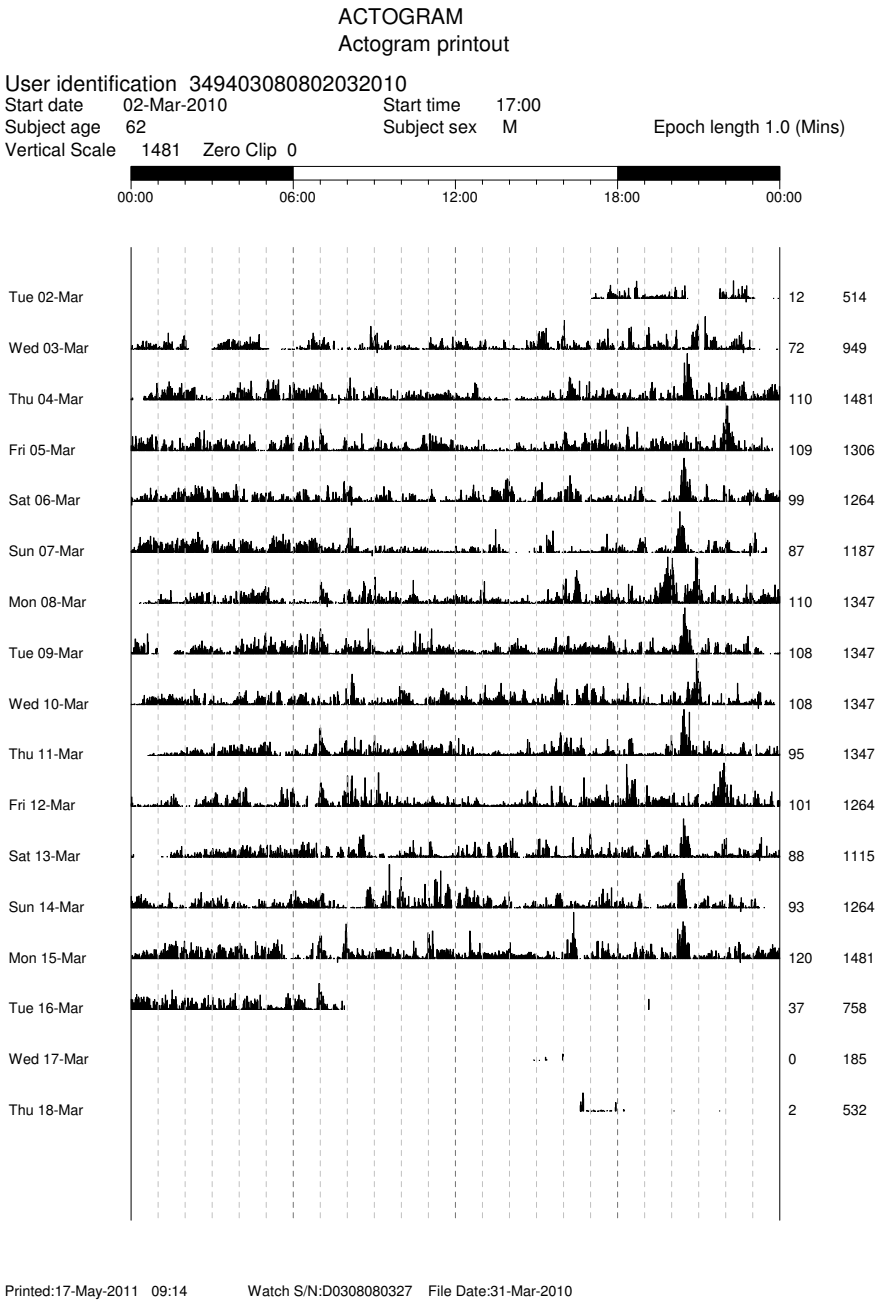
In the HA-ID study population, obesity is highly prevalent (48%, measured with waist-hip ratio) [18] and physical activity levels are extremely low.[3] Sleep deprivation contributes to mechanisms leading to increased insulin resistance, decreased energy expenditure and increased appetite, which in turn can lead to obesity.[19] As mentioned earlier, long bedtimes are associated with physical functional decline. [20] This emphasizes that sleep is an important link in a healthy lifestyle, and therefore it needs to be a point of attention in prevention and education programs on obesity and physical activity in people with ID. In this study, more daytime movement activity was associated with a better sleep-wake rhythm. Studies in the general older population already

Figure 2 Actogram



In this actogram, nightly movement activity is visible (left side). Also, periods of inactivity are visible during daytime. This pattern seems to be stable over the days.

Figure 3 Actogram



In this actogram, it is not possible to distinguish a normal sleep-wake rhythm. Activity continues during the day and night.

showed the beneficial effects of daytime physical activity on both sleep quality[21] and the sleep-wake rhythm.[22] This should be an extra stimulus to promote daytime activity in older adults with ID.

Routine versus individualized care

Older adults with ID (especially people who need assistance with activities of daily living) appear to spend a lot of time in bed, and many have sleep problems. In our study long bedtimes are associated with depression symptoms, and in the older general population spending long time in bed is associated with physical function decline.[20] A longer time in bed often results in a longer sleep time, which in turn can also cause negative health effects (*Chapter 1*). More awareness among professionals regarding long bedtimes and potential negative health outcomes is needed.

Yet, improvement of ID care goes beyond more awareness of sleep problems. In the general population people have to comply with daily routines like work, often leading to a mismatch between the personal sleep-wake rhythm and daily work schedules – a so-called 'social jetlag' – which is associated with negative health outcomes.[23] Care professionals may tend to persist in daily routines, but also high workload might hamper putting clients to bed at their preferred time. The results of this study can be a basis for a policy changes in intellectual disability care, aiming at a more individual approach of sleep needs. For older adults with ID bedtimes and get-up times should be adapted to their personal sleep-wake rhythm as best as possible.

CONCLUDING REMARKS

Sleep problems frequently occur in older adults with ID, and their sleep-wake rhythm is more fragmented and less stable than in older adults in the general population.

This thesis hands useful information regarding the use of actigraphy in both epidemiological research and clinical practice. Although further research is needed, actigraphy should become a routine diagnostic instrument. The evidence-base of the hypothetical model provided in this chapter has to be strengthened in further research, but can already function as a guideline for diagnosis and intervention. More awareness among professionals working with people with ID regarding sleep and the sleep-wake rhythm is needed, and an individual approach of sleep needs is of importance to improve wellbeing and health in people with intellectual disabilities.

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Appendix I

Study healthy ageing and intellectual disabilities: Recruitment and design

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Research in Developmental Disabilities (2011), 32(3): 1097-106

ABSTRACT

Questions encountered in epidemiologic health research in older adults with intellectual disabilities (ID) are how to recruit a large-scale sample of participants and how to measure a range of health variables in such a group. This cross-sectional study into healthy ageing started with founding a consort of three large care providers with a total client population of 2322 clients of 50 years and over, and two academic institutes. This consort made formal agreements about a research infrastructure and chose three research themes: 1. Physical activity and fitness, 2. Nutrition and nutritional state, and 3. Mood and anxiety. Subsequently, preparation was started by carefully reviewing and selecting instruments to measure a wide set of health variables to answer the research questions. Specific demands of these instruments were that they could be executed efficiently and accurately on-site in a large sample of participants and that the burden of these measurements for participants as well as their caregivers was as minimal as possible. Then, preparation was continued by designing and executing a thorough communication plan for clients, legal representatives and staff of the care providers, preceding the informed consent procedure. In this plan, which had a top-down structure, specific attention was given to personally informing and motivating of key stakeholders: the professional caregivers. This preparation led to a recruitment of 1050 participants (45.2%) and to high participation rates in key parts of the assessment. A detailed description is provided about the recruitment and organization and the selected instruments.

INTRODUCTION

Life expectancy of adults with intellectual disabilities (ID) is lengthening towards that of adults without intellectual disabilities, but daily practice indicates that this ageing is relatively often not a healthy ageing. With a higher risk of motor impairments, sensory impairments and epilepsy since earlier in life, these people are prone to develop multiple physical and mental comorbidities at older age [1-3]. 'Frail patients' (multiple diagnoses, complex medical routines, frequent hospitalisation, functional impairment) [4], requiring individualised managed care, are expected to be highly prevalent in this population. Furthermore, functional deterioration is frequent [5], leading to diagnostic and therapeutic uncertainty, transfers from community-based to central residential settings, and high costs.

With these risks in mind, three Dutch care organizations (Abrona, Huis ter Heide; Amarant,Tilburg; Ipse de Bruggen, Zwammerdam) and two academic departments (Intellectual Disability Medicine, Department of General Practice, Erasmus MC in Rotterdam; Center for Human Movement Sciences, UMCG, Groningen) intended to start a large-scale project to study health in older adults with intellectual disabilities in 2006. Inspired by questions of the care organizations themselves (formulated by client panels and staff panels), three themes were chosen: 1. Physical activity and fitness, 2. Nutrition and nutritional state, and 3. Mood and anxiety. These themes cover a substantial impact on health and quality of life and are supposed to have strong mutual relationships, but have hardly been studied in ageing people with ID. The scientific aims of this project were: a. To perform baseline assessments of prevalence rates and secondary health effects for each theme and to identify risk groups. b. To assess mutual relationships between the themes and their underlying concepts. c. To select and evaluate diagnostic tools to assess each theme.

To meet these aims, an observational cross-sectional design was chosen for this multi-centre research project. However, before such a study in this particular and complex target population could be executed, two major obstacles needed to be dealt with.

The first obstacle in the execution of such a study is caused by the specific living circumstances of older adults with ID. Many older adults with ID depend on a care system, involving family and professional caregivers. Lack of involvement, commitment and ultimately support by the care system can be an obstacle to the recruitment of a large, representative sample, as well as to participation in the assessments which would be a part of the study.

The second obstacle is how to measure a range of health characteristics in older adults with ID. In the general population, preventive health checks are used to collect data about certain health characteristics or risk factors, like the Canadian Study of

Health and Ageing [6], or the Cardiovascular Health Study [7]. This kind of screening is not applicable to the population of older adults with ID because self-report questionnaires, neuropsychological tests and often physical tests may require a certain level of cognitive and physical abilities which may not be compatible with that of older adults with ID.

Because of such barriers, most published epidemiological research in adults with ID is based on existing (medical) records or registries, or observations of professional caregivers [8-13]. With this method, underrecognition of certain health problems or risk factors is to be expected [14], due to communication difficulties of the participants and lack of suitable diagnostic instruments. Another solution is to limit the number of participants, [15]. With this solution, extrapolation of the results is hampered since the number of participants is often limited or narrowed by strict exclusion criteria, thus often underestimating the actual problems in this group [16].

This gives rise to the following research question: How to successfully measure health in older adults with intellectual disabilities in a large, representative sample?

MATERIALS AND METHODS

Before starting the actual study, measures were taken to ensure optimal circumstances for executing a large-scale study. Therefore, the formation of a consort and description of the base population will be presented first. The method section then proceeds with a detailed description of the selection of instruments and organization of measurements, after which the standard informed consent procedure is described. Subsequently, extra activities undertaken to optimize recruitment will be described, such as extra activities in communication and consent procedures. Inclusion, representativeness and participation are described as main outcome measures.

Founding a consort

Former research has shown the importance of cooperation and commitment of different management levels to provide the necessary conditions for a successful execution of a large-scale study in the field [17-19]. For this reason, three large care providers and two academic departments joined together in a consort, and preparation of a first large-scale study was started at CEO level in 2006. Formal agreements were made about financing and grant acquisition, responsibilities, communication, project management and infrastructure, involvement of clients and client representatives. Agreement was reached on the following aims of the consort: 1. to increase knowledge on healthy ageing in intellectual disability by means of scientific research, 2. to increase the scientific attitude of staff of care providers by means of participation in

research and continuous education, 3. innovation of care by means of implementation of research outcomes. In the preparatory phase and during the execution of the study, the consort discussed about policy, practical issues, results and future directions on three management levels: CEO-level, level of the boards of directors, and middle-management level, to ensure embedding of and commitment to this project.

The members of this consort cooperated in obtaining a governmental grant for this first research project (granted by the Netherlands Organisation for Health Research and Development, 2007, nr. 57000003).

Base population

The three involved care providers in the consort mentioned above provided financial and organizational support and gave access to a large population of older adults with intellectual disabilities receiving any type of care or support from these care organizations.

The care organizations are geographically located in different regions of the Netherlands, both in urban and rural areas and all provide care to a broad spectrum of clients, varying in level of intellectual disability, mobility and living arrangements and all including different care settings: central residential settings, community-based homes, day activity centres and supported living. Together they provide care for 8550 persons with intellectual disabilities, which is approximately 10% of the total Dutch client population of specialized care providers [20]. The distribution of clients primarily receiving care (35%) and clients primarily receiving support (65%) is similar as that in the total Dutch client population with ID [20]. Furthermore, the percentage of older adults (50 years and over) in their client population (10%) is similar to that in the total Dutch population with ID [20]. We therefore consider this base population to be representative for the total Dutch client population of older adults with intellectual disabilities.

Materials

The selection of diagnostic methods had to be performed with great care. A detailed description of the selection process of instruments within each subtheme stretches too far for this paper, but has been published elsewhere [21-22].

In general, reliability, validity and feasibility in this specific population were important criteria in the selection of instruments.

As far as feasibility is concerned, the instruments had to be applicable in large-scale research, which means they had to be not too time-consuming and suitable for a large part of this heterogeneous population. Where possible, instruments which were also used in the general (older) population were chosen. This enables comparison between this specific population of older adults with intellectual disabilities and the general

population. Furthermore, they had to be executable by a large group of professionals, without high risks of differences between test observers. Due to the on-site nature of the assessments, instruments had to be ambulatory available, and if possible, non-invasive. The costs of the instruments were also an important factor, considering future use in clinical practice.

For the physical fitness tests and the instruments measuring anxiety and depression, a literature search and evaluation of the retrieved instruments did not result in a definite evidence-based choice for an instrument. Expert meetings were used to incorporate the clinical experience of scientific and care professionals in the final choice. In some cases English instruments had to be translated into Dutch and tested for feasibility and reliability, for example the questionnaires for anxiety and for eating disorders. A pilot study in November 2008 was used to evaluate those instruments, as well as the feasibility of the entire set of instruments.

The definite selection of instruments is presented in the Appendix, with a distinction between measurements requiring active involvement of the participant and measurements without active involvement of the participant.

Procedure

The large-scale nature of an epidemiological study puts three specific demands on the organization of measurements. The organization needs to be efficient, the measures need to be executed accurately and the burden of these measurements for participants as well as their caregivers needs to be as minimal as possible. The burden for participants and their caregivers was considered a central factor in designing the organization of measurements. The feasibility of this organization was also tested in the pilot study and led to minor adjustments in the instruments and organization.

To complete all assessments efficiently, and to comply with one of the aims of the consort as well, the measurements needed to be executed by groups of test administrators, consisting of professionals of the involved care providers. To enhance their commitment and to optimise the organization, they were informed and consulted in an early stage of the study. Their preferences considering planning and location were followed as much as possible, and interference with existing (medical) routines was avoided as much as possible. To enhance efficiency even further, the particularly time-consuming diagnostic process of psychiatric disorders (through expert interviews) was replaced by a two-step model, with a screening for all participants by self-report or informant-report questionnaires, and only a diagnostic interview for those participants who scored above cut-off points on the questionnaires. Cognitive, social and emotional capabilities determined if a participant could be assessed by self-report questionnaires, administered by a trained test assistant in a screening interview. To ensure accurate administration of the assessments in this large group of test admin-

istrators, they were all trained by the researchers themselves or external experts and regularly checked on correct test assessment and scoring during the entire duration of the study.

Professional caregivers of the clients were informed in an early stage of the study, even before the consent procedure had been started. After consent, involved caregivers were consulted about their preferences and suggestions for the organization of the measurement, to increase their collaboration during the assessments. These preferences were used as input for the final schedule of measurements for individual participants. Involvement and cooperation was thus managed by careful communication and organization.

In order to enhance participation during the assessments, we needed to keep the impact for participants and caregivers as low as possible. All diagnostic assessments needed to be organised at settings nearby participants, preferably locations they were familiar with. Furthermore, all assessments needed to be carried out by trained professionals of the health care organizations themselves, who were familiar to most of the participants. We decided that to decrease the burden of participation even further, all assessments needed to be concentrated in a period of two weeks for a participant, and all participants of the same living facility needed to be clustered together in the same two weeks, to decrease the impact for the involved professional caregivers too. The assessment consisted of parts where active involvement of the participant was necessary (i.e. physical examination) and of parts with no need of active involvement of the participant (i.e. questionnaires for professional caregivers), and the advice of the professional caregiver was followed concerning what parts were too stressful for a specific client.

In these two weeks, the emphasis of the assessment was on the first day, with a physical examination and a physical fitness test for the participants, and questionnaires to be completed by the professional caregivers. In the following two weeks the participants carried a pedometer and an accelerometer, and had appointments for a mealtime observation of swallowing and a short interview structured by self-report questionnaires about anxiety and mood and, if consented to, a venipuncture. Only when a participant scored above cut-off points in this screening for anxiety and/or depression, an in-depth diagnostic interview by trained behavioural therapists with client and/or a professional caregiver took place (all assessments described in more detail in the Appendix).

After the assessment on the first day, the participant received a medal, and after the whole two weeks, each participant received a certificate of participation. The professional caregiver received a report with a summary of the results of the assessment, with advice whether to consult a physician or behavioural therapist or not.

Standard informed consent procedure

We aimed to include all clients aged 50 years or older receiving care or support by one of the three health care organizations (at the 1st of September 2008). No other exclusion criteria were applied. This selection method is likely to result in a very heterogeneous cohort with regard to aetiology and disabilities, reflecting the heterogeneity in the actual population of older adults with intellectual disabilities. All eligible clients were invited to participate from November 2008 to July 2010.

Separate consent procedures were followed for clients who were capable of understanding the available information and deciding themselves to participate or not in this research project, and clients who were not capable of doing so. In some health care organizations this distinction was already available from their databases, in others we sought advice from the involved behavioural therapists in this matter, following the guidelines of WGBO [23], the Dutch law that provides in rights and obligations between patient and health care professionals.

For clients who could make their own decision regarding consent for participation, information consisted of an introductory letter, an information booklet and a consent form, all with adjusted texts and pictograms to be easily readable. For clients who were not able to make this decision themselves, their legal representatives were approached, again with an introductory letter, an information booklet and a consent form. In case of doubt or unavailable information about the capability of the clients to decide for themselves, we first approached the legal representatives, giving them the possibility to forward this decision to the clients.

The study would not interfere with routine medical practice. Ethical approval was obtained (number 2008-234) from the Ethics Committee of the Erasmus University Medical Center. The study followed the guidelines of the Declaration of Helsinki [24].

Optimizing recruitment

- Extra feature in the organizational structure is that this study was executed by PhD students, who were each employed by one of the health care organizations. This resulted in further strengthening of the connection between research and daily practice and at the same time complying with one of the requirements of the grant organization.
- A time period of around six months was reserved for the communication and practical preparation of the measurements. Extra efforts were made to design a detailed communication plan. Previous projects have shown that the success of a study in ID care depends on the commitment of the professionals in the participating health care organization [25]. Informing and motivating all involved professionals as well as different management levels is essential. Furthermore, information should be adapted to the particular professionals who are informed, for example manage-

ment versus professional caregivers. Within the three health care organizations, a top-down information route was applied, from top management to the teams of professional caregivers, and this route was extended horizontally to the local ethical committees and client councils. Preceding the study, routine meetings of these groups were used to provide oral and written information. Only after this information route was fully completed, including the level of the professional caregivers, the consent procedure was started.

- Local ethical committees and boards of clients and client representatives of the three involved care organizations were informed as well and they formally consented to this research project. This created support on different levels of the involved care organizations.
- The invitations to the participants were sent in sequential batches, to limit the time between consent and assessment and therewith minimize the loss of participants due to lack of motivation.
- Extra efforts were made to receive responses of all invited participants. Telephone calls were made to announce the sending of the consent materials, and if not returned in time, telephone reminders were made to obtain the missing consent forms. This offered the opportunity to clients and/or their caregiver to ask remaining questions about the study.
- The consent procedure was accompanied by extra information about the possibility to exclude measurements which were too stressful for a specific participant. This took away expected concerns of legal representatives and/or professional caregivers and was therefore an important extra activity in the consent procedure: After consent, intellectual or physical disabilities of various levels were taken into consideration in the actual participation in different parts of the assessment. Furthermore, the advice of the professional caregiver was to be followed concerning which parts of the assessment would be too stressful or not possible to execute for a specific client and thus be omitted. At all times unusual resistance to (parts of) the assessment by the client was leading [26].

Outcomes

Inclusion

Numbers of clients in the different phases in the consent procedure will be presented, with a detailed description of non-participants.

Representativeness

To determine if the resulting sample would be representative for the base population, we collected administrative data of all clients aged 50 year and over (gender, age, type

Table 1 ZZP Classifications ID care [27]

ZZP score	*Content of ZZP*
1 VG	Residence with minimal support
2 VG	Residence with support
3 VG	Residence with support and care
4 VG	Residence with support and intensive care
5 VG	Residence with support and very intensive care
6 VG	Residence with intensive support, care and regulation of behaviour
7 VG	(Enclosed) Residence with very intensive support, care and regulation of behaviour
Functional indication	Support with no residence (only day care or ambulatory support)

of living facility and ZZP-score). ZZP (ZorgZwaartePakket) is the Dutch classification of levels of support, care and/or treatment as a basis for long-term financing [27] (Table 1). ID care and mental health care (MHC) have different ZZP-classifications. A small number of clients may be indicated according to the ZZP classification for mental health care, although having an intellectual disability as well. For clients who participate in day activities within the consort and obtained residential care from other care providers, the ZZP score needed to be collected elsewhere.

To determine representativeness of the included sample, we used Pearson's Chi-square test for independence, with null hypothesis that the participants and non-participants are similar (i.e. that characteristics are not depending on group).

Participation

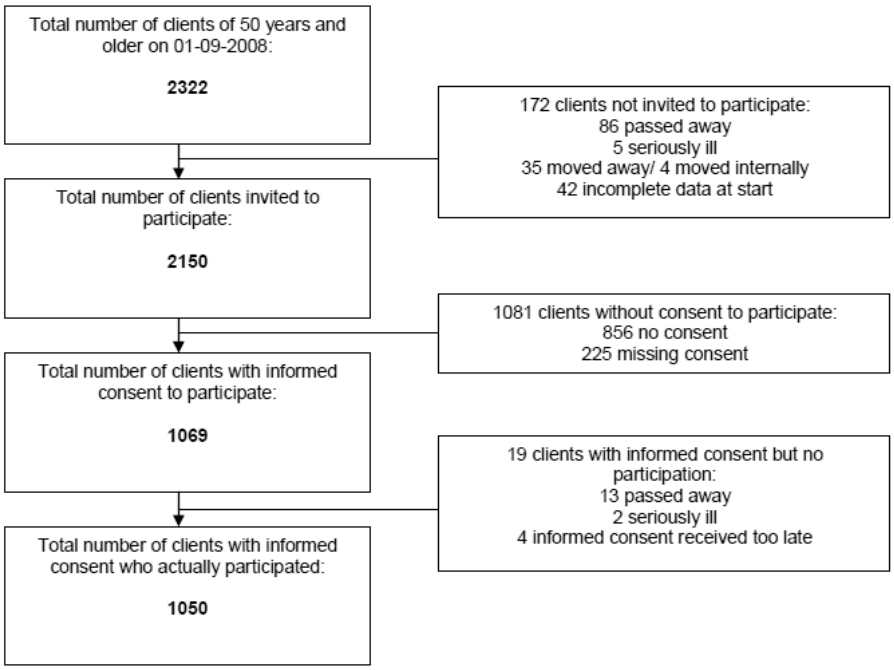
To evaluate whether health was successfully measured in this sample of older adults with intellectual disabilities, participation rates are given for four key measurements of the complete health assessment (physical examination, physical fitness test, questionnaires completed by caregivers, interviews). Data on all other measurements will be provided in separate papers concerning those measurements.

RESULTS

Inclusion

In Figure 1 the results of the recruitment procedure are shown. Although the consent rate (consent/invited) was 1069/2150 (49.7%), the total rate of participants of the total cohort (total number/participants) was 1050/2322 (45.2%).

Figure 1



Representativeness

In Table 2 the numbers are presented for the total population of older adults in all three care organizations, for participants and for non-participants, including the contributing Chi-square terms per category. The categories with the largest deviation from the expected numbers are bold, to show which categories cause the significant differences between both groups. Overall Chi-square statistics are presented in Table 3.

Table 2 Representativeness of the study population

	Total population	Participants		Non-participants	
	N	N	$(X_o-X_e)^2/X_e$	N	$(X_o-X_e)^2/X_e$
Total	2322	1050		1272	
Gender					
Male	1253	539	1.34	714	1.11
Female	1069	511	**1.58**	558	1.30
Age					
50 – 54 years	638	304	0.83	334	0.69
55 – 59 years	605	246	2.78	359	2.14
60 – 64 years	471	224	0.57	247	0.47
65 – 69 years	235	118	1.29	117	1.06
70 – 74 years	181	90	0.82	91	0.68
75 – 79 years	110	47	0.15	63	0.12
80 – 84 years	56	11	**8.08**	45	**6.66**
85 – 89 years	19	8	0.04	11	0.03
90 – 94 years	7	2	0.45	5	0.38
Residential status					
Central setting	1159	557	0.65	602	0.56
Community-based	867	432	2.13	435	1.85
Independently living with ambulatory support	192	43	**23.93**	149	**20.76**
With relatives	19	7	0.37	12	0.32
Unknown	85	11		74	
Level of care (ZZP-scores)					
Only day care indication	21	6	1.54	15	1.37
Only indication ambulant care	125	37	**8.26**	88	**7.41**
1 VG	23	12	0.11	11	0.10
2 VG	95	39	0.78	56	0.69
3 VG	308	138	0.41	170	0.37
4 VG	366	207	**6.64**	159	**5.86**
5 VG	690	325	0.01	365	0.01
6 VG	202	93	0.07	109	0.06
7 VG	278	142	0.84	136	0.75
MHC ZZP scores	8	2	0.85	6	0.77
Unknown	206	49		157	

Table 3 Chi-square statistics

Characteristic	Chi-square (df)	p
Gender	5.3 (1)	0.028
Age	27.41 (8)	0.001
Type of living facility	50.55 (3)	<0.001
Level of care	41.06(9)	<0.001

Table 4 Participation to parts of the health assessment

Measurement	Participation
Physical examination (or part of it)	90%
Physical fitness test (or part of it)	87%
Questionnaires by the caregivers	94%
Interviews participants themselves	20%

Participation

Participation to parts of the health assessment is presented in Table 4.

CONCLUSION AND DISCUSSION

This paper describes how to successfully include a large sample of older adults with ID and to measure their health. A selection of instruments suitable for large-scale health assessment in this group is presented. Involvement of top and middle management in the entire process and a thorough communication plan (with a focus on key groups such as professional caregivers) proved of paramount importance to effectively organize this kind of large-scale research projects.

Not documented in this study, but an important factor in recruitment and measurements, was the actual involvement and cooperation of professional caregivers. Feedback from management of all levels in the care organizations, combined with our personal experiences in this process, suggest that the professional caregivers reacted positively to the personal communication and cooperativeness of the researcher to follow their preferences in the organization of measurements, leading to widespread cooperation during the consent procedure as well as the measurements themselves.

The actual percentage of clients with informed consent was 49.7 %. This percentage seems low, but considering the extensive health screening, which could be seen as a burden for the participant, it might be relatively good. In a multi-centre study with only an assessment of visual and hearing function, the consent percentage was 61% [19].

The absence of exclusion criteria (except for age) led to a very heterogeneous population. The study population showed significant differences in all categories between participants and non-participants, so it is not a completely representative sample for the total Dutch client population. The significant difference for the category 'gender' was caused by a small overrepresentation of women. For age, the significant difference was caused by an underrepresentation of 80-84 year-olds. This could be explained by the small numbers in the higher age groups, with large consequences for representativeness by small deviations in absolute numbers. Older adults with supported living and often with an indication of ambulant care only, proved hard to reach or to motivate to participate in this study, resulting in an underrepresentation of this group in both the categories 'residential status' and 'ZZP-scores'. One possible explanation might be that they do not recognise themselves as clients of services for people with ID or do not want to be labelled as 'intellectually disabled'. On the other hand, clients with an indication of residence with support and intensive care are overrepresented. Weighting will have to be applied for the results to be generalised to the complete older adult client population with ID in the Netherlands.

Researchers of earlier large-scale studies in populations with intellectual disabilities have reported a number of obstacles, which were avoided in this study by the carefully prepared communication routes and set-up of assessments [25]. Already in 2004, Evenhuis et al concluded that local coordination, sufficiently supported by the management, was the key factor in a successful organization of an epidemiological study in ID services [19]. Meuwese et al (2005) concluded that it is not possible to organize a large-scale intervention study without the active cooperation of the management to provide sufficient resources and support [17]. Sjoukes et al (2006) studied concept-mapping as a method to effectively introduce complex interventions, but concluded this method alone was not sufficient. This method resulted in actions which were primarily operational and ad hoc, instead of changing strategic policies of the care organizations. This resulted in a lack of motivation of the professional caregivers and the middle management [18]. In our study, involvement of top and middle management was secured in the research infrastructure. Next to management involvement in decision-making and policy strategies, they provided necessary conditions and solutions for problems in the execution of this study.

Next to the involvement of top and middle management, this paper provides a few other take home messages for the infrastructure of a large-scale multi-centre study for adults with ID. First of all, good preparation of the organization of measurements is as important as designing the research protocol, and requires just as much effort and time. This preparation consists mainly of writing and executing a thorough communication plan, with specific attention for key stakeholders (i.e. professional caregivers). Involved professionals of any kind within the care organizations need to

be informed and trained timely and to enhance cooperation they need to have a say in the organization and planning of the assessments. A more detailed description of the research infrastructure and management of involvement and cooperation will be published elsewhere.

APPENDIX

Measurements with active involvement of the participant

Type	Outcome	Details
Physical assessment	Height	Seca stadiometer, type 214. Body Mass Index calculated: weight divided by squared height.
	Knee height	Formulas Chumlea et al. [28] for calculating body height.
	Weight	Digital floor scale (Seca robusta type 813). Body Mass Index calculated: weight divided by squared height.
	Fat percentage	Formulas Durnin and Womersly [29] for calculating fat percentage from the sum of four skinfolds: triceps, biceps, subscapular and suprailiacal. Thickness of skinfolds measured with skinfold caliper (Harpenden).
	Body circumferences	Flexible tape for hip, waist, calf and upper arm circumference. Waist-to-hip ratio calculated: waist circumferences divided by hip circumference.
	Blood pressure	Omron M7.
	Ankle-Arm-Index	Omron M7 (arm). Boso classico and 8-MHz Doppler probe (Huntleigh MD II) (ankle). Ankle-arm-index calculated: systolic blood pressure ankle divided by systolic blood pressure arm..
	Bone Quality	Ultrasonometer (Lunar Achilles Insight) for measuring bone stiffness calcaneus.
Fitness Assessment	Manual dexterity	Box and block test [30].
	Response time	Response time test.
	Balance	Berg Balance Scale [31].
		5 m walking speed (comfortable and fast).
	Muscle strength	Grip strength [32] with Jamar Hand Dynamometer (#5030J1, Sammons Preston Rolyan, USA).
	Muscle endurance	30s Chair stand [33].
	Cardiorespiratory endurance	10m Incremental shuttle walking test [34]. Results of this test recalculated to VO2max [35].
	Flexibility	Extended version of Modified back saver sit and reach test [21,36]
Diary	Food intake	3-day food intake diary
Two weeks at home	Rest-activity rhythm	Actiwatch AW 7 (Cambridge Neurotechnologies)
	Physical activity	Pedometer (NL-1000, New Lifestyles, Missouri USA)
Meal time observation	Swallowing problems	Dysphagia Disorders Survey [37].
Interview (if possible)	Self-report depression	Inventory of Depressive Symptomatology Self Report (IDS-SR) [38]. Phrasing of the questions adapted to people with ID.
	Self-report anxiety	Glasgow Anxiety Scale for people with an Intellectual Disability (GAS-ID) [39]. Translated version of the GAS-ID into Dutch.
	Self-report anxiety	Hospital Anxiety and Depression Scale (HADS) [40] -anxiety subscale. Phrasing of the questions adapted to people with ID
	Social contacts	Checklist about number of contacts with family, friends and peers and visiting leisure-clubs.
	Quality of life	Intellectual Disability Quality of Life (IDQOL-16) [41]

Measurements with active involvement of the participant *(continued)*

Type	Outcome	Details
Interview	Diagnostic interview depression and/or anxiety	Participants with scores above the preset cut-off scores on one of the depression or anxiety questionnaires further examined by behavioural scientists trained in assessing the PAS-ADD-10 interview with participant or his/her caregiver [42]
Venipuncture	Biochemical markers	Fasting plasma levels: glucose, cholesterol, HDL-cholesterol, triglycerides, CRP, Hb and albumin.
Measurements without active involvement of the participant		
History	Medical files	Checklist for general practitioners or ID-physicians
	Psychological files	Checklist for psychologists or behavioural therapists
	Dental files	Checklist for dentists
Questionnaires professional caregiver	Malnutrition	Mini Nutritional Assessment (MNA) [43].
	Eating disorders	Screening Tool of fEeding Problems (STEP) [44]. Translated version in Dutch.
	Gastro-oesophageal reflux disease (GORD).	GORD Questionnaire: a newly developed questionnaire consisting of 50 items involving risk factors and symptoms of gastro-oesophageal reflux disease.
	Informant-report depression and anxiety	Anxiety, Depression, And Mood Scale (ADAMS) [45]. Translated version of the ADAMS into Dutch.
	Somatic complaints	Somatic complaints subscale of the Symptom Checklist-90 (SCL-90) [46]
	Life-events	Checklist Life Events. Newly developed checklist based on other checklists, earlier life event-studies and experience from professionals working with people with ID.
	Social outcome	Checklist about number of contacts with family, friends and peers and visiting leisure-clubs.
	Cognitive functioning	Dementia questionnaire for people with intellectual disabilities (DMR) [47]
	Activities of daily life and mobility	Barthel Index [48]
	Instrumental activities of daily Life	Questionnaire based on the Instrumental Activities of Daily Living of Lawton and Brody [49] and the Groningen Activities Restriction Scale [50-51].
	Mobility	Questionnaire based on the Hauser Ambulation Index [52] and the characteristics of the Gross Motor Function Classification Scale [53].
	Physical activity	Questionnaire about the participants' habitual physical activity.
Interview	Diagnostic interview depression and/or anxiety	Participants with scores above the preset cut-off scores on one of the depression or anxiety questionnaires further examined by behavioural scientists trained in assessing the PAS-ADD-10 interview with the caregiver [42].

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Summary

Chapter 1

This thesis investigates aspects of sleep and the sleep-wake rhythm in older adults with intellectual disabilities (ID). Sleep deprivation in older adults in the general population are associated with poorer quality of life, cognitive decline, depression, disability in basic activities of daily living and the necessity of placement in a home for the elderly. Also long sleep time is associated with negative health outcomes in older adults, like poor self-rated health and quality of life, high cholesterol levels and depression and anxiety disorders. Overall, both short and long sleep duration are significant predictors for mortality. All people with ID have some form of brain dysfunction, and in combination with age-related changes to brain structures regulating sleep and wake, older adults with ID might be extra vulnerable to develop sleep-wake disturbances. Both night sleep and the sleep-wake rhythm in older adults with ID were of interest. Until now no epidemiological research had been performed on these topics in this population. Because life expectancy nowadays has increased in people with ID, knowledge about night sleep and the sleep-wake rhythm is of importance for optimal care. Also, for both epidemiological research and individual diagnostics of sleep problems, an objective tool to investigate sleep that is suitable for older adults with ID is needed.

Night sleep and the sleep-wake rhythm were studied in the 'Healthy Ageing and Intellectual Disabilities' (HA-ID) study – a large cross-sectional epidemiological study that addressed many aspects of health in older adults (50 years and older) with intellectual disabilities in the Netherlands. Because previous research on sleep in people with ID was mainly based on caregiver interviews, we aimed to investigate night sleep and the sleep-wake rhythm using objective measurements. Polysomnography is too burdensome for the majority of people with ID; therefore we measured sleep using actigraphy (the Actiwatch). The Actiwatch is a watch-like device that measures movement activity, and based on this activity several parameters of the sleep-wake pattern can be calculated.

The main aims of this study were to investigate the validity of actigraphy in older adults with ID, the prevalence of sleep problems in older adults with ID using actigraphy, and which factors are associated with night sleep and the sleep-wake rhythm in this population.

Chapter 2

To investigate how sleep problems are defined in research among adults and older people with ID, and to collect information on the prevalence, associated factors and therapy for sleep problems in this population, we performed a systematic literature review. In previous studies on sleep problems in adults with ID, the definitions used to describe a sleep problem are not uniform. The reported estimated prevalence rates

of sleep problems ranged from 8.5% to 34.1%. Sleep problems were associated with challenging behaviour, respiratory disease, visual impairment, psychiatric conditions, and using psychotropic, antiepileptic and/or antidepressant medication. Little information was found on older people specifically. Two studies on non-pharmaceutical interventions for sleep problems in a larger study sample suggest that non-pharmaceutical interventions are beneficial. Research on sleep problems in adults and older people with ID has mainly focused on subjectively derived data, and associations were mainly described as correlations.

Chapter 3

In Chapter 3, data obtained in the first year of the HA-ID study were studied to explore to what degree Actiwatch measurements were successful in older adults with ID, and to study the influence of the different sensitivity settings of the Actiwatch Sleep Analysis software on sleep parameters. A complete measurement of at least seven days and nights, including at least one weekend day, was considered successful. Of 563 participants who were asked to wear the Actiwatch, 35.5% had a successful measurement. Main causes for an unsuccessful measurement were primarily problems with wearing the device and incomplete information on bedtime and get-up time. Application of different sensitivity settings of the Sleep Analysis software resulted in clear differences of all sleep parameters. Based on this data we concluded that it needs to be investigated which sensitivity setting of the Actiwatch gives most valid results in this specific group.

Chapter 4

To study which sensitivity setting of the Actiwatch gives most valid results in older adults with ID, two Actiwatch devices (Actiwatch AW7 and Actiwatch 2) were compared to polysomnography in ten older adults with mild ID, for two consecutive nights in their own living environment. A 1-minute epoch-to-epoch comparison was performed for the Actiwatch and PSG data, for all data collected during nighttime. The high sensitivity setting of the Actiwatch appeared most suitable to detect sleep disturbance in older adults with ID (wake detection percentage of 54.6%, sleep detection percentage of 89.7%). On average, values of sleep parameters calculated using the high sensitivity setting approximate the values of sleep parameters measured with PSG. Outcomes were similar for the two Actiwatch types.

Chapter 5

In Chapter 5 we focused on the data that were collected during daytime in the Actiwatch versus polysomnography comparison study. Outcome measures were the percentage of time that was scored as 'sleep' by both the Actiwatch and PSG of all the

time that was scored as 'sleep' by the Actiwatch in total, and the percentage of time that was scored as 'wake' by both the Actiwatch and PSG of all the time that was scored as 'wake' by the Actiwatch in total. A large amount of time that was scored as 'sleep' by the Actiwatch during daytime was actually 'wake' according to polysomnography. Based on this pilot, evaluating daytime sleep in older adults with ID using the Actiwatch seems not advisable.

Chapter 6

In Chapter 6 we compared the sleep-wake rhythm of older adults with ID to that of older adults in the general population, and investigated which factors are associated with the sleep-wake rhythm in older adults with ID. Outcome measures were stability (interdaily stability), fragmentation (intradaily variability) and amplitude (relative amplitude) of the sleep-wake rhythm.

Compared to older adults in the general population (n=56), the sleep-wake rhythm of older adults with ID (n=501) was significantly less stable, more fragmented, and had a lower relative amplitude. Higher age, dementia, depression, visual impairment, severe hearing impairment, epilepsy and spasticity are independently associated with a more disturbed sleep-wake rhythm in this group. The sleep-wake rhythm is more stable in females and those living at a setting for more intensive care. Higher physical activity levels are strongly associated with both a less fragmented and a more stable sleep-wake rhythm in older adults with ID.

Chapter 7

In Chapter 7 we studied sleep and its associated factors in older adults with ID. We investigated the distribution and inter-correlations of objective sleep parameters and which factors are independently associated with these sleep parameters, and estimated the prevalence of sleep problems. Variables of interest were the sleep parameters time in bed, sleep onset latency, total sleep time, wake after sleep onset, sleep efficiency and get-up time latency. To estimate the prevalence of sleep problems, provisional definitions of sleep problems based on sleep parameters were drafted.

Time in bed was very long (mean 630 minutes) in older adults with ID. Longer time in bed was independently associated with female gender, higher age, more severe level of ID, living at a central facility, wheelchair dependence and depressive symptoms. Sleep onset latency was associated with Down syndrome and higher body-mass index. Total sleep time was longer in female, and wake after sleep onset was longer with higher age and in participants with visual impairment. The prevalence of sleep problems was: 23.9% settling problem, 63.1% night waking problem, 20.9% short sleep time, 9.3% early waking problem. 72% of the participants had at least one problem, and 12.3% had three or more sleep problems.

Chapter 8

We studied how many sleep problems that were found in the HA-ID study were known by professional caregivers (n=301), and the concordance between objectively measured sleep parameters with client self-report (n=80). Professional caregivers were asked if their client had a sleep problem. Sleep problems were categorized as 'no sleep problem', 'settling problem', 'night waking problem' or 'unspecified problem'. Participants who were capable of self-report were interviewed using the Inventory of Depressive Symptomatology Self Report (IDS- SR), and their answers were compared to Actiwatch measurements. We found that of all sleep problems that were determined according to the HA-ID definition, the majority (73%) was reported as 'no sleep problem' by the professional caregiver. The agreement between client self-report and Actiwatch measurements was poor for time to fall asleep (SOL), night waking (WASO) and early waking (GTL), but for self-reported total sleep time (TST) a significant correlation with Actiwatch measurements was found. It might be useful to develop a tool that enables self-report of individual experience of sleep as an addition to objective sleep measurements.

Chapter 9

In this chapter the main results of our study, strengths & limitations, and directions for further research and clinical practice are discussed. A major strength of this study is that objective measurements were performed in a large sample of older adults with ID. A hypothetical model on factors that can influence night sleep and the sleep-wake rhythm in this population is provided, which can be a basis for both further research and clinical practice. Further research should first focus on genetic factors resulting in sleep-wake disturbances. Second, epidemiological research is needed to study causality of relationships, the effects of sleep disturbances on health and wellbeing, and to study which factors are specific for older adults with ID compared to older adults in the general population. Also, further validation of the Actiwatch is recommended.

Although further research is needed, actigraphy should become a routine diagnostic instrument. More awareness among professionals regarding sleep and the sleep-wake rhythm is needed, and an individual approach of sleep needs is of importance to improve care for older adults with intellectual disabilities.

Samenvatting

Hoofdstuk 1

In dit proefschrift wordt het onderzoek naar slaap en het slaap-waak ritme van ouderen met een verstandelijke beperking beschreven.

Bij ouderen in de algemene populatie is slaapgebrek gerelateerd aan een slechtere kwaliteit van leven, achteruitgang in denken, depressie, beperkingen in het dagelijks functioneren en de noodzaak om te verhuizen naar een verzorgingshuis. Ook lang slapen is geassocieerd met negatieve gezondheidseffecten bij ouderen, zoals slechtere zelfgerapporteerde gezondheid en kwaliteit van leven, hoog cholesterol, en depressie- en angststoornissen. Over het algemeen zijn zowel te kort als te lang slapen significante voorspellers voor sterfte.

Alle mensen met een verstandelijke beperking hebben enige vorm van onderontwikkeling van of schade aan de hersenen. Daarnaast vinden met toename van de leeftijd veranderingen plaats in de hersenstructuren die slaap en wakker reguleren. Hierdoor zijn ouderen met een verstandelijke beperking mogelijk extra kwetsbaar om een slaap-waak stoornis te ontwikkelen. Tot nu toe is er nog geen epidemiologisch onderzoek verricht naar slaap en het slaap-waak ritme van ouderen met een verstandelijke beperking. Omdat de levensverwachting van mensen met een verstandelijke beperking is toegenomen, is kennis over nachtelijke slaap en het slaap-waak ritme van belang voor optimale zorg. Daarnaast is er een instrument nodig dat slaap objectief kan meten, voor zowel epidemiologisch onderzoek als voor het diagnosticeren van slaapproblemen bij individuen.

Slaap en het slaap-waak ritme zijn onderzocht in het onderzoek 'Gezond Ouder met een verstandelijke beperking' (GOUD). Dit is een grootschalig cross-sectioneel epidemiologisch onderzoek om verschillende gezondheidsaspecten van ouderen (50 jaar en ouder) met een verstandelijke beperking in Nederland in kaart te brengen. Omdat eerder onderzoek naar slaap bij mensen met een verstandelijke beperking vaak gebaseerd was op interviews van de begeleiders, wilden wij de nachtelijke slaap en het slaap-waak ritme op een objectieve manier onderzoeken. Polysomnografie (het meten van de hersenactiviteit om het slaappatroon in kaart te brengen, met behulp van elektroden op het hoofd) is een goede manier om dit te doen, maar dit is te belastend voor het merendeel van de mensen met een verstandelijke beperking. Daarom hebben wij ons onderzoek uitgevoerd met actigrafie (de Actiwatch). De Actiwatch is een soort horloge dat beweging meet, en op basis van de hoeveelheid beweging kunnen verschillende parameters van slaap en het slaap-waak ritme berekend worden. De belangrijkste doelen van deze studie waren: onderzoeken of actigrafie een valide methode is om slaap te onderzoeken bij ouderen met een verstandelijke beperking, bepalen hoe vaak slaapproblemen voorkomen bij deze mensen, en onderzoeken welke factoren geassocieerd zijn met slaap en het slaap-waak ritme.

Hoofdstuk 2

Om te onderzoeken hoe slaapproblemen gedefinieerd worden in studies bij volwassenen met een verstandelijke beperking, en om informatie te verzamelen over hoe vaak slaapproblemen voorkomen, welke factoren met slaapproblemen samenhangen en hoe slaapproblemen behandeld worden in deze doelgroep hebben werd een literatuur onderzoek verricht. Hieruit bleek dat de gebruikte definities voor slaapproblemen niet gelijk zijn. Het voorkomen van van slaapproblemen bij volwassenen met een verstandelijke beperking varieerde van 8.5% tot 34.1%. Slaapproblemen waren geassocieerd met gedragsproblemen, ziektes van de luchtwegen, oogproblemen, psychiatrische problemen, en het gebruik van medicatie tegen epilepsie en depressie. Er waren twee studies die interventies voor slaapproblemen beschreven, zonder slaapmedicatie te gebruiken. Uit deze studies bleek dat deze interventies effectief waren. Er was in de literatuur nog weinig beschreven over ouderen met een verstandelijke beperking. Over het algemeen is eerder onderzoek naar slaapproblemen bij mensen met een verstandelijke beperking gebaseerd op de subjectieve waarneming van begeleiders, en het was niet altijd duidelijk welke factoren gerelateerd waren aan slaapproblemen (er was vaak niet gecorrigeerd voor andere factoren).

Hoofdstuk 3

In hoofdstuk 3 wordt ingegaan op de gegevens die in het eerste jaar van de GOUD studie verzameld waren. Het doel was om te onderzoeken in welke mate de Actiwatch metingen succesvol waren bij ouderen met een verstandelijke beperking, en om te onderzoeken wat de invloed van de verschillende instellingen van de Actiwatch software is op de uitkomstmaten van slaap. Een meting van ten minste zeven dagen en nachten, inclusief ten minste één dag in het weekend, werd gezien als succesvol. Het bleek dat van de 563 deelnemers die werd gevraagd mee te doen met de Actiwatch meting, 35.5% een succesvolle meting had. De belangrijkste oorzaken voor een niet succesvolle meting waren vooral het niet willen dragen van de Actiwatch, en onvolledige informatie over de tijd van naar bed gaan en opstaan. Het toepassen van verschillende instellingen van de software op de data resulteerde in duidelijke verschillen in de uitkomstmaten van slaap. Op basis van deze data concludeerden wij dat nader onderzoek nodig is over welk gevoeligheidsniveau de meest valide resultaten oplevert in deze specifieke doelgroep.

Hoofdstuk 4

Om de vraag te beantwoorden welke instelling (ook wel gevoeligheidsniveau) van de Actiwatch de meeste valide resultaten oplevert voor ouderen met een verstandelijke beperking, werden twee Actiwatch typen (Actiwatch AW7 en Actiwatch 2) vergeleken met polysomnografie (het meten van de hersenactiviteit om het slaappatroon in kaart

te brengen, met behulp van elektroden op het hoofd) bij tien ouderen met een lichte verstandelijke beperking. Het onderzoek duurde twee aaneengesloten dagen en nachten en vond plaats in de eigen woning van de deelnemers. De gegevens verzameld gedurende de nacht (van de Actiwatch en polysomnografie) werden van minuut tot minuut vergeleken. Het bleek dat het hoge gevoeligheidsniveau van de Actiwatch het meest geschikt was om slaapproblemen op te sporen bij ouderen met een verstandelijke beperking. Uitkomstmaten van slaap berekend voor dit hoge gevoeligheidsniveau kwamen bij benadering goed overeen met dezelfde uitkomstmaten berekend met polysomnografie. De resultaten van deze studie golden voor beide typen Actiwatch.

Hoofdstuk 5

In hoofdstuk 5 zijn de gegevens beschreven die overdag verzameld waren in de vergelijkingstudie tussen de Actiwatch en polysomnografie. We wilden weten of de Actiwatch goed kon inschatten of iemand sliep overdag. Uitkomstmaten waren: het percentage tijd dat was gescoord als 'slaap' door zowel de Actiwatch en polysomnografie van alle tijd die als 'slaap' gescoord was door de Actiwatch in totaal, en het percentage tijd dat was gescoord als 'wakker' door zowel de Actiwatch en polysomnografie van alle tijd die als 'wakker' gescoord was door de Actiwatch in totaal. Het bleek dat een grote hoeveelheid tijd die door de Actiwatch gescoord was als 'slaap' in werkelijkheid 'wakker' was volgens polysomnografie. Op basis van deze studie is het af te raden om de Actiwatch te gebruiken om dutjes overdag op te sporen.

Hoofdstuk 6

In hoofdstuk 6 wordt ingegaan op het slaap-waak ritme van ouderen met een verstandelijke beperking, en wordt dit ritme vergeleken met ouderen in de algemene populatie. Uitkomstmaten waren de stabiliteit en de fragmentatie van het slaap-waak ritme. Vergeleken met ouderen in de algemene populatie (n=56) is het slaap-waak ritme van ouderen met een verstandelijke beperking (n=501) significant minder stabiel en meer gefragmenteerd. Een hogere leeftijd, dementie, depressie, oogproblemen, ernstige gehoorproblemen, epilepsie en spasticiteit waren onafhankelijk gerelateerd aan een meer verstoord slaap-waak ritme in deze groep. Het slaap-waak ritme was meer stabiel bij vrouwen en bij mensen die op een centrale voorziening wonen. Een grotere hoeveelheid lichamelijke activiteit was sterk geassocieerd met zowel een minder gefragmenteerd en meer stabiel slaap-waak ritme bij ouderen met een verstandelijke beperking.

Hoofdstuk 7

In dit hoofdstuk wordt ingegaan op de nachtelijke slaap en factoren die hiermee samenhangen. We onderzochten de verdeling en onderlinge correlaties van objectief

gemeten slaapparameters (met de Actiwatch) en welke factoren onafhankelijk invloed hebben op deze slaapparameters. Ook onderzochten we hoe vaak slaapproblemen voorkomen bij ouderen met een verstandelijke beperking. De onderzochte slaap parameters waren tijd in bed, de tijd die nodig was om in slaap te vallen (slaap latentietijd), totale slaaptijd, tijdsduur van 's nachts wakker liggen, slaapefficiëntie, en tijd tussen wakker worden en opstaan 's morgens. Om in te schatten hoe vaak slaapproblemen voorkomen werd op basis van voorgaand onderzoek in de algemene populatie een definitie voor een slaapprobleem opgesteld.

Het bleek dat de tijd in bed erg lang was (gemiddeld 10.5 uur) bij ouderen met een verstandelijke beperking. Deze tijd in bed was langer bij: vrouwen, mensen met een hogere leeftijd, mensen met een ernstigere verstandelijke beperking, mensen die op een centrale voorziening wonen, mensen die afhankelijk zijn van een rolstoel, en bij mensen met symptomen van een depressie. De slaap latentietijd was langer bij mensen met Down syndroom en bij mensen met een hoger lichaamsgewicht. De totale slaaptijd was langer bij vrouwen, en de tijdsduur van 's nachts wakker liggen was langer bij mensen met een hogere leeftijd en bij mensen oogproblemen. De volgende slaapproblemen kwamen voor bij ouderen met een verstandelijke beperking: 23.9% inslaapprobleem, 63.1% doorslaapprobleem, 20.9% een te korte slaaptijd en 9.3% te vroeg wakker worden 's morgens. Van alle deelnemers had 72% ten minste één slaapprobleem, en 12.3% had drie of meer slaapproblemen.

Hoofdstuk 8

We hebben onderzocht hoeveel slaapproblemen die gevonden waren in de GOUD studie (hoofdstuk 7), ook als zodanig bekend waren bij begeleiders (n=301). Ook onderzochten we de overeenkomst tussen objectief gemeten slaap parameters met zelfrapportage door cliënt (n=80). Aan persoonlijk begeleiders werd gevraagd of hun cliënt een slaap probleem had. Deze problemen waren gecategoriseerd als 'geen slaapprobleem', 'inslaapprobleem, 'doorslaapprobleem' of 'ongespecificeerd slaapprobleem'. Deelnemers aan de GOUD studie die in staat waren tot zelfrapportage werden geïnterviewd met de 'Inventory of Depressive Symptomatology Self Report (IDS-SR)' vragenlijst. De antwoorden op de vragen met betrekking tot slaap werden vergeleken met de uitkomsten van de Actiwatch meting. We vonden dat van alle slaapproblemen gevonden in het GOUD onderzoek (hoofdstuk 7), 73% werd benoemd als 'geen slaapprobleem' door de persoonlijk begeleider. De overeenkomst tussen zelfrapportage en de Actiwatch meting was zwak voor de uitkomstmaten tijd om in slaap te vallen, 's nachts wakker worden en te vroeg wakker worden. Voor de totale slaaptijd werd wel gevonden dat zelfrapportage en de Actiwatch meting aan elkaar gerelateerd waren. In de praktijk kan het nuttig zijn om naar kwalitatieve ervaring van slaap te vragen (in plaats van kwantitatief), als aanvulling op een objectieve meting met de Actiwatch.

Hoofdstuk 9

In dit hoofdstuk zijn de belangrijkste resultaten van in dit proefschrift samengevat. Daarnaast worden de sterke en zwakke punten van de studie, en aanbevelingen voor vervolgonderzoek en de praktijk bediscussieerd. Een belangrijk sterk punt van deze studie is dat objectieve metingen zijn gebruikt in een grote groep ouderen met een verstandelijke beperking.

Ook wordt in dit hoofdstuk een hypothetisch model besproken, over factoren die mogelijk slaap en het slaap-waak ritme in deze doelgroep kunnen beïnvloeden. Dit model kan als basis dienen voor zowel vervolgonderzoek als in de praktijk. Voor vervolgonderzoek wordt aanbevolen om verder in te gaan op genetische factoren die mogelijk ten grondslag liggen aan een verstoord slaap-waak ritme. Ten tweede is verder epidemiologisch onderzoek nodig om te onderzoeken of de gevonden associaties (hoofdstuk 6 en 7) oorzaak of gevolg zijn van slaapproblemen, om te onderzoeken wat de effecten van slaapproblemen zijn op gezondheid en algemeen welbevinden, en om te onderzoeken welke factoren specifiek zijn voor ouderen met een verstandelijke beperking ten opzichte van ouderen in de algemene populatie. Verder valideren van de Actiwatch voor mensen met een verstandelijke beperking wordt ook aanbevolen. Hoewel vervolgonderzoek nodig is, moet actigrafie toegevoegd worden aan het diagnostisch arsenaal van artsen voor mensen met een verstandelijke beperking en gedragsdeskundigen. Zorgprofessionals moeten zich meer bewust worden over slaap en het slaap-waak ritme van hun cliënten. Een individuele benadering van slaapbehoefte is van belang om de zorg voor ouderen met een verstandelijke beperking te verbeteren.

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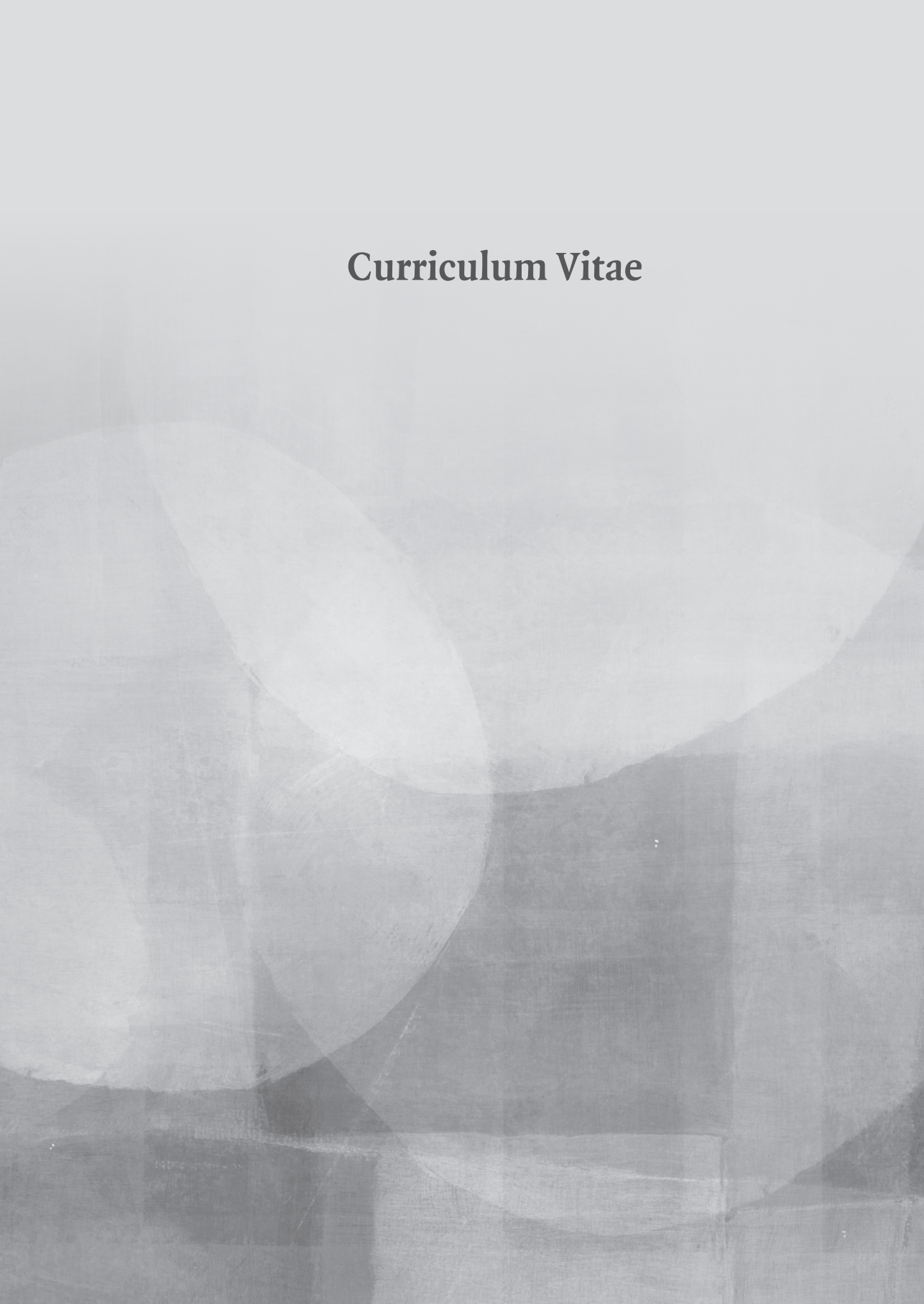
Curriculum Vitae



CURRICULUM VITAE

Ellen van de Wouw - van Dijk is op 6 november 1985 geboren in Berkel-Enschot.

Na het behalen van haar atheneum diploma aan het Theresialyceum te Tilburg (2004) ging zij geneeskunde studeren in Rotterdam. Naast haar studie werkte ze in het studententeam op de kraamafdeling van het Sophia Kinderziekenhuis, en vervulde ze een bestuursfunctie bij het Erasmus Studentenkoor. Tijdens haar keuze-onderzoek maakte zij kennis met de leerstoel Geneeskunde voor Verstandelijk Gehandicapten. Hier maakte zij een start met de analyse van de slaapdata van het onderzoek Gezond Ouder met een verstandelijke beperking (GOUD). Na het behalen van haar artsexamen in 2010 kwam zij op de afdeling werken als promovenda, op het onderwerp slaap en slaap-waak ritme bij ouderen met een verstandelijke beperking. Naast analyse van de data van GOUD zette zij zelf een kleine studie op om het meetinstrument om slaap te onderzoeken te valideren bij ouderen met een verstandelijke beperking. De resultaten van haar onderzoek presenteerde zij onder andere op het IASSID congres in Halifax (Canada) en het EUGMS congres (Brussel). In 2012 deed zij met het team GP-STAR van de afdeling Huisartsgeneeskunde mee aan de Roparun als fietser.

In maart 2013 is zij gestart met de huisartsopleiding bij het Erasmus MC in Rotterdam. Ellen is op 2 november 2011 getrouwd met Geert, en zij wonen sinds kort in het Brabantse dorp Terheijden.

PhD portfolio

PHD PORTFOLIO

Summary of PhD training and teaching

Name PhD student: Ellen van de Wouw – van Dijk
Erasmus MC Department: Intellectual Disability Medicine, Department of General Practice

PhD period: Nov 2010 – December 2012
Promotor: Prof. dr. H.M. Evenhuis
Supervisor: Dr. M.A. Echteld

1. PhD training

	Year	Workload (Hours/ECTS)
General courses		
- Biomedical English Writing and Communication	2012	4.0
- BROK ('Basiscursus Regelgeving Klinisch Onderzoek')	2012	1.0
Specific courses (NIHES Research school)		
- Introduction to clinical research	2011	0.9
- Biostatistics for clinicians	2011	1.0
- Regression analysis for clinicians	2012	1.9
Seminars and workshops		
- Workshop NVAVG Lustrum day	2011	1.0
- Workshop NVFVG study day	2011	1.0
- Workshop AVG AIOS science day	2012	0.5
Presentations		
- Departmental presentations (oral presentations)	2010-2012	1.0
- Department of Genetics & Chronobiology (oral presentation)	2012	0.8
(Inter)national conferences		
- Symposium 'Sleep & Epilepsy' Kempenhaeghe (attendance)	2011	0.3
- Dutch Congress 'Focus on Research' (poster presentation)	2011	1.0
- 14th IASSID World Congress, Halifax, Canada (oral presentation & poster presentation)	2012	4.0
- 8th Congress of EUGMS, Brussels, Belgium (two poster presentations)	2012	1.0
Other		
- CPO mini course (attendance)		0.3

2.Teaching

	Year	Workload (Hours/ECTS)
Supervising Master's theses		
- Supervising Medical Student master thesis project	2011	3.0
Other		
- Supervising student session 'How to judge a paper'	2012	0.3

Publications

PUBLICATIONS

van Dijk E, Hilgenkamp TIM, Evenhuis HM, Echteld MA. (2012). Exploring the use of actigraphy to investigate sleep problems in older people with intellectual disability. Journal of Intellectual Disability Research, 56(2): 204-11

van de Wouw E, Evenhuis HM, Echteld MA. (2012). Prevalence, associated factors and treatment of sleep problems in adults with intellectual disability: a systematic review. Research in Developmental Disabilities, 33(4): 1310-32

de Vos BC, **van de Wouw E**. (2012). Comments on "Effect of three weeks of continuous airway pressure treatment on mood in patients with obstructive sleep apnea: a randomized placebo-controlled trial". Sleep Medicine, 13(7): 965-6

Maaskant M, **van de Wouw E**, van Wijck R, Evenhuis HM, Echteld MA. (2013). Circadian sleep-wake rhythm in older adults with intellectual disabilities. Research in Developmental Disabilities, 34(4):1144-1151

van de Wouw E, Evenhuis HM, Echteld MA. (in press). Comparison of two types of Actiwatch with polysomnography in older adults with intellectual disabilities: a pilot study. Journal of Intellectual and Developmental Disability