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REVIEW ARTICLE

Ageing of adults who are blind: A scoping review

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Abstract

The ageing process of adults with a disability may differ from the typical ageing process, yet few studies have addressed ageing of adults who are blind. However, a broad scope of literature exists on ageing with a visual impairment that includes adults who are blind. People who are blind may age differently than people with a visual impairment. Furthermore, it cannot be inferred from studies on the ageing of visually impaired adults that changes are due to the ageing process alone, since vision may decline further as well. This article presents a scoping review of studies on the ageing of adults who are blind, examining the areas of decline due to ageing, differences compared to non-blind adults, additional contributing factors and support. A systematic literature search was performed from inception up to July–October 2023 in Scopus, Medline, Embase, CINAHL, APA PsycInfo and Web of Science. Thirteen articles met the eligibility criteria. Analysis led to four broad areas: physical, sensory, cognitive and psychological. In several of these areas, the decline due to ageing was similar for people who were blind or non-blind. Declines specific to people who were blind were in spatial memory and engagement to the outer world. Two abilities were identified where blind people outperformed sighted people: attention and working memory and active tactile acuity. Overall, ageing blind adults were shown to have additional risks and hence need extra support. Interventions may focus on physical and cognitive exercise, braille training, risk screening, education and social activities. More research is needed to replicate studies and disambiguate results, to include areas that have not been investigated specifically for this group, to differentiate between different types of blindness and to investigate systematically the needs and support of blind adults who are ageing.

KEYWORDS
ageing, blindness, decline, review

INTRODUCTION

The global population is ageing rapidly, stressing the need for improving knowledge and skills in geriatric care to deal with a variety of problems, including multimorbidity.[1] The general process of ageing is associated with higher dependency, frailty, cognitive and functional decline and chronic health conditions.[2–4] In a longitudinal study of functional decline in old age, it was found that functional limitations may typically co-occur in three classes referring to mobility, hearing and visual problems.[5]

The ageing process of adults with a disability may differ from a typical ageing process and has been studied separately for a number of distinct disabilities.[6] Ageing adults with disabilities experience a higher rate of chronic conditions, and in many cases, such chronic conditions and

ageing symptoms are undiagnosed, under-treated or not fully addressed.[7] One of the complexities in studies on ageing with a disability is to distinguish what is related to the disability versus the ageing process.[7]

Several studies have investigated the health and well-being of elderly people with a visual impairment. For example, anxiety and loneliness have a high prevalence among older people with a visual disability,[8] and visual impairment is associated with an increasing likelihood of developing dementia.[9] However, most studies that investigated the intersection between visual impairment and ageing deal with age-related visual impairment, meaning that the decline in vision is a consequence of the ageing process. Regarding studies that apply to ageing people who already had a visual disability prior to ageing, a question that arises is: Do these results also hold for people who are blind? For adults with a visual disability who are ageing, two processes may be responsible for change, namely (i) ageing and (ii) a further decline of vision. In contrast, for adults who are blind, only the process of ageing may cause change or decline. To isolate the ageing process from the (further) decline of vision, this study focused on the ageing process of people who are blind.

Individuals who are blind develop coping strategies such as strategic planning.[10] In addition, elevated sensory or cognitive abilities to compensate for the lack of visual input have been identified.[11–13] As ageing causes functional decline, these strategies may become less accessible, and the other (elevated) sensory abilities may also decline. Therefore, this ageing process differs from that for sighted people, not only with regard to the process of decline but also in terms of dealing with the consequences of the decline. Hence, it is paramount to understand the ageing process of people who are blind.

The present study presents a scoping review that systematically examines the existing literature on the ageing of people who are blind to explore the research conducted in this area. Hereby, the focus is on the course of decline due to ageing. Research questions include: (i) What topics have been studied concerning ageing of people who are blind? (ii) In which abilities is a decline due to ageing found? (iii) What differences are found compared with non-blind people? (iv) What other factors contribute to the ageing of adults who are blind (for a specific outcome measure)? and (v) How can blind people who are ageing be supported?

Key points

- It is important to study ageing of adults who are blind separately from the ageing of adults having an (age-related) visual disability, because their outcomes may differ.
- Although blind people may outperform sighted individuals in some tasks, ageing blind adults experience additional risks and needs and therefore require additional support.
- Ageing-related health outcomes may be influenced by the age of becoming blind or type of blindness, which should be considered in future research and practice.

METHOD

This review follows the Joanna Briggs Institute guidance for scoping reviews[14] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement extension guidelines for reporting scoping reviews.[15] The study was preregistered at the open science framework (OSF).[16]

Search strategy

For this scoping review, multiple systematic searches were performed between June and October 2023 (by JCFK, AKH and MM; see Appendix S1 for the exact dates and the full search strategies) using the following databases: Elsevier/Scopus, OVID/Medline, Embase.com, Ebsco/CINAHL, Ebsco/APA PsycINFO, Clarivate Analytics/Web of Science Core Collection and Google Scholar. The search terms included 'ageing', 'frailty' and 'blindness'. Editorials, letters and conference abstracts were excluded from the search. Duplicate articles were excluded by a medical information specialist (JCFK) using Endnote X20.0.1 (https://support.clarivate.com/Endnote/). No limits were imposed on publication date or language.

Study selection

After identifying the initial pool of articles ($n = 6133$), these were screened on title and abstract by two researchers (MM and either AKH or AK), using Rayyan (rayyan.ai). In case of conflict, a third researcher (AK or AKH) was included in the discussion. The articles that were selected based on abstract and title were additionally screened on the full text. Also at this stage, two researchers (AKH and MM) were involved. In case of conflict or uncertainty whether to include an article, additional researchers (AK, EO and PSS) were involved in the discussion. The following inclusion and exclusion criteria were used:

Inclusion

- Empirical articles involving blind human adults who were already blind before a decline in functioning due to ageing;
- Empirical articles that focused on a decline in functioning as a result of ageing;

- Articles with an element of 'time' in the design (e.g., a longitudinal study or a cohort study with different age groups).

Exclusion

- Articles in which no distinction was made between participants who were visually disabled or blind.
- Articles with a focus on:
  - Palliative and terminal care;
  - Diseases or conditions where blindness was not the primary symptom;
  - Medical treatments such as surgery or medication.

There was no explicit inclusion or exclusion criterion for (mean) participant age, since ageing for people with disabilities is known to start often at an earlier age and shows varying disability trends.[17] Inclusion of studies with participants below the age of 40 years was discussed among the project group. The study by Timio et al.[18] on blood pressure described participants for whom the average age at the end of the longitudinal study was 32 years. After discussion, it was decided to include this study, since it shows that a 20-year period could have meaning for later ages as well, since (average) blood pressure is known to increase gradually from a young age.[19]

The PRISMA flow diagram of the selection process is shown in Figure 1, where 200 additional records identified by Google Scholar were reported as records identified from databases in column 1.[20] A total of 13 studies were selected for data extraction.[18,21–32]

Quality assessment and coding

The quality of the included (quantitative) articles was assessed using the Mixed Method Appraisal Tool (MMAT).[33] This was done independently by two researchers (AKH and MM). Any discrepancies were discussed and resolved through consensus. The assessment of quality was performed to provide additional information but was not used to exclude articles. For the assessment of the articles, see Appendix S2.

The articles were coded independently by two researchers (AKH and MM), using ATLAS.ti (version 23), to find relevant information concerning the research questions.

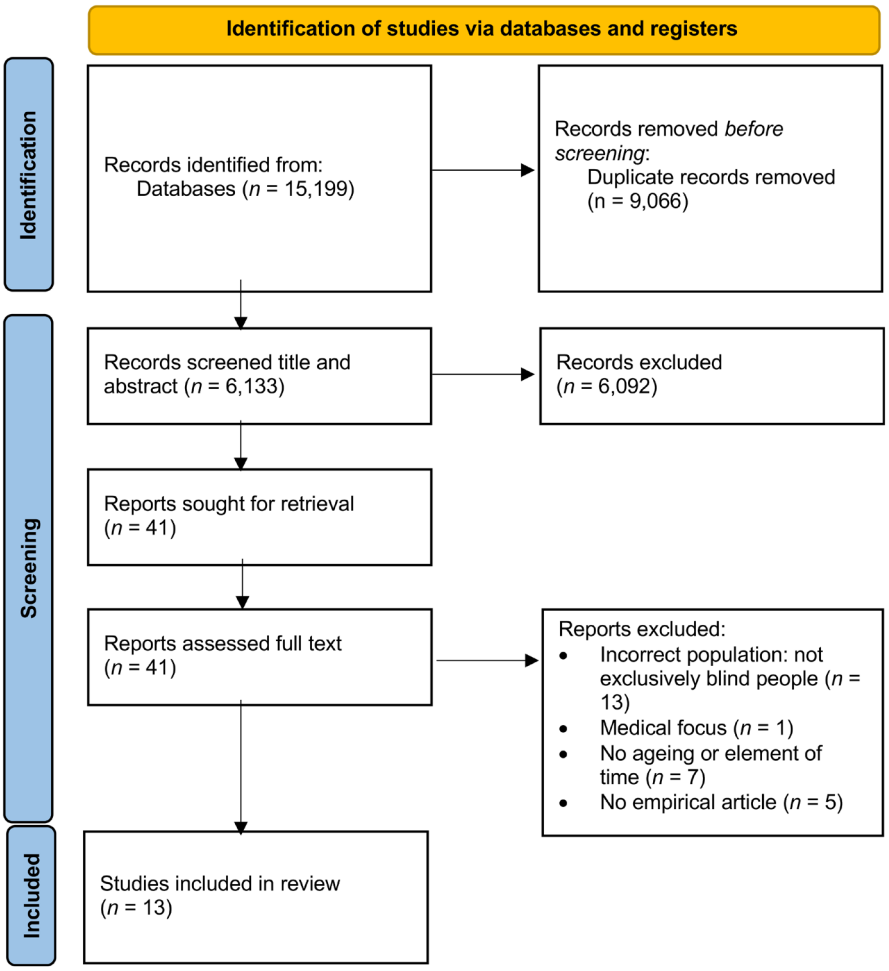

FIGURE 1 Flow diagram of selection process.

Resulting answers and themes were discussed among these researchers, as well as a larger group of authors until consensus was reached.

RESULTS

The articles included ($n = 13$) are summarised in Table 1, where information about study aim, design, sample size and findings are listed. Most of the studies (six) were based in the United States, two studies were conducted in Italy and one each in France, Poland, Israel, Canada and China. Two articles present a cohort study, where blind participants were followed over time. The other (11) articles present an analytical cross-sectional study, where data of blind participants (and control groups) were analysed at a single point in time. In these studies, the element of time that was required for inclusion of the articles came either from the division into different age groups or from the contribution of the variable 'age' in regression analysis. Sample sizes varied from 6 to 1335. The average sample size was 138 for the cohort studies and 229 for the cross-sectional studies.

Blindness was defined in only three of the included articles, and this was done in (slightly) different ways. Blindness was defined as 1. visual acuity worse than 3/60, or a visual field of 10 degrees or less[22]; 2. visual acuity worse than 6/60 (20/200), or a visual field of 20 degrees or less[29] and 3. visual acuity worse than 6/120 (10/200), or a visual field of 20 degrees or less.[31] Based on the demographic variables of the participant groups, subjects in several studies fell within these definitions, although inclusion was often based on self-report.[21,25,26,32] Two studies included a few additional participants who had better than 6/120 (20/400) visual acuity, but were using braille.[27,29] Other investigations used the term blindness without giving a formal definition or details regarding the visual acuity of the participants.[18,24,28] Several studies recruited their participants via specialised associations or facilities for people with blindness. In Table 1, each article is summarised, after which specific results are presented in a combined way, answering the research questions.

Areas of study

Four broad topic areas have been identified in which ageing was studied in adults who were blind:

1. Physical
   a. Falling[32]
   b. Blood pressure[18]
   c. Coronary heart disease[22]
   d. Menopause[30]
   e. Circadian period[26]
2. Sensory
   a. Tactile perception and acuity[23,27–29]
   b. Smell[24]
3. Cognitive
   a. Spatial memory[21]
   b. Attention and working memory[25]
4. Psychological
   a. Psychological and social engagement[31]

This list shows that only in the area of tactile acuity and perception was more than one article found. Both Martiniello et al.[29] and Legge et al.[27] assessed the effect of age on tactile acuity. Furthermore, Legge et al.[23] investigated whether tactile acuity in people who were blind can be explained by lifelong experience with focused attention to touch. In addition, Gilbert and Catalano[28] studied stereognosis, that is, the act of perceiving and understanding objects by touch.

Apart from the area of tactile acuity and perception, the other areas of study were represented by one article only. Therefore, no strong conclusions can be drawn in these areas (see Discussion). For one of the studies,[29] this was particularly the case. Lehrer aimed to study the relationship between blindness and fertility. The result of interest to this review, namely the correlation between age at loss of light perception and age at menopause, followed an explorative analysis, supported by only four participants. Hence, this result is not sufficiently supported and this article was excluded from the remainder of this study.

Decline due to ageing and differences compared to non-blind people

Several of the articles included described a decline of abilities over time for people who are blind.[21,24,25,28,31] In addition, most made a comparison between blind and non-blind people.[18,21,23–25,27,28,31,32] Below, these articles are summarised with respect to these two aspects, that is, decline over time and differences compared with non-blind people. Additional results relating to one of these two areas are discussed thereafter.

First, a decline was found in stereognosis. Gilbert and Catalano[28] noted that younger blind participants were better at identifying objects by touch (stereognosis) than older blind subjects. In addition, within the older participants, the 60-year-old group was superior to the 70-year-old group. The decline over time for participants who are blind was similar to that of non-blind participants up to 60 years of age, with no significant difference being found between blind and sighted subjects. However, in the 70-year-old group, significantly fewer errors in object recognition were made by participants who were sighted compared to those who were blind.

Second, the sense of smell was found to decline over time. Sorokowska and Karwowski[24] hypothesised a positive (compensation) effect of visual impairment on olfactory memory, meaning that they expected blind people to maintain their odour recognition ability into increasing

TABLE 1 Summary of the studies included.

References	Study aim	Study design	Sample size	Key findings
Bachar & Shanan[31] 1997 (Israel)	To investigate the effects of long-lasting blindness on coping, social- and psychological disengagement	Analytical cross-sectional study	*N* = 150. Groups: blind, sighted. Age groups: 46–55, 55–65 years	Blind participants showed early disengagement from the outer world and scored lower on social and psychological engagement and direct active coping
Gilbert and Catalano[28] 1964 (United States)	To compare tactile perception in sighted and blind participants at different ages	Analytical cross-sectional study	*N* = 200. Groups: blind, sighted. Age groups: 20–39, 60–69, 70+ years	Young (blind and sighted) participants performed better than older participants, although individuals of all groups differed widely. In the age group of 60–69 yrs, there was no difference between the blind and sighted. In the age group of 70+ yrs, sighted individuals performed better than the blind group
Kendall et al.[26] 2001 (United States)	To measure the effect of age on circadian period in blind people with no light perception	Cohort study	*N* = 6, Mean start age = 38	Participants (all male) showed a longer circadian period during the second measurement after at least one decade in midlife
Legge et al.[23] 2019 (United States)	To investigate if tactile acuity remains intact in old age when there is a lifelong experience with playing the piano and to find out if there is a difference from people who are blind	Analytical cross-sectional study	*N* = 21. Age groups: 19–30 years, 57–75 years. Groups for comparison are from Legge et al.,[27] 2008	Lifelong experience with touch helped to preserve tactile acuity into old age. The pianists performed better than the non-pianists at old age. The blind group performed better than the pianist group at old age
Legge et al.[27] 2008 (United States)	To test the tactile acuity for blind and sighted participants as a function of age in two tactile-acuity charts	Analytical cross-sectional study	*N* = 139. Ages: 18–82 years. Groups: blind, sighted	Blind subjects retained their tactile acuity when ageing while sighted participants showed a decrease. No significant correlation was found with braille reading speed, the amount of daily reading or the age at which braille was learned
Lehrer[30] 1981 (United States)	To investigate the relationship between light perception and fertility	Analytical cross-sectional study	*N* = 18. Groups: light perception (Mean age = 61.7 years), no light perception (Mean age = 48.9)	The incidence of pregnancies was found to be the same for women with and without light perception. A negative linear correlation was found (*N* = 4) between age at loss of light perception and age at menopause
Martiniello et al.[29] 2022 (Canada)	To assess the effect of age on tactile, motor and cognitive abilities in braille reading	Analytical cross-sectional study	*N* = 46, ages: 23–88 years	Tactile sensitivity decreased with age. No relation was found between increased age and braille reading speed. Active tactile acuity, reading frequency and braille learning age were significantly correlated with braille reading speed
Pigeon and Marin-Lamellet[25] 2017 (France)	To investigate the age-related changes in attentional capacities and working memory in people who are blind	Analytical cross-sectional study	*N* = 85. Groups: blind, sighted. Age groups: below 50 years, above 60 years	Blind participants obtained higher scores and had faster reaction times than sighted participants in multiple tests. People who were blind followed a similar age-related cognitive trajectory to that of sighted people
Qin et al.[22] 2021 (China)	To investigate the risk factors and prevalence associated with coronary heart disease among middle-aged and elderly patients with visual impairment	Analytical cross-sectional study	*N* = 1335, ages: 40–65+ years	A lower degree of vision, a resting heart rate below 60 beats per minute and insufficient physical activity were found to be strong, independent predictors of coronary heart disease

(Continues)

TABLE 1 (Continued)

References	Study aim	Study design	Sample size	Key findings
Ruggiero et al.[21] 2022 (Italy)	To investigate how ageing affects allocentric and egocentric spatial memory in individuals with different degrees of visual experience	Analytical cross-sectional study	*N* = 160, ages: 22–71 years, Groups: congenitally blind, adventitiously blind, blindfolded sighted, sighted. Age groups: young (22–35 years), elderly (60–71 years)	The ability to process allocentric information was influenced by both age and visual status. Congenitally blind elderly participants were less accurate than the younger and sighted groups. Congenitally and adventitiously blind elderly participants were slower than all other groups
Sorokowska and Karwowski[24] 2017 (Poland)	To investigate whether blind people have better olfactory memory than sighted people and the effect of age on this memory	Analytical cross-sectional study	*N* = 202, ages: 16–65 years. Groups: blind, sighted	No positive effect of visual impairment on olfactory memory. In a memorisation task of smells, an age-related decline was found in hit-rate ('old' smells correctly judged as 'old') among blind individuals, while an age-related increase in false alarms ('new' smells judged as 'old') was found among sighted participants
Timio et al.[18] 1989 (Italy)	To evaluate the blood pressure change with age in congenital blind participants and to compare with a control group	Prospective cohort study	*N* = 270. Groups: congenital blind, sighted. Mean starting ages for the blind and sighted groups were 11.7 years and 12.4 years, respectively	Blood pressure increased less with age for congenital blind individuals than for sighted individuals in a 20-year period
Tobis et al.[32] 1990 (United States)	To measure the change in frequency of falling among people who are blind, deaf or non-impaired, as they age	Analytical cross-sectional study	*N* = 165. Groups: blind, deaf, non-impaired. Age groups: 60–75 years, over 75 years	The blind demonstrated a higher rate of falls than the deaf or non-impaired, among individuals aged over 60 years. The more elderly blind (75+) did not show the increase in falling demonstrated by the deaf and non-impaired

age. However, they found an age-related decline in correct hits (in a memory task where participants had to indicate which smells were presented previously) among blind individuals, which suggests that daily smell training was not enough to enhance olfactory function. Their study showed a decline in odour recognition ability for both participants who were blind or sighted, but in different ways. Participants who were blind showed an age-related decline in correct hits ('old' smells correctly identified as 'old'), whereas sighted participants showed an age-related increase in false alarms ('new' smells judged as 'old'). There was no significant difference between the younger groups of sighted and blind participants, but the older sighted participants outperformed the older blind participants on some of the scales tested (hit and miss rates).

Third, allocentric spatial memory was not preserved during ageing in different groups. Ruggiero et al.[21] investigated the egocentric (subject-to-object) and allocentric (object-to-object) spatial memory of young and elderly participants, where they differentiated between variants of blindness: congenitally blind (long-term visual deprivation), adventitiously blind (late onset blindness), blindfolded sighted (short-term visual deprivation) and sighted (full visual availability). For egocentric judgements, no significant differences were found between the groups, meaning that people, whether blind or sighted, maintained their subject-to-object spatial frame of reference while ageing. For allocentric judgements, congenitally blind participants were significantly less accurate than all the other groups. In addition, congenitally and adventitiously blind elderly participants were slower than all other groups (although the adventitiously blind elderly were not less accurate).

Fourth, attention and working memory were found to function less well with ageing. Pigeon and Marin-Lamellet[25] stated that adaptation to blindness could enhance attention and working memory in young people, and set out to study the effect of ageing on these abilities for people who are blind. They performed auditory computerised tests assessing selective, sustained and divided attention, attentional switching and working memory. The researchers found an ageing effect on most of their measured variables, showing, as they expected, a decline in attentional and working memory of people who are blind. The study compared the performance of people who are blind versus those who are sighted. Participants who are blind showed improved attentional capacities compared to their sighted counterparts, even for older people. These blind participants obtained higher scores and had faster reaction times in many of the variables measured. The trajectories of cognitive age-related decline were found to be similar for blind and sighted people, meaning that both performed less well on tasks assessing selective, sustained, divided attention, attentional flexibility and working memory as they became older.

Finally, a decline in psychological and social engagement was found. Bachar and Shanan[31] compared blind to sighted subjects (matched by age, sex and cultural origin)

with respect to psychological and social engagement. Psychological engagement was linked to the concept of 'readiness for active coping' and defined as the extent of mental–emotional investment in the outer world. Social engagement was measured by conscious reports of involvement in social activities. It was found that disengagement from the outer world occurred in blind persons earlier than in sighted persons, where psychological disengagement preceded social disengagement. The sighted participants were only used as reference group, and therefore, no results about a possible decline for the sighted controls were presented. The study made no comparison with age, neither for blind nor sighted people. The data suggest that there was no decline for sighted people, but no strong conclusions can be drawn. Table 2 summarises the above results.

An additional result in the context of decline over time, is the outcome of the study by Kendall et al.[26] They did not find a decline but rather a change over time in the intrinsic circadian period (the duration of a sleep–wake cycle) of totally blind persons. Kendall et al.[26] hypothesised that a shortening of the intrinsic circadian period at a later age explains the often-experienced early wakening of elderly people (blind and non-blind). They measured the circadian period of seven totally blind men (no light perception) having a free running circadian rhythm, meaning that their sleep–wake pattern is not aligned with a 24-h cycle. Contrary to their expectation, participants had a significantly longer circadian period at later age.

In the article included, some additional results were reported highlighting differences between blind and non-blind individuals. Older blind people were found to have better tactile acuity than older sighted people,[23,27] and both young and old blind participants had better attentional capacities and memory[25] than sighted age-matched groups. Their number of falls did not increase due to ageing, contrary to non-blind people, although the absolute frequency of falls was higher for people who were blind.[32] Furthermore, Timio et al.[18] found that the blood pressure increase over 20 years was less consistent for people with congenital blindness (who were living in a home care facility up to a certain age) than for a sighted control group. Finally, Qin et al.[22] found that blindness was associated with coronary heart disease at a later age.

TABLE 2 Decline in ability due to ageing for blind versus non-blind.

Ability/area	Decline of blind people	Decline of non-blind people
Stereognosis	Yes	Yes
Smell	Yes	Yes
Allocentric spatial memory	Only for congenitally blind	No
Attention and working memory	Yes	Yes
Psychological and social engagement	Yes	(no)

Contributing factors in studies on ageing of blind adults

Many of the included articles controlled for, reported on or matched their participants with respect to factors that were potentially associated with the outcome measures. For example, in the study on blood pressure, Timio et al.[18] wrote that the groups were homogeneous for mean age, ethnic background and family history of hypertension and that the mean urinary sodium excretion did not differ between the blind participants and the control group. These factors are very specific for the outcome measure of interest, and many different outcome measures were investigated in the articles included. Therefore, there were only a few factors common to more than one study.

Some articles classified the degree or type of blindness into different groups (see also Table 1), such as congenital blindness versus acquired blindness or light perception versus no light perception. Congenital blindness was found to have more ageing consequences than adventitious blindness with respect to allocentric spatial memory,[21] and less ageing consequences than no blindness with respect to blood pressure.[18]

The gender of the participants was reported in all but one[32] of the included articles. Two studies had similar gender distributions (or matched pairs) in the blind and sighted groups,[18,31] while five studies investigated gender but no significant effects were found.[21,23,24,27,28]

Most factors included in the study designs only applied to the outcome measure of the specific study. Therefore, the remainder of this section only reports on the factors or variables that were found to have a significant effect on the outcome. The study into braille reading performance[29] found that active tactile acuity, reading frequency and braille learning age were significantly correlated with braille reading speed. The most significant association with reading speed was the age at which braille was learned.

The study into engagement with the outer world[31] found that education and assistance reduced differences considerably between the blind and sighted participants. Blind participants who reported receiving more assistance showed better scores on readiness for active coping, intelligence and social engagement.

Qin et al.[22] found age and blindness to be risk factors for developing coronary heart disease. Although some additional risk factors were found, these were not necessarily related to blindness, as the study focussed on a population of people with vision impairment.

Support

Many of the included articles presented recommendations for the elderly blind, based on their results. Tobis et al.[32] suggested that people who are blind may be helped by reducing vulnerability to falls by enhancing musculoskeletal strength through exercise. Interventions to enhance

physical functioning was also mentioned by Qin et al.[22] who suggested that this, in addition to risk screening, could be effective in the prevention of coronary heart disease. A specific type of physical training, namely braille use, was mentioned by Martiniello et al.[29] They found frequency of braille use was a vital correlate of braille reading outcomes, irrespective of the age at which braille was learned. Therefore, they recommended that older braille users should be provided with frequent opportunities to use braille to enhance their tactile skills.

Pigeon and Marin-Lamellet[25] stated that cognitive training could be an option for the rehabilitation of aged blind people as it may help them to deal with age-related cognitive decline. Furthermore, they mentioned that being engaged in social activities is a means of cognitive stimulation and can attenuate age-related cognitive decline and therefore preserve functional autonomy. In a similar vein, Ruggiero et al.[21] advised the development of cognitive intervention to maintain and rehabilitate the spatial abilities of (congenitally) blind people. Finally, Bachar and Shanan[31] showed that the level of education (low: ≤10 years of schooling; high: ≥11 years of schooling) and degree of assistance (low, moderate or high) received reduced the differences between the sighted and the blind groups, which means that these factors can help to prevent people who are blind from early disengagement from the outer world.

DISCUSSION

The articles included in this review were found to fit into four broad areas: physical, sensory, cognitive and psychological. The findings suggest that there are some aspects of the ageing process in which blind people decline differently from sighted individuals. People who are blind disengage earlier from the outer world when ageing than non-blind people,[31] and those who are congenitally blind decline with respect to allocentric memory due to ageing.[21] Performance of smell,[24] attention and memory[25] and identification of objects,[28] however, decline due to ageing in both blind and sighted people. Additional results highlight some further differences between blind and sighted ageing adults. The tactile acuity of older blind people was better than for older sighted people,[23,27] and blind people, both old and young, showed improved attentional capacities compared with sighted individuals.[25] Also, blood pressure rose less with age in blind than sighted people.[18] However, blind people experience more falls than sighted individuals, although the number of falls did not rise with age.[32] Additionally, blind people had a higher risk for coronary heart disease as they age.[22] Therefore, although ageing blind people show a similar decline to sighted people for several areas and actually perform better in other aspects, they form a group having additional risks that are important to study.

Comparison of results

In the area of tactile perception and acuity, several articles were included which allowed comparison. For instance, Martiniello et al.[29] and Legge et al.[27] both assessed the effect of age on tactile acuity. Legge et al.[27] used two active acuity tests, where the participants could actively move their finger, whereas Martiniello et al.[29] used two active acuity tests and two passive acuity tests, where a stimulus was presented to a fixed finger. Legge et al.[27] found that the tactile acuity of participants was preserved in older age and explained the contradiction of their results with the existing literature from the fact that they measured active tactile acuity, whereas most other studies assessed passive tactile acuity. However, Martiniello et al.[29] used both active and passive tests and concluded that tactile acuity decreases with age. This apparent contradiction was due to the choices that were made for follow-up analyses. Martiniello et al.[29] reported on four acuity tests, two of which (one active and one passive acuity test) showed a correlation with age (the other two tests showed no significant correlation with age), from which they concluded that tactile acuity decreased with age. Interestingly, one of these tests, the active acuity test, was also used by Legge et al.[27] In agreement with Martiniello et al.[29] they found a weak correlation (with borderline significance) using this test. However, they followed up this result with two additional tests showing (i) no significant difference in tactile acuity between the younger and older blind groups and (ii) no significant effect of age on tactile acuity using regression analysis.[27] Based on these results, Legge et al.[27] concluded that tactile acuity is preserved in old age. Hence, the initial result of a weak correlation between tactile acuity and age led to opposite conclusions in these investigations. Given the more elaborate analyses by Legge et al., the conclusion that active tactile acuity is preserved in old age for people who are blind is perhaps more justified. A further difference between these two studies can be found in the fact that Legge et al.[27] reported no significant correlation between braille reading speed and tactile acuity, whereas Martiniello et al.[29] observed that active tactile acuity, reading frequency and braille learning age were significantly correlated with braille reading speed. Summarising the main finding regarding tactile perception and acuity of ageing people who are blind, it was found that the identification of objects (stereognosis) became increasingly difficult with age,[28] while tactile acuity is preserved with age[27] which can be explained by lifelong experience with focussed attention on touch.[23]

In the other areas reviewed (physical, cognitive and psychological), a direct comparison of results was not possible due to the use of different outcome measures. However, on a higher level, some general observations on and comparison of the studies can be made. Considering the aims and hypotheses of the studies included, a dichotomy described as 'difficulty vs. advantage' can be

found. Some investigations highlighted the difficulty of ageing while being blind, while others highlighted a (possible) advantage for people being blind. Difficulties for ageing blind people were reported with respect to social engagement,[31] braille reading,[29] heart disease[22] and spatial memory.[21] In contrast, (hypothesised) advantages (e.g., less decline in the specific area over time compared with sighted people) for people who are blind were investigated in the areas of smell,[24] blood pressure,[18] attentional capacities and working memory[25] and tactile acuity.[27]

One of the articles belonging to the 'difficulty' side of the aforementioned dichotomy was different than the others, since its hypothesis applied to both blind and non-blind people. Kendall et al.[26] stated that ageing often causes people to wake up early and hypothesised that this was related to a shorter circadian period (for all ageing adults). They studied this effect in totally blind adults, since their circadian period is not influenced by a daylight pattern. Contrary to their expectations, they found a longer circadian period for all participants after a decade.

Not all studies hypothesised blindness (together with ageing) as being either a difficulty or an advantage. Two studies did not lie on either side of the dichotomy; the first of which departed from the idea that there is no definite information concerning the relative superiority or inferiority of the blind with respect to stereognosis, and set out to test this in a setting which also considered the influence of age.[28] The second study embedded a group of people who were blind into a larger setting, also including people who were deaf or non-impaired, in order to compare neuromuscular and visual perceptual feedback in the process of ageing.[32]

In light of the above-mentioned contrast (advantage vs. difficulty), two articles are interesting to compare with respect to the explanations of their findings. Bachar and Shanan[31] interpreted the early disengagement of people who were blind as premature ageing caused by stress due to blindness. Timio et al.[18] found that the blood pressure of blind people rose less than that of sighted people, and hypothesised that this was because of lower visual and cognitive stress levels in the blind. Hence, the explanations given for the results are opposite (i.e., blindness produces more stress vs. blindness produces less stress) and are therefore hard to align. Compared with other literature, studies can be found regarding the early ageing of people with disabilities,[17] stress caused by vision loss[34] and stress in relation to congenital blindness,[35] which are supportive of Bachar and Shanan's findings and conclusions.

Several of the included studies that reported or hypothesised some advantage of blindness, acknowledged the difficulty of ageing with blindness at the same time.[25,27,28,32] From this, it may be inferred that although blindness may carry certain advantages, this does not compensate for the difficulties of ageing with blindness.

Embedding of results in other literature

The results of the studies included can be compared with other investigations. Most results were in agreement with previous research, as the authors of the included articles noted. However, some found differences that should be reflected upon. For instance, Sorokowska and Karwowski[24] explained that when vision is missing, other cognitive functions may become better developed through sensory compensation and hypothesised that blind people may have superior olfactory abilities. However, they did not find evidence for this, and even found that older sighted participants outperformed their blind counterparts. They explained the discrepancy between their results and other studies[36] by varying methods and the possibility that some tests were not equally suitable for sighted and blind participants.[24] In addition, with respect to sensory compensation in general, other investigations found that the degree of sensory compensation was dependent on both the domain and the specific task used.[37] The greatest sensory compensation was found in the auditory and tactile domain,[38] whereas marginal compensation was found in the olfactory system.[39]

Kendall et al.[26] based their hypotheses on the commonly held view that the intrinsic circadian period shortens during human ageing. They found, however, that the circadian period lengthened significantly during at least one decade for totally blind men. In their discussion, they addressed the fact that the evidence for a shortening of the circadian period is quite limited, and addressed methodological differences between studies that might explain these differences. In addition, they suggested that there may be other reasons for older people to wake up earlier than younger individuals, such as the idea that the homeostatic sleep drive may be weaker in the elderly. Elsewhere, it was noted that besides a less efficient circadian mechanism, other common medical problems of old age such as hypertension, respiratory diseases, physical disability, dementia, pain, depression and anxiety are all associated with sleep disturbances.[40]

Pigeon and Marin-Lamellet[25] found that blind participants obtained higher scores and had faster reaction times than sighted participants in multiple auditory tests with respect to attentional capacities and working memory. In their discussion, they highlighted the difference with studies that measured cognitive ability of people with an age-related visual impairment who exhibited lower performance than sighted people of the same age. They stated that ageing with blindness does not have the same effect on cognition as ageing with an (age-related) visual impairment. A possible explanation according to Pigeon and Marin-Lamellet[25] is that the cognitive and visual decline of people with an age-related visual impairment may share common biological causes. Other literature has also found an enhancement of cognitive abilities in people who are blind,[41] while the relation between visual impairment and cognitive impairment was confirmed in a meta-analysis.[42]

With respect to support for ageing people who are blind, the included articles made recommendations for physical exercise, braille exercise, risk screening, availability of social resources such as education and availability of help, cognitive training and staying engaged in social activities. Several of these suggestions are supported by other literature, and interventions in these areas have been investigated. Exercise programmes have improved the balance score of the visually impaired elderly, but their effect on limiting falls remains unclear.[43] However, in a meta-analysis of an elderly visually impaired group, it was found that, after intervention, static balance ability was improved.[44] In general, physical exercise is promoted for both elderly and visually impaired people.[45–48] Cognitive training programmes for the elderly without disability were found to improve memory and subjective cognitive function.[49] However, many cognitive training programmes use visual feedback,[50] which means that these cannot be used for people who are blind. In addition to cognitive training programmes, social interaction and social support were found to have important protective effects against age-related cognitive decline.[51–53] Finally, risk screening for coronary heart disease has also been proposed for older people in general.[54,55]

Limitations of this review study

Many articles exist regarding the ageing of people who are blind, most of which use the term ageing to indicate the process of growing older. In the search procedure of the present study, the terms 'ageing', 'aging' and 'age-related' were used to search for articles. However, it may be possible that additional articles exist about ageing of blind people, whose authors chose different words to describe ageing. The same is true for the concept of blindness. The terms 'blind' and 'blindness' were used in this search, but additional articles may have been missed that used other words to describe people who are blind. Furthermore, we did not include articles concerning ageing persons who are blind if there was not any element of time in the design (see inclusion criteria). This requirement was necessary to be able to measure a change over time. Therefore, the present review comprises only a specifically defined part of all articles concerning the ageing of people who are blind.

Future research

Based on the different results in this review, there are areas that could be explored in future research. In the study on blood pressure,[18] the blind participants were living in a home care facility up to the age of 21 (but continued to participate in the study after this age), which caused their diet to be homogenous up to this age. Therefore, this study should be replicated to determine how the blood pressure of congenitally blind persons over time compares with that of controls when the diet can be self-determined and older ages are included.

Bachar and Shanan[31] found that blind people disengaged earlier from the outer world than sighted people. However, they did not compare blind people of different ages. Future research should compare blind people across a range of ages or include a longitudinal study to find out how, when and why the psychological and social engagement of blind people declines over time.

Pigeon and Marin-Lamellet[25] noticed a difference in results (in fact, opposite findings) with respect to the cognitive ability of people who are blind versus those with a visual disability. This suggests that it is important to separate these groups in research on ageing. Accordingly, the results of studies on ageing of people with a visual disability may not hold for people who are blind and should therefore be replicated with a separate group of blind people. Furthermore, fewer areas have been studied in ageing people who are blind compared with those with a visual disability. Future research on the ageing of people who are blind should focus on these areas as well, including for example physical activity, dementia, anxiety and loneliness.[8] In addition, future research on blind people who are ageing should include abilities that are known to decline as a consequence of age. For example, hearing is known to decline with age,[5] but is also known to be elevated for early blind people,[13] and is therefore important to study.

The topic of sensory compensation, that is, the process of neural reorganisation after sensory loss, has been studied with respect to people who are blind, but is also a topic of debate.[24,37] In addition to senses that compensate for vision loss, it has been shown that cognitive processes can compensate for vision loss.[56] Future research on the topic of compensation could include the component of ageing (as was done by Pigeon and Marin-Lamellet[25]) to see whether the (hypothesised) compensation is maintained into old age, to determine whether this compensation is achieved by all people or only by a specific group and to investigate what is needed to maintain this compensation as long as possible.

In the articles included, some results have been found for specific subgroups of blind people, which may be worth exploring in future studies. For example, some results only apply to congenitally blind people[18,21] or to those with no light perception.[26,30] The fact that differences exist with respect to the type of blindness implies that it is important to take this factor into account in future research. People with a specific type of blindness may have different ageing risks and needs. This was illustrated by Legge et al.,[27] who stated that the age-related loss in tactile acuity for sighted people may explain why late-blinded individuals are rarely successful in learning braille.

Regarding stereognosis, an accelerated decline was found from 60 to 70 years of age.[28] As a possible explanation, the researchers mentioned that whereas the 60-year-olds of both the blind and sighted groups were

living in the community, most of the individuals in the 70-year-old blind group were living in a home care facility for the blind, and this may have accelerated the decline. Therefore, it is important that future research includes a broad age range to be able to examine the full trajectory of a specific decline, *and* that additional information is included in the analysis to determine which variables are correlated with a possible accelerated decline. New hypotheses for prevention of decline could emerge from such work.

The articles included suggest ways in which ageing blind people can be supported and proposed various (cognitive and physical) interventions. However, future research is needed to implement and evaluate these suggested interventions. As an additional and necessary step, the needs reported by the group itself should be investigated.

Conclusion

This study reviewed the literature on the ageing of adults who are blind, focusing on the areas or abilities of decline due to ageing, differences compared with non-blind adults, additional contributing factors and support. Four broad categories were found in the included studies, namely, physical, sensory, cognitive and psychological. Some of the studies focused on the difficulty of ageing while being blind, while others highlighted a specific enhanced ability due to blindness. Difficulties or higher risks for the ageing adults who were blind were found with respect to psychological and social engagement, braille reading, heart disease and allocentric spatial memory (the latter for the congenitally blind only). Elevated abilities (compared with non-blind people) were found in active tactile acuity and cognitive abilities. Taken together, although blindness is associated with some advantages, the group of ageing blind adults experienced additional risks and hence need greater support. The studies included recommended physical exercise, braille exercise, risk screening, availability of education and assistance, cognitive training and remaining engaged in social activities. Differences with respect to health outcomes or functional decline could depend on the age at which the participants became blind. Further research is needed to replicate studies and disambiguate results, to include new areas that have not been investigated specifically for the group of blind people and to investigate systematically the needs and support of blind people who are ageing.

AUTHOR CONTRIBUTIONS

Aline K. Honingh: Conceptualization (equal); data curation (equal); formal analysis (lead); funding acquisition (supporting); methodology (lead); writing – original draft (lead); writing – review and editing (lead). **Astrid Kok:** Conceptualization (equal); data curation (equal); writing – review and editing (equal). **Mitchel Mesker:** Data curation (equal); formal analysis (equal); writing – original draft (supporting); writing – review and editing (equal). **Johannes C. F. Ket:** Data curation (lead); writing – original draft (equal); writing – review and editing (equal). **Erik Olsman:** Conceptualization (equal); funding acquisition (equal); writing – review and editing (equal). **Bert Veneberg:** Conceptualization (supporting); funding acquisition (supporting); writing – review and editing (supporting). **Paula S. Sterkenburg:** Conceptualization (lead); funding acquisition (lead); writing – review and editing (equal).

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interests.

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SUPPORTING INFORMATION

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