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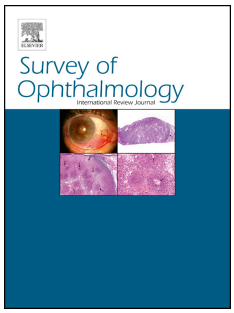

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Interventions to improve functioning, participation and quality of life in children with visual impairment: a systematic review

Ellen BM Elsman, MSc[1], Mo Al Baaj, MSc[1], Prof Gerardus HMB van Rens, MD, PhD[1,2], Wencke Sijbrandi, MSc[3], Ellen GC van den Broek, MSc[4], Hilde PA van der Aa, PhD[1], Wouter Schakel, MSc[1], Martijn W Heymans, PhD[5], Ralph de Vries, MSc[6], Mathijs PJ Vervloed, PhD[7], Prof Bert Steenbergen, PhD[7], Ruth MA van Nispen, PhD[1]

[1] Amsterdam UMC, Vrije Universiteit Amsterdam, Department of Ophthalmology, Amsterdam Public Health research institute, PO Box 7057, 1007 MB Amsterdam, the Netherlands
[2] Department of Ophthalmology, Elkerliek Hospital, Wesselmanlaan 25, 5707 HA Helmond, The Netherlands
[3] Bartiméus, Van Renesselaan 30a, 3703 AJ Zeist, The Netherlands
[4] Royal Dutch Visio, PO Box 1180, 1270 BD Huizen, The Netherlands
[5] Amerdam UMC, Vrije Universiteit Amsterdam, Department of Epidemiology and Biostatistics, Amsterdam Public Health research institute, PO Box 7057, 1007 MB Amsterdam, The Netherlands
[6] Medical Library, Vrije Universiteit, PO Box 7057, 1007 MB Amsterdam, The Netherlands
[7] Behavioural Science Institute, Radboud University, PO Box 9104, 6500 HE Nijmegen, The Netherlands

Corresponding author:
E.B.M. Elsman
Email: e.elsman@vumc.nl
Amsterdam University Medical Centers
Location VU University Medical Center, PK4X191
PO Box 7057
1007 MB Amsterdam
Tel: +31-20-4444795
Fax: +31-20-4444745

Abstract

Visual impairment in childhood often has lifelong implications. In order to aim for the highest levels of functioning, participation and quality of life and to ensure children's wellbeing, children should be entitled to the most effective rehabilitation programs. We review evidence for the effectiveness of rehabilitation interventions for children with visual impairment to improve skills and behavior, thereby improving participation and quality of life as an ultimate goal. Of the 441 potentially relevant articles identified, 66 studies met our inclusion criteria (i.e. 28 randomized controlled trials [RCTs], 18 non-RCTs, and 20 before-after comparisons [BAs]). The results suggest that sports camps, prescription and training in the use of low vision devices and oral hygiene programs might be effective in improving functioning and elements of participation and quality of life in children with visual impairment. Other interventions showed mixed or negative results. The results should be interpreted with caution because of moderate to high risk of bias and suboptimal reporting. Heterogeneity of results and the use of over 50 different outcome measures prevented a meta-analysis. Future studies should focus on promising interventions for which effectiveness is still unclear (e.g. mobility, social skills), with adequately designed methodology.

Keywords: visual impairment; children; rehabilitation; review; functioning; participation; quality of life; outcomes; intervention

1. Introduction

In 2015, 252.6 million people worldwide were visually impaired, of whom 36 million people were classified as blind.[14] An estimated 19 million children below the age of 15 years were visually impaired (1% of the total population in this age group), of whom 1.4 million had irreversible blindness (0.08% of the total population in this age group).[120] Understandably, these children and their parents experience major challenges regarding overall development, participation in society and self-reliance.[60,63,88] Children with visual impairment have their whole lives ahead and, in case of incurable eye or brain diseases, often have no choice but to live with their visual impairment for many years. Therefore, aiming for the highest levels of functioning, participation in society and quality of life ensures these children's well-being.

Children with visual impairment require access to early intervention and low vision rehabilitation services, which aim to improve functioning in daily life and social participation, and possibly more general aspects of well being such as quality of life and psychosocial functioning. The introduction of the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY) by the World Health Organization (WHO) made the concept of participation for children relevant.[119] Although different definitions of participation exist[52,110], we used the conceptualization of participation by the ICF-CY in the current review. The ICF-CY defines participation as 'a person's involvement in life situations'. Furthermore, the WHO combines participation with the construct 'activities', which is defined as 'the execution of a task' and operationalizes these constructs using the nine domains of the Activities & Participation component of the ICF-CY, i.e. learning and applying knowledge, general tasks and demands, communication, mobility, self-care, domestic life, interpersonal interactions and relationships, major life areas, and community, social and civic life. Quality of life is also a broad concept, and consists of physical, emotional, and social functioning.[94,108]

At present, a variety of interventions for children and their parents have been developed and implemented in early intervention and low vision rehabilitation services. Currently, in many countries including the Netherlands, facilities for people with disabilities are under pressure because of financial considerations. In view of the increasing choice of interventions available and the increased striving for professionalism in healthcare, there is a strong need for evidence regarding the effectiveness of interventions to achieve positive outcomes. Children with visual impairment are entitled to the most effective rehabilitation programs, and the importance of assessing the effectiveness of interventions is stressed by the WHO and in the UN Convention on the Rights of Persons with Disabilities.[110,121] Binns and coworkers performed a systematic review on the effectiveness of low vision rehabilitation services in adults and children, but they only found two studies aimed at children aged 0-18.[9] These studies used a relatively weak before-after comparison design. One study compared reading ability before and after the prescription of optical magnifiers, but did not control for natural development over time.[26] The second study compared the possession and utilization of low vision aids before and after low vision service setup.[92] More recently, Thomas et al. and Barker et al. performed Cochrane systematic reviews on the effectiveness of, respectively, assistive technology and optical reading aids in children and young people with visual impairment.[5,107] Because of the focus on randomized controlled trials (RCTs) in Cochrane reviews, no studies met the inclusion criteria and they concluded that there is a lack of high quality evidence regarding the use of assistive technology and optical reading aids in children and young people with visual impairment.

Because of the limited results yielded by previous systematic reviews, no conclusions can be drawn about the effectiveness of interventions aimed to improve quality of life, participation and functioning in children with visual impairment. In view of the increasing availability of interventions, we believe it is important to conduct a broad-up-to-date systematic review, using more liberal inclusion criteria, to provide a complete overview of studies performed in this field. Children, parents and health-care providers require evidence to make informed decisions about the allocation of personal, institutional and public resources. In this study we give an overview of the available evidence for the effectiveness of rehabilitation interventions for children with visual impairment to improve skills and behavior, thereby improving functioning, participation and quality of life as an ultimate goal. Furthermore, we will critically evaluate available information from studies, resulting in an agenda for future research, implementation and practice policies.

2. Identified studies of interventions to improve functioning, participation and quality of life

2.1 Characteristics of included studies

The database searches resulted in the identification of 27,754 articles (Figure 1). After screening of titles and abstracts, 441 articles remained of which 277 could be assessed. The available full text articles were screened on in- and exclusion criteria and assessed for eligibility. Together with articles identified through searches in reference lists of previously retrieved reviews and the grey literature, this resulted in 64 articles, describing 66 different studies (28 RCTs,[3,7,13,16,19,21,32,33,39,47,50,54,56,57,58,61,62,66,69,72,78,83,85,93,98,114,124,127] 18 non-RCTs,[1,2,6,11,15,20,27,35,44,51,55,65,74,75,82,89,96,105] and 20 before-after comparisons (BAs)[8,12,26,28,30,40,43,46,70,71,73,84,90,91,95,97,111,113,122,126]). The articles of McMahon and Kederis described two different studies.[57,58,70,71] The 66 included studies were published between 1964 and 2018, and 37 (56.1%) of them were published in the last decade (2008-2018)[1,2,3,13,15,16,19,20,21,27,28,30,32,33,35,39,40,43,46,51,54,62,65,69,70,71,73,74,75,78,82,83,85,89,91,96,98,105,113,114,127] (Table 1). The majority of the studies was conducted in the USA[7,11,12,26,35,44,47,55,56,57,58,61,65,66,70,71,72,78,84,91,93,95,124], one in Canada,[8] eleven in Europe (i.e. UK,[50,111,122] Germany,[6] the Netherlands,[13,27,51,83,89] and Greece[69,82]), 28 in Asian countries (i.e. Iran,[54] Turkey,[1,15,16,30,105,113,114,126,127] India,[20,21,28,39,40,43,46,62,74,75,90,96] Jordan,[2] Pakistan,[85] Japan,[97] Taiwan,[19] and Thailand[3,98]), and three in African countries (i.e. Nigeria,[32,33] and Egypt[73]). Total follow-up ranged from 2 days[56] to 3 years[7].

---------- Figure 1 about here ----------

---------- Table 1 about here ----------

2.2 Participants in included studies

Table 1 provides details on the demographic and clinical characteristics of participants included in the different studies that were found. The studies included in total 4327 participants, with sample sizes ranging from 10[97] to 671 participants[75]. Drop-out ranged from 0%[1,2,3,6,11,12,13,15,16,19,20,26,28,30,32,33,35,39,40,44,47,50,51,54,55,56,57,62,65,66,70,71,72,73,78,82,84,85,89,91,93,95,96,97,105,111,113,114,126,127] to 54%[43]. Age of participants ranged from 2 months[7] to 23 years[91] and 0% to 70% were female[57].

Fourteen studies reported a cut-off criterion for visual acuity.[1,11,13,21,27,28,30,35,47,51,54,75,78,89] Slightly more often, studies reported the degree of visual impairment (e.g. severe visual impairment, legal blindness) or fulfillment of certain criteria for low vision (e.g. the criteria for low vision of the WHO or the ICD criteria).[1,6,16,20,39,40,44,50,56,62,69,75,90,93,96,105,113,114,124] In some cases, authors quantified the number of participants with a certain degree of visual impairment, i.e. how many participants had visual impairment and how many participants were blind.[32,39,74,85,90,97,111,126] Thirteen studies reported the number of participants that fell into a visual acuity range or reported the visual acuity of each individual participant[7,8,12,13,15,21,26,27,43,61,78,95,113], whereas 18 studies reported the diagnoses or cause of visual impairment of their participants[1,6,12,13,21,26,27,40,43,51,56,61,72,73,78,89,90,93]. In almost all studies, participants had visual impairment or blindness caused by various eye conditions.[1,2,3,6,7,8,11,12,13,15,16,19,20,21,26,27,28,30,32,33,35,39,40,43,44,46,47,50,54,55,56,57,58,61,62,65,66,69,70,71,72,74,75,78,82,83,84,85,89,90,91,93,95,96,98,105,111,113,114,122,124,126,127] In one study all participants had infantile nystagmus[51] and in one study they all had glaucoma.[73] As is often the case in studies involving children, there was large variation in the diagnoses or causes of visual impairment, but albinism, nystagmus and retinopathy of prematurity (ROP) were commonly reported. Remarkably, 17 studies reported participants had visual impairment, without providing cut-off criteria for visual acuity or information about the degree of visual impairment, nor providing information about the diagnoses of participants.[2,3,19,33,55,57,58,65,66,70,71,82,83,84,91,98,122,127]

2.3 Interventions and comparisons in included studies

The studies included in this review investigated a broad range of interventions (Table 1). For studies focusing on physical performance, interventions included (group-based) training programs[1,12,16,19,54,69,74,75,82,97,105], provision of information[56,91], sports camps[11,71,84] and training in trail-following tasks[89]. For studies focusing on oral health, interventions included oral health education programs[3,20,28,39,96,126] and tooth brushing instructions[46,62,85,98]. Group-based programs[32,33,55,65,66,73] and physical activity programs[30,70,95] were used as interventions in studies focusing on psychological outcomes. Studies investigating functioning and development had intensive (home-based) early intervention programs[6,7,21,83], attention training[15], creativity training[2], prescription of low vision devices[40,43] and admission to a care unit[122] as intervention condition. With respect to reading performance, interventions included (braille) reading training[47,50,57,58], (training in) the use of optical aids[26,35,113], and crowded training[51]. Studies investigating social skills used social skills training[93,127], assertiveness training[61], communication training[44,72] and visual perception training[114] as intervention. Viewing behavior was investigated by interventions on video games[78] and training in visual aids[13,27,90]. For studies focusing on mobility, interventions included programmed orientation and mobility instruction materials[124] and distance estimation training[111]. As comparisons in RCTs and non-RCTs, studies used a control group who received no intervention or was put on a waiting list, a control group who received usual care, or a control group who received an alternative or light intervention. For the latter, the authors did not always state which group was the intervention group and which group was the control group (marked with * in Table 1).

2.4 Outcome measures of included studies

Table 1 provides an overview of the outcome measures used in the different studies that were found to assess the effectiveness of low vision rehabilitation programs. The effectiveness was evaluated in various ways, with little consensus on the most suitable approach, which hinders comparisons between studies. Most questionnaires were used in one study only; few studies applied the same

instrument, and if they did they often used different versions of the instrument. For instance the movement ABC was used in two studies [69,89] to measure fine motor skills and balance, but the studies used two different versions of the movement ABC, and only the writing task was used in one study. The Bruininks-Oseretsky Motor Proficiency Test – Short form was used in three studies[1,69,82] to measure motor skills and balance, but again studies used two different versions. Two studies had BMI as outcome measure[16,19], whereas one study reported age and height of the participants[12]. Two studies might have used the same instrument to measure parental stress, but Platje and coworkers refer to the instrument as Parenting Stress Index (with references)[83] whereas Behl and coworkers refer to the instrument as Parenting Stress Inventory (without reference)[7] so it is unclear if the same questionnaire was used. Three studies used the Sports Camp Evaluation Instrument,[70,71,84] but no information on validity of this instrument was provided. To measure self-concept, two studies used the Tennessee Self-Concept Scale,[55,65] but two different versions were used as well. This was also the case for two studies who used two different versions of the L.V. Prasad-Functional Vision Questionnaire to measure functional vision.[40,43]

Studies assessing oral health status showed more consistency in outcome measures. Three studies used the Modified Quigley Hein Plaque Index[39,96,98], adapted by Turesky et al., whereas six studies used the Plaque Index[3,20,28,46,62,126] of Loe and Silness. In addition, three studies used the Gingival Index[20,98,126] of Loe and Silness, and one study used the Gingival Index[96] of Lobene and coworkers.

To assess oral health knowledge and oral hygiene practice, both Hebbal and Ankola, as well as Yalcinkaya and Atalay constructed their own questionnaires[46,126], without providing any measures of reliability or validity. The questionnaire developed by Yalcinkaya and Atalay was also used in the study of Ganapathi and coworkers.[39] Debnath and coworkers also constructed their own questionnaire to assess knowledge, attitude and practices regarding oral health and provided a measure for internal consistency reliability (Cronbach's Alpha).[28] Sack and Gaylord-Ross also developed their Peer Questionnaire and Teacher Observation Checklist themselves, and did not provide measures of reliability and validity either.[93] Al-Dababneh and coworkers constructed a Creativity Questionnaire,[2] and reported on the developmental process of the questionnaire and also provided a Cronbach's Alpha. Kim developed the Role Play Test from various sources.[61]

Several studies assessed the effectiveness of a program or training by using performance measures, such as studies evaluating reading performance by measuring reading speed, or viewing behavior by measuring visual performance or task performance. Reporting psychometric properties for these types of measures is less common, and only three studies[26,35,113] provided a reference to the reading and writing tests they used.

2.5 Quality of included studies

Almost all RCTs had an unclear risk of selection bias, because in most cases methods of randomization were not described,[3,13,16,19,32,33,39,47,54,56,57,58,62,66,69,93,124,127] and allocation concealment was never described in all but two studies[21,85] (Figure 2, Table 2 and 3, Supplementary file 1). Due to the nature of interventions offered in rehabilitation, all RCTs used a pragmatic design in which blinding of personnel and participants was not feasible. For the majority of studies, the risk of detection bias was rated as unclear, because it was not reported whether outcome assessment was done by a blinded assessor.[3,16,19,21,32,33,50,54,56,57,58,62,66,69,72,98,114,124,127] Eight studies were rated as having low risk of bias on this aspect, because the assessor was blinded[7,13,39,47,61,83,85] or outcomes were

electronically obtained.[78] Furthermore, one study was rated as having high risk of bias because of using an unmasked assessor.[93] Risk of attrition bias (i.e. no or low drop-out, drop-out unrelated to outcome or treatment allocation) was rated low for all but one RCT, which was rated as unclear risk because the drop-out was 36% and it was unknown in which group drop-out occurred.[13] Risk of reporting bias was often unclear, because trial registrations and study protocols were not available.[3,7,13,16,19,32,33,47,50,54,56,57,58,61,62,66,69,72,78,85,93,98,114,124,127] The study of Ganapathi et al. was rated as having high risk of reporting bias, because post-test measures were not performed for the control group,[39] whereas the studies of Platje et al. and Christy were rated as low risk of reporting bias, because a protocol and/or trial registration was available.[21,83] Other sources of bias were often rated as unclear,[13,19,21,32,33,39,47,50,54,56,57,58,62,66,72,93,98,114,124,127] because no information on baseline imbalances were provided, or it was unclear whether baseline imbalances were statistically significant. Seven studies were rated as having low risk of bias on this aspect, because baseline differences between groups were not statistically significant or baseline differences were adjusted in the analyses.[3,7,16,61,69,78,83,85] From all RCTs, the study of Qureshi and coworkers and Platje and coworkers were rated as having the least risk of bias,[83,85] whereas the study of Sacks and Gaylord-Ross was rated as having the most risk of bias.[93]

All BAs and most of the non-RCTs[1,2,11,15,20,27,35,51,65,74,89,96,105] were rated as having serious risk of bias due to confounding. For BAs, this is linked to the study design chosen, whereas for non-RCTs, most studies did not control or correct for all possible confounders. Five studies used proper matching techniques to control for confounding.[6,44,55,75,82] Almost all non-RCTs[1,2,11,20,35,44,51,55,65,74,75,82,89,96,105] and BAs[8,12,26,28,30,46,70,71,73,84,90,95,97,111,113,122,126] were rated as having low bias in selection of participants, because all eligible participants were included. Bias in the selection of participants was rated as moderate for three non-RCTs, because of low response rates[15,27] or the intervention and follow-up did not coincide for all participants.[6] Moreover, three BAs were rated as having moderate bias, all because of low response rates.[40,43,91] All non-RCTs were rated as having low risk of bias in classification of interventions, because the intervention status was well defined. For BAs, this could not be assessed because only one intervention was offered. All non-RCTs and BAs were rated as having low risk of bias due to deviations from intended interventions, and most non-RCTs[1,2,6,11,15,20,35,44,51,55,65,74,75,82,89,96,105] and BAs[12,26,28,30,40,43,46,70,71,73,84,91,95,97,111,113,126] were rated as having low risk of bias due to missing data because no or low drop-out, or drop-out was unrelated to the outcome or treatment. For one non-RCT[27] and three BAs[8,90,122] the risk of bias due to missing data was unclear, because no information on reasons for drop-out were provided, or it was unknown in which group drop-out occurred. For both non-RCTs and BAs, the assessment of bias in the measurements of outcomes were mixed. Three non-RCTs were rated as having low risk on this aspect, because the assessors were blinded.[27,74,75] Seven studies were rated as having moderate risk, because it was unknown whether the assessors were blinded, but it was thought to have minimal influence on the outcome,[20,35,44,51,82,89,105] whereas seven studies were rated as having serious risk (i.e. unknown whether the assessor was blinded and a subjective outcome or different time-points of measurements for groups).[2,6,11,15,55,65,96] The study of Aki et al. was rated as having unclear risk of bias in measurements of outcome, because it was unclear who the assessors were.[1] In the BAs, nine studies were rated as having moderate risk of bias,[12,26,28,46,71,90,97,111,113,126] whereas the remaining studies were rated as having serious risk of bias.[8,30,40,43,70,73,84,91,95,122] All non-RCTs and all but one of the BAs[43] were rated as having moderate risk of bias in selection of reported results. None of the studies had a protocol available, but there were no indications of selective reporting or subgroup

analyses. The study of Gothwal and coworkers was rated as having serious risk of bias on this aspect, because they performed an explorative study, making it likely that they only reported the results that were of significance.[43] All BAs and most of the non-RCTs[1,2,6,11,15,20,27,35,51,55,65,74,89,96,105] were rated as having serious overall risk of bias. Only the studies of Grumpelt and Rubin[44], Pineio and coworkers[82] and Mohanty and coworkers[75] were rated as having moderate overall risk of bias, and the study of Mohanty and coworkers[75] was rated as having the least risk of bias.

---------- Figure 2 about here ----------

---------- Table 2 about here ----------

---------- Table 3 about here ----------

3. Effectiveness of interventions to improve functioning, participation and quality of life

Main outcomes of the included studies and effect sizes (if applicable) are presented in Table 4. Twenty-two of the 66 (33.3%) included studies did not provide sufficient details on pre- and post-intervention data for effect sizes to be calculated.[2,8,11,28,32,35,40,44,47,50,54,55,74,78,84,90,91,93,111,122,124,127] This makes it even more difficult to perform study comparisons. Below the key findings of each of the included studies are described, grouped by the main subjects of the studies.

---------- Table 4 about here ----------

3.1 Physical performance

Seventeen studies focused on physical performance of which five were RCTs,[16,19,54,56,69] seven were non-RCTs,[1,11,74,75,82,89,105] and five were BAs.[12,71,84,91,97] Four studies assessed the effectiveness of interventions on (fine) motor skills,[1,56,82,89] whereas (dynamic) balance was evaluated in three studies.[11,54,69] Physical performance and fitness was assessed in four studies[19,71,74,97], whereas body composition was assessed in two studies.[12,16] Two studies investigated cardiovascular parameters.[12,105] Motor speed,[75] physical activity time,[91] sports skills,[84] and auditory reaction time[105] were all evaluated in one study.

Joseph investigated whether different types of verbal information feedback had a positive impact on motor skills of children who are blind (i.e. insufficient vision to read print or use their vision for learning). Mean performance significantly increased over the course of the sessions for all groups (small to moderate effect sizes), but the most extensive program improved performance the most (although not significantly). Moreover, results were not maintained once verbal information

feedback was stopped.[56] Robinson and Lieberman investigated the effectiveness of providing information to parents via the parent resource manual on physical activity time of children with visual impairment, but found no differences.[91]

Eleven studies investigated (group-based) training programs. Jazi and coworkers examined the effect of balance exercises on the dynamic balance of children with visual impairment (i.e. visual acuity 20/70 or worse in the better eye after correction). Children in the intervention group scored significantly higher on dynamic balance after the program, whereas no difference was found in the control group.[54] Similarly, Mavrovouniotis and coworkers examined the effect of Greek dances and Pilates on balance of children who are blind. After the program, children in the intervention group had improved significantly, whereas no difference was found in the control group. Effect sizes for the intervention group were large.[69] Pineio and coworkers investigated the impact of an adapted kinetic intervention program on the motor development of children with visual impairment. Participants in the intervention group improved significantly on all subscales and the complete test (large effect size), but no difference was found in the control group.[82] Aki and coworkers compared the effectiveness of a motor training program guided by a physiotherapist (intervention) or delivered at home by parents who were instructed by the physiotherapist (control) on the motor skills of children with visual impairment (i.e. fit into the severe low vision category according to ICD-9-CM; visual acuity 40/200 or worse). The intervention group significantly improved on all subtests, whereas the control group significantly improved on seven of the eight subtest. A large effect size was found for the intervention group, whereas a small effect size was found for the control group. Post intervention scores on five of the eight subtests were significantly higher for the intervention group compared to the control group, while no difference was found in the remaining subtests. The authors concluded that training programs in both a clinical environment provided by a physiotherapist, as well as a home surrounding provided by parents can improve the motor proficiency of children with low vision. They found that complex skills such as balance, coordination and response to stimuli could be trained by a physiotherapist because changing the specific activities according to the child's reactions requires specific knowledge.[1] Shindo and coworkers investigated the impact of endurance training on physical and psychic symptoms and physical resources in young males with visual impairment or blindness. Physical and psychic symptoms improved in all participants after training, and some parameters of physical resources (i.e. maximal oxygen uptake, maximal ventilation and workload) also increased significantly (small to large effect sizes). However, no difference was found on any of the other parameters (i.e. stepping rate, pedaling speed and strength, muscle strength, skinfold thickness, body height and weight).[97] Similarly, Blessing et al. evaluated the effects of endurance training on cardiovascular fitness and body composition of visually impaired children. They found significant improvements in skinfold thickness (small effect sizes) and cardiovascular variables (small to moderate effect sizes) after training. Weight increased significantly after training (small effect size), but according to the authors, this might partly be caused by maturational changes. Moreover, the weight gain was thought to be primarily an accumulation of lean tissue as the result of the endurance training.[12] Taskin evaluated the effectiveness of an aerobic training program on auditory reaction time and maximal oxygen uptake in children with visual impairment (blind 3 classification). Both outcomes improved significantly in the intervention group, but not in the control group (large effect size). The difference between the intervention and control group was statistically significant for both outcomes after the intervention (large effect size).[105] Mohanty and coworkers investigated the effect of yoga training on motor speed in children with legal blindness (visual acuity

less than 20/200 or visual field limited to 20°), and found significant improvement in motor speed for the intervention group (moderate effect sizes), but no significant differences for the control group. The authors suggest that yoga may offer an effective, safe alternative training modality for enhancing health in children with visual impairment.[75] In a second study, Mohanty and coworkers applied yoga to increase muscular fitness in visually impaired children. At baseline, there was no difference between the intervention and the control group, whereas after the intervention the yoga group had a significantly higher proportion of participants who passed the test. Chen and Lin studied the impact of rope jumping exercise on physical fitness of visually impaired students. The intervention group showed significant improvements in sit-and-reach and aerobic capacity (moderate effect sizes), but no differences were found for body mass index and sit-up. The control group showed no significant improvements on any of the variables. The difference between the intervention and control group was statistically significant after the intervention for sit-and-reach and aerobic capacity (small to moderate effect sizes).[19] Last, in children with severe visual impairment, Caliskan and coworkers compared a goalball intervention with movement education. Body fat percentage decreased in both groups, but only in the goalball group significantly (small effect size). Body mass index decreased significantly in the goalball group (small effect size) but increased in the movement education group. The authors conclude that maturation confounds the results, but movement education might be preferred for boys, whereas goalball might be preferred for girls.[16]

Three studies investigated the effectiveness of sports camps. Black and coworkers compared the effectiveness of an outdoor adventure camp (intervention) with a traditional residential physical activity program (control) on dynamic balance and spatial veering in children with visual impairment (visual acuity of 20/200 or less). Both dynamic balance and spatial veering improved significantly in the intervention group, while no significant improvements were found in the control group.[11] Ponchillia and coworkers investigated the impact of a sports education camp on sports skills of children with visual impairment, and found significant improvements in sports skills after the intervention.[84] A similar study conducted by McMahon in which children also significantly improved their sports skills. Effect sizes were all small.[71]

Reimer and coworkers examined the effect of training in trail-following tasks on fine motor skills of children with vision impairment (visual acuity between 20/400-20/67). The trail-following tasks consisted of sheets with four trails of small symbols printed on them, with a picture marking its beginning to a corresponding picture marking its end. For this purpose they compared a group of children who followed the trails with a stand magnifier (intervention) with a group who followed the trails without a visual aid using their finger (control). Significant improvements in fine motor skills were found after training for both groups (moderate to large effect sizes), irrespective of the use of a visual aid during training.[89]

3.2 Oral health

Self-care is one of the domains of the Activity and participation component of the ICF-CY, and oral health is part of self-care. Therefore, studies focusing on oral health were included in this systematic review. All studies originated from Asian countries. Ten studies aimed to investigate the effect of different methods to improve oral health in children with visual impairment: five RCTs,[3,39,62,85,98] two non-RCTs,[20,96] and three BAs.[28,46,126] All studies assessed the effectiveness of interventions on oral health status. Furthermore, three studies also considered the effectiveness of interventions on oral health knowledge,[28,39,126] and two studies on oral hygiene practice.[28,46]

Six studies evaluated the effectiveness of various oral health education programs. Ganapathi and coworkers evaluated the effectiveness of various sensory input models on oral health education among blind children. They compared four intervention groups with a control group. The intervention groups received oral health education by either audio, braille, tactile tooth models or a combination of the previous (multisensory). In all intervention groups, oral health knowledge significantly increased and plaque scores significantly decreased after the intervention (moderate to large effect sizes), but no post-measures were taken for the control group. For increasing knowledge, the multisensory group was significantly superior to the audio and tooth models group, which were significantly superior to the braille group. For plaque scores, the multisensory group, audio group and tooth models group were significantly superior to the braille group.[39] In a similar study in children with legal blindness from birth, Chowdary and coworkers compared an intervention group who received a combination of verbal, braille and tactile oral hygiene awareness intervention with two control groups, one of which received a verbal and tactile oral hygiene awareness intervention whereas the other received a verbal and braille oral hygiene awareness intervention. All groups showed a significant, gradual decline in plaque and gingival scores from baseline to follow-up (large effect sizes). At six months follow-up, the intervention group showed significantly greater decline in plaque scores compared to the control groups. For gingival scores, the verbal and braille group showed the greatest decline, and was significantly different from the verbal and tactile group.[20] Arunakul et al. compared visually impaired children in two intervention groups with a control group. The intervention groups received oral hygiene education kits and brushing instructions either with sodium fluoride mouth rinse or without sodium fluoride mouth rinse, whereas the control group received brushing instructions only. All groups improved significantly in gingival index and plaque index (large effect sizes), but only the intervention groups improved their *Streptococcus mutans* level (moderate to large effect sizes). The intervention groups improved significantly compared with the control group (small to large effect sizes).[3] Shetty and coworkers investigated blind children and compared an intervention group who received a one-month oral health education program with a control group who received the education program for two weeks. Both groups improved significantly on gingival index, plaque index and number of the counted colonies of the bacteria *S. mutans* (small to large effect sizes). The intervention group improved significantly compared with the control group (large effect sizes).[96] Yalcinkaya and Atalay found significant improvements in oral health knowledge, plaque index and gingival index after completion of their oral health education program (small to large effect sizes) in a sample comprising of blind and visually impaired children.[126] Similarly, Debnath and coworkers found significant improvements in children with visual impairment (visual acuity ≤20/200) regarding knowledge, attitudes and practices (e.g. number of times brushing twice daily, use of floss) regarding oral health after their intervention, and a significant change in the percentage of children having a fair plaque index.[28]

Four studies assessed the effectiveness of tooth brushing instructions. Smutkeeree and coworkers compared the effectiveness of two methods of tooth brushing, namely the horizontal scrub method (intervention) and the modified bass method (control) in children with visual impairment. Both groups significantly reduced the plaque index and gingival index (large effect sizes), and there was no significant difference between the groups.[98] Hebbal and Ankola investigated the effectiveness of the audio tactile performance technique on oral health status and oral hygiene practice in children with blindness and visual impairment. After the program, the number of children having proper oral hygiene practice increased, although the result was not significant. The plaque index decreased

significantly after the program (large effect size).[46] Krishnakumar and coworkers also investigated the effectiveness of the audio tactile performance technique in children with visual impairment (i.e. fitting into categories 3, 4 and 5 of visual impairment according to the ICD) and compared it to a control group receiving audio education. Plaque scores of the intervention group decreased significantly (large effect size), whereas no difference was found in the control condition.[62] Qureshi and coworkers compared an intervention group who received a guided tooth brushing program with a control group who received a verbal oral hygiene message in children with blindness and visual impairment. The intervention group significantly reduced their oral hygiene index score (large effect size).[85]

3.3 Psychological outcomes

Nine studies assessed the effectiveness of interventions on psychological outcomes, which we considered to be part of the concept quality of life, including three RCTs,[32,33,66] two non-RCTs,[55,65] and four BAs.[30,70,73,95] One study looked at the effectiveness of interventions on self-image,[66] one study on psychological wellbeing,[32] one study on motivation to work,[33] one study on self-determination,[65] three studies on self-concept,[30,55,65] two studies on self-esteem,[65,73] one study on attitude towards blindness and locus of control,[55] one study on sleep quality and behavioral and emotional states,[30] one study on perception of competence,[95] one study one self-perception,[70] and one study on anxiety, depression and activities of daily living.[73]

Six studies assessed the effectiveness of group-based programs. Locke and Gerler compared different training programs' impact on self-image in children with visual impairment. Both the two intervention groups and the two control groups improved after the intervention, but none of these changes were statistically significant.[66] Eniola and Ajobiewe compared locus of control training and emotional intelligence training with a control group to assess its effectiveness on psychological wellbeing in children with visual impairment and blindness. The two intervention groups improved significantly compared to the control group, although emotional intelligence training was superior to locus of control training.[32] In a similar study, Eniola and Adebiyi compared emotional intelligence training with goal setting with respect to motivation to work in children with visual impairment. Motivation to work increased significantly in both groups (large effect sizes), and the data suggest that emotional intelligence might have a more positive impact than goal setting, although no significant difference was found.[33] According to the study of Levin and Rotheram-Fuller, a group-based empowered curriculum did not lead to changes in self-determination, self-concept and self-esteem in children with visual impairment. No changes for the control group were found either. Despite lack of results in quantitative findings, the authors state that data that were derived qualitatively suggest that the empowered curriculum is a useful intervention for engaging students with visual impairment.[65] In contrast, investigating children with visual impairment, Johnson and Johnson were able to find significant improvements in self-concept in an intervention group which received group counseling, compared to the control group that received no intervention. They also found significant improvements in attitude towards blindness and locus of control in the intervention group compared to the control group.[55] Mohamed and coworkers conducted a study among adolescents with primary or secondary glaucoma in which they evaluated a group-based educational program as well. After the program, children reported significantly less problems in activities of daily living. Furthermore, children's scores on anxiety, depression and self-esteem all improved significantly. Large effect sizes were found for anxiety and self-esteem, whereas the effect size for depression was small.[73]

Three studies evaluated the effectiveness of physical activity programs. McMahon investigated the effectiveness of a sports camp on self-perception, which improved significantly among children with visual impairment (moderate to large effect sizes).[70] In a similar study, Shapiro et al. found significant improvements in perception of competence of children with visual impairment who attended a sports camp (small effect sizes).[95] Dursun and coworkers evaluated the effectiveness of an ice-skating program on sleep quality, self-concept and behavioral and emotional states in children with visual impairment (best corrected visual acuity of 20/200 in the better eye). Sleep quality improved significantly after the program (moderate effect size), while self-concept deteriorated significantly (large effect size). Mixed results were found for behavioral and emotional states (moderate to large effect sizes). The authors hypothesized that ice-skating requires reasonable balance and motor skills, which are often less developed in children with visual impairment compared to controls. As other studies indicate a strong correlation between self-esteem and motor performance, ice-skating may have provoked negative thoughts about themselves.[30]

3.4 Functioning and development

Nine studies focused on functioning and development. Of those, three were RCTs,[7,21,83] three were non-RCTs,[2,6,15] and three were BAs.[40,43,122] Two studies assessed the effectiveness of intervention on functional vision,[40,43] and two on general development.[6,122] One study looked at the effectiveness on child and family functioning,[7] and one study focused on cognition, activities of daily living and quality of life.[15] One study focused on positive parenting,[83] one on creativity,[2] and one on impact of vision impairment.[21]

Four studies investigated the effectiveness of intensive (home-based) early intervention programs. Behl and coworkers compared children with visual impairment (visual acuity 20/200 or worse) in a group who received an intensive, individualized, home-based intervention with a group who received usual care, i.e. parent group meetings which were less intensive. In both groups child functioning improved (large effect sizes), and although there was no significant difference in total score on any of the time points between groups, data suggests that the usual care group improved more. For family functioning, there were no significant differences between groups on any of the time points, and mixed results were found for the outcome measures. Some outcomes improved due to the intervention (in both groups) (e.g. FSS), whereas no difference or deteriorations occurred in other outcomes (e.g. FRS). Effect sizes were small to moderate.[7] Beelmann and Brambring also compared a home-based early intervention program with care as usual in children with congenital blindness. In full-term children, the intervention group was significantly superior to the control group on general development at 30 months (large effect size), but not at any of the other time points. In preterm children, differences between the intervention and control group tended to be small, but data suggested superiority of children in the control group, particularly at older ages (small to moderate effect sizes.)[6] In children with visual impairment, Platje and coworkers compared an intervention group who received an attachment-based video-feedback parenting intervention (VIPP-V) in combination with care as usual to a control group who received only care as usual. No differences were found in parental sensitivity or quality of parent-child interaction, but parenting self-efficacy significantly increased in the intervention group (small effect sizes) and there was a trend towards decreased parenting stress (small effect sizes).[83] Christy compared four methods of low vision service delivery in children with visual impairment (best corrected visual acuity less than 6/12 to light perception in the better eye, or visual field <20°. Significant differences after low vision service provision on impact of vision impairment were found for all groups (small to large effect sizes). The

effect sizes of the center- and community-based arm was significantly higher than in the other arms.[21]

Calik and coworkers investigated the effectiveness of attention training on cognition, quality of life and activities of daily living of children with visual impairment. After the program, children in the intervention group showed significant improvements on cognition (large effect size), quality of life (small effect size) and activities of daily living (large effect size), while the control group showed no difference. Significant differences between the groups in cognition, quality of life and activities of daily living were found after the program, in favor of the intervention group (small to large effect sizes).[15]

Al-Dababneh and coworkers investigated whether a training program aimed at developing creative abilities would increase the creativity of children with visual impairment. They found that the intervention group gained significantly more than the control group in all scale dimensions.[2]

Two studies assessed the effectiveness of the prescription of low vision devices and training in their usage on functional vision. Participants in the study of Gothwal and coworkers were prescribed optical devices (including telescopes and magnifiers), electronic devices (including portable video magnifiers and closed-circuit television) and/or nonoptical devices (e.g. reading stand, reading lamp, filter for glare control and needle threader). Children were provided training in the use of the prescribed devices and optional training in orientation and mobility, computer use and activities of daily living. The authors found a significant improvement In children with visual impairment on the LVP-FVQ II score, an instrument to assess functional vision, indicating improvements on that domain after the prescription and training in the usage of low vision devices (moderate effect size).[43] In line with these results is the study of Ganesh and coworkers, who prescribed telescopes, magnifiers and nonoptical devices (e.g. lamps, reading stands, writing guides, bold-lined not books and large print books) and provided training in its use. They found significant improvements on the LVP-FVQ scores post visual rehabilitation in children with visual impairment (i.e. inclusion in the category of visually impaired as per the WHO criteria for low vision), especially in those activities related to academic output.[40]

Williams and coworkers evaluated the effect of admission to a care unit on the development of children with a visual impairment. After the program, children showed significant improvement on social adaptation and sensorimotor understanding. There was a trend towards significance for exploration of the environment, but there was no difference in responses to sound and verbal comprehension nor in expressive language. The authors hypothesized that this might be caused by the institutionalized setting, the lack of formal speech and communication training in the unit or the way in which the staff interacted with the children was not sufficiently modified to take account of the children's handicaps.[122]

3.5 Reading performance

Eight studies focused on reading performance: four RCTs[47,50,57,58], two non-RCTs,[35,51] and two BAs.[26,113] All studies looked at the effectiveness of interventions on (braille) reading skills.[26,35,47,50,51,57,58,113] Moreover, two of the studies investigated the effectiveness on comprehension,[26,50] one study on critical print size, reading acuity and acuity reserve,[51] and one study focused on writing speed and legibility of writing.[113]

Four studies assessed the effectiveness of various (braille) reading training programs. Howell investigated the effectiveness of braille training in legally blind subjects (i.e. using braille as primary reading media) using either the freehand method or the pacing method, whereas the control group received no intervention. The two intervention groups significantly increased their braille reading rate compared to the control group; there was no significant difference between the intervention groups. Training did not result in significant differences in comprehension for any of the groups.[50] Kederis and coworkers also investigated the effect of pacing training in braille readers. Both the intervention group and the control group showed large significant reductions in reading time (small to large effect sizes), but the groups did not differ significantly from each other. The authors hypothesized that the reduction was mainly caused by motivation (i.e. those with the greatest reduction received a monetary award), and training did not have an influence. Furthermore, comprehension in the experimental and control group deteriorated, although not significantly.[58] In a second study, Kederis and coworkers again found that motivation was probably the only factor that caused a significant change in reading among braille readers. Both the experimental and the control group significantly decreased their reading time (moderate to large effect sizes), and the control group showed a greater reduction than the intervention group, although the groups did not differ significantly. Again, reductions in reading time were accompanied by deteriorations in comprehension, both for the experimental and the control group (small to large effect sizes).[57] Last, Heber evaluated the effectiveness of braille tape reader training in children using braille (visual acuity 20/2000 or less in the better eye after best correction). The intervention group increased their reading speed compared to the control group, but the results were not transferred to reading braille in a traditional manner.[47]

Three studies investigated the effectiveness of (training in) the use of optical aids. Farmer and Morse compared a group of children with low vision (visual acuity 20/70 or worse) who received training with magnifiers (intervention) with a group of children who received training in large print use (control). Both groups improved on their reading skills, but the intervention group made more profound gains. Children in the control group only increased their reading rate, whereas children in the intervention group improved in type size, reading rate and reading comprehension.[35] Uysal and Düger investigated the effect of reading and writing training with the use of optical assistance prescribed by an ophthalmologist (e.g. eyeglasses, telescopic glasses and magnifying glasses) on reading and writing speed and writing legibility in children with visual impairment (i.e. satisfying the criteria for low vision according to the ICD-10-CM). After attending training, children significantly increased their reading and writing speed, but writing legibility was not significantly improved; effect sizes were all small.[113] Similarly, Corn and coworkers evaluated the effect of the prescription of optical devices (including magnifiers, monocular telescopes and light-absorptive lenses) on reading and comprehension rates of children with visual impairment. They found that using optical devices improved silent reading and silent comprehension rates, but not oral reading and oral comprehension rates. The authors state that this might suggest that for children with low vision, oral reading does not demonstrate the level of skills that children have. Effect sizes were all small, except for silent reading speed, where a large effect size was found.[26]

Huurneman and coworkers compared a group of children with infantile nystagmus (visual acuity 20/31-20/400) who received crowded training (intervention) with a group who received uncrowded training (control). In the uncrowded training group, children had to report the orientation of a C by pressing a corresponding key on the keyboard. Feedback was given after each trial. Letter size was

reduced if at least 7 of 10 answers were correct; otherwise, letter size was increased. The crowded training group was instructed to identify a target C surrounded by six Cs of the same size in another orientation. Children had to report the orientation of the target C. Spacing was reduced if at least 7 of 10 answers were correct; otherwise spacing was increased. The authors concluded that training significantly improved reading acuity and affected minimum critical print size, irrespective of training condition, although moderate effect sizes were found for the intervention group, versus small effect sizes for the control group. Training did not have an influence on maximum reading speed and acuity reserve.[51]

3.6 Social skills

Seven studies focused on social skills, including five RCTs,[61,72,93,114,127] one non-RCT,[44] and one BA.[8] Four studies had social skills as an outcome measure.[8,61,93,114] Furthermore, one study looked at the effectiveness of interventions on social competence and social validation,[93] one study focused on activity performance,[114] one study on adolescent-parent communication,[72] one study on empathic skills and communication skills,[127] one study on assertiveness, self-criticism and helplessness,[61] and one study on speed of listening skills.[44]

Two studies investigated the effectiveness of social skills training. Yildiz and Duy investigated whether a group-based psycho-education program had a positive effect on the empathic and communication skills of children with visual impairment. Compared to the pretest, the intervention group improved significantly on both empathy and communication after the intervention, but the differences between the groups were not statistically significant.[127] In legally blind children (congenitally visually impaired), Sacks and Gaylord-Ross compared two intervention groups, who received either peer-mediated social skills training or teacher-directed social skills training with a control group. For both intervention groups, significant improvements were found on social skills, social competence and social validation, while the control group only showed improvements on a few aspects of social skills. Both intervention groups improved significantly more than the control group on social competence. Upon closer examination, the changes in the peer-mediated group were larger than in the teacher-directed group, but this result was not statistically significant.[93]

Kim assessed the effectiveness of assertiveness training in children with visual impairment, and compared the intervention group to a control group who received no intervention. After the intervention, there were no significant differences between the intervention and control group on social skills as rated by participants, parents and teachers, assertiveness as rated by participants and observers and cognitive distortions as rated by participants. Both the intervention and the control group improved on all measures from pre-test to post-test, except for assertiveness rated by participants, which improved in the intervention group but deteriorated in the control group.[61]

Two studies examined the effectiveness of communication training. McConnell studied whether the Partner's Program was effective on enhancing adolescent-parent communication in visually impaired children. They did not find any significant differences in adolescent-parent communication, and effect sizes were small.[72] Grumpelt and Rubin assessed the effectiveness of speed listening training at high speed (intervention) compared to normal speed (control) in blind children. Both groups significantly deteriorated at post-test, delivered at high speed, as compared to pre-test, which was delivered at normal speed, but the intervention group deteriorated less.[44]

Bieber-Schut investigated whether developmental drama workshops had a positive influence on the social skills of children with visual impairment, which was indeed the case.[8]

Uysal and Düger evaluated the effectiveness of visual perception training in children with visual impairment (i.e. fitting into the low vision category according to the ICD-10-CM) and compared a group of children who trained with a computer (intervention) to a group who trained with paper and pencil (control). Both groups improved significantly on social skills (small to moderate effect sizes) and activity performance (large effect sizes), and neither of the groups was superior to the other.[114]

3.7 Viewing behavior

Four studies focused on viewing behavior. Of those, two were RCTs,[13,78] one was a non-RCT,[27] and one was a BA.[90] Two studies evaluated the effectiveness of interventions on visual functioning,[78,90] one study on viewing behavior,[13] and one study on task performance.[27]

Nyquist and coworkers investigated the effectiveness of video games on visual functioning in children with visual impairment (best corrected binocular visual acuity 20/60-20/800 and visual field at least 35°). Visual functioning included foveal motion perception, single target motion discrimination, multi-target direction comparisons, visual crowding, and visual search. They compared two intervention groups, who either received an action video game or modified attentional tracking, to a control group who received a control video game. The action video game was called “Ratchet and Clank: Dreadlocked”, which was played on a PlayStation 2. In the modified attentional tracking task, the participant has to track target balls and discriminate motion direction. The control group received a video game called “Lumines”, which is similar to “Tetris”. Both intervention groups showed significant improvements after training, except for foveal motion perception, whereas no difference was found for the control group, except for visual search. Data suggested that modified attention tracking resulted in more profound improvements than action video games, but there was no significant difference between the groups.[78]

Three studies assessed the effectiveness of training in visual aids. Investigating children with visual impairment (visual acuity 20/50 or less in the better eye after best possible correction), Boonstra et al. compared a group who received training with a magnifier (intervention) to a group who received training without a magnifier. After training, both groups significantly improved their duration of observing time and the distance from which they viewed the symbols on the LH chart (consisting of Lea symbols) near vision test single and on the LH chart near vision line (moderate effect sizes). There was no significant difference between the groups.[13] A study using the same criteria for visual impairment was conducted by Cox et al., who found that both the experimental and control group improved significantly in the number of trails followed after training (large effect sizes). They employed the same training strategy as Reimer and coworkers:[89] children in the intervention group followed trails (made of small symbols printed on a sheet) with a stand magnifier, whereas children in the control group followed trails without a visual aid using their finger. When looking at the proportion of trails followed correctly, the children in the intervention group who were trained with the magnifier gained significantly more than the children in the control group who were trained without a magnifier.[27] Last, Ritchie evaluated whether children with severe visual impairment who received training in the use of a visual aid improved their visual functioning, i.e. whether children correctly responded to questions about a set of visual material presented to them. Children were prescribed a lobster pot stand magnifier, a fleximag stand magnifier, closed-circuit television, a

monocular telescope or a binocular telescope, or a combination of these visual aids. The material chosen varied for the aid prescribed, and included various near visual (motor) tasks. In this study, 50% of the children improved on visual functioning.[90]

3.8 Mobility

Two studies focused on mobility: one RCT,[124] and one BA.[111] One study assessed the effectiveness of interventions on motor, sensory, concept and mobility skills[124] and the other study on the performance of estimating distances.[111]

In children with severe visual impairment (i.e. light perception or less), Wood compared an intervention group who received programmed orientation and mobility instruction materials to a distal control group and an onsite control group. Both control groups received a regular educational program. Compared to the control groups, the intervention group improved significantly on all intervention content areas.[124]

Ungar and coworkers evaluated a training for estimating distances from a map in children with visual impairment, and concluded that the children improved after training.[111]

4. Discussion of the results

4.1 Summary of the results

This systematic review thoroughly assesses the effectiveness of all interventions published aimed at increasing functioning, participation and quality of life, or skills and behaviors that determine these constructs, in children with visual impairment. The main finding of this review is that the number of high-quality studies is limited. Of the 441 articles that were of potential interest, only 66 met our inclusion criteria.

Most of the included studies were aimed at investigating the effectiveness of interventions on physical performance (n=17), oral health (n=10) or psychological outcomes (n=9). Fewer studies focused on reading performance (n=8), functioning and development (n=8) or social skills (n=8). Only a few studies investigated the effects on viewing behavior (n=4) or mobility (n=2), even though mobility is often mentioned as an important factor impacting functioning, participation and quality of life in children.[22,81,87,88,103] Only one study investigated the effect of an intervention, amongst other outcomes, specifically on general quality of life of the participants.[15] In addition, two studies used the LVP-FVQ to assess functional vision,[40,43] one study used the IVI_C to assess impact of visual impairment,[21] and several studies used measures on areas that belong to the concept of quality of life, that is to assess development, child functioning and activities of daily living,[6,7,73,122] although often not specifically developed for children with visual impairment.

The included studies showed that offering physical training[1,12,16,19,54,69,74,75,82,97,105] or sports camps[11,71,84] are likely to be effective in increasing physical performance, since the effect sizes found were moderate to large. The study of Mavrovouniotis and coworkers that examined the effect of Greek dances and pilates on balance of children who are blind found the largest effect sizes.[69] In addition, the study of Mohanty and coworkers was rated as being least susceptible to bias among the non-RCTs and BAs.[75] Providing information alone proved not to be effective for improving physical performance.[56,91] Training in trail following tasks was effective in improving fine motor skills, irrespective of the use of visual aids.[89]

Interventions aimed at improving oral health were all effective,[3,20,28,39,46,62,85,96,98,126] and effect sizes were mostly large. Oral health interventions combining multiple elements and with long duration were more effective than those with fewer elements and shorter durations. The largest effect sizes for pre-test versus post-test results were found in those studies who had an intervention group combining several intervention elements (e.g. the multisensory group in the study of Ganapathi and coworkers,[39] the group who received a combination or verbal, braille and tactile oral hygiene awareness training in the study of Chowdary and coworkers[20] and the group who received brushing instructions, oral hygiene education and mouth rinse in the study of Arunakul and coworkers[3]). However, compared to the control interventions, which often entailed light interventions consisting of only one element, the results were less distinctive and effect sizes were smaller. Moreover, the study of Ganapathi and coworkers was rated as high risk of bias because no post-measures were conducted for the control group.[39]

Group-based programs to improve psychological outcomes showed mixed results.[32,33,55,65,66,73] The largest effect sizes were found by Mohamed and coworkers, in which a group-based educational program resulted in significantly less problems in activities of daily living, anxiety, depression and self-esteem; however, this study did not use a comparison group.[73] Sports camps seemed to be effective in improving psychological outcomes,[70,95] whereas ice-skating deteriorated psychological outcomes.[30] This might suggest that the type of physical activity influences the results. However, none of these studies employed a control group.

Intensive home-based early intervention programs did not show to be effective in improving functioning and development compared to low-intensity programs,[6,7,83] and the effectiveness of admission to a care-unit was also limited;[122] effect sizes were mostly small. Rehabilitation at a low vision rehabilitation center was effective, however, in particular when combined with a home-based program with support from the community.[21] Provision of low vision devices were effective in improving functioning and development, although these studies did not use a control group.[40,43] Attention training[15] and a program to increase creativity[2] turned out to be effective as well. Especially the study of Çalik and coworkers found relatively large effect sizes for the intervention group when pre- and post-test scores were compared.[15] The studies of Platje and coworkers[83] and Christy[21] were rated as having the least bias, and therefore the evidence resulting from these studies is rather strong.

Training for reading that was offered in the studies included in this review showed not to be effective,[47,50,57,58] which might be due to the type of training used or focus on outcomes placed in the included studies. Most studies focused on increasing reading speed, which is at the expense of reading comprehension. When offering interventions to increase reading speed in children, one should be aware that this could have negative effects on reading comprehension. Focus should be placed in order to make sure that interventions for increasing reading speed do not lead to deteriorations in comprehension. Provision of low vision devices resulted in improved reading skills, but effect sizes were mostly small.[26,35,113] As a result one can question whether using low vision aids is useful for every individual or just for some. However, none of these studies used a control group. Huurneman and coworkers found that uncrowded and crowded training significantly improved reading acuity and affected minimum critical print size. Training did not have an influence on maximum reading speed and acuity reserve.[51]

Studies showed that a drama workshop[8] and visual perception training[114] were effective in improving social skills, but the results of social skills/assertiveness training[61,93,127] were rather mixed. Communication training did not seem to be effective in improving social skills,[44,72] and the low susceptibility to bias of the study of Grumpelt and Rubin[44] makes the quality of the evidence rather strong. The study of Uysal and Düger showed the largest effect sizes, both for the intervention group as for the control group. However, the only difference between the intervention and the control condition was the medium with which they received training: the intervention group received visual perception training with the computer, whereas the control group received training with paper-and-pencil.[114]

Video games[78] and the provision of low vision devices[13,27,90] improved viewing behavior with moderate to large effect sizes; however, the control group who trained without a magnifier also improved in the studies of Cox and coworkers and Boonstra and coworkers[13,27]

Although limited in number, interventions to improve mobility were likely to be effective as well.[111,124] These studies provided insufficient information to calculate effect sizes.

4.2 Limitations of the included studies

Despite the evidence for the effectiveness of certain interventions outlined above, the results must be interpreted with caution. For instance the interventions aimed at improving oral health showed to be the most effective, with generally large effect sizes. For unknown reasons these studies were all conducted in Asian countries. This raises the question whether oral health in children with visual impairment is also an issue on other continents and whether the intervention results can be generalized to those countries. Furthermore, over 40% of the included studies were older than a decade, and the investigated interventions might be outdated, especially because technology advances rapidly. In addition, follow-up periods were often short and sample sizes were small. Only three studies reported use of a power analysis to calculate the minimum number of participants necessary to detect clinically important differences,[21,28,83] and only one study conducted cost-effectiveness analyses.[7] The included studies showed large variability in age of the participants, degree of visual impairment and causes of vision loss of participants (if even reported), and duration of follow-up. This makes it difficult to compare studies and results with each other.

Many RCTs and non-RCTs did not have a control group that received no intervention, or that was put on a waiting list or received care as usual. Offering no treatment or putting controls on a waiting list has the largest likelihood of finding large effect sizes,[4] requires smaller sample sizes, and is potentially useful for interventions that have not been evaluated previously.[77] However, there might be ethical problems if there is an alternative treatment available, and may cause participants to decline enrollment.[77] In the included studies, a light or alternative intervention was often the comparison treatment, and the researchers did not state which group was the intervention group and which group was the control group. Comparing an intervention group to a control group receiving a light intervention or alternative intervention requires very large sample sizes and often these studies were underpowered.[36,77] As such, type II error risk (rejecting a valuable intervention) increases.[77] To a degree, this also accounts for control groups receiving usual care, depending on its effectiveness.[77] Moreover, care as usual may include many sources of variation, and it is often unclear what it precisely entails.[76,77,112] In addition, we found a substantive number of BAs, which do not employ a control group. The use of a control group is of great value, because it increases

confidence that the findings could be attributed to the intervention studied, and not to other factors.[9] In children, using a control group is even more valuable because of their natural development. No single control condition is perfect, and each condition has its advantages and disadvantages.[77] It is important that researchers consider the advantages and disadvantages of the various control conditions before selecting a study design, and keep the study purpose in mind. If the control condition has to be consistent with practice, care as usual might be the best option. However, in case small sample sizes are foreseen and the intervention has not been studied before, an exploratory trial in which a control group that receives no intervention or is put on a waiting list might be the preferred method.

The number of high-quality studies was limited. The lack of high quality designs in intervention studies might be due to some methodological limitations in the study of children with visual impairment and blindness that were already described in 1977[53] and are still valid today. Amongst others these are the relatively low incidence of blindness and visual impairments and the heterogeneity of this population because of differences in age of onset, etiology and the large number of comorbid disorders. In most RCTs, randomization methods (i.e. random sequence generation and allocation concealment) were not reported adequately, introducing possible selection bias. As expected, blinding of participants was not possible due to the nature of the intervention, and in those studies in which it was clear who the assessors were, it was often unclear whether assessors were blinded. Several studies lacked a proper description of the intervention they were investigating, and therefore it was not clear what the intervention precisely entailed. Reporting bias was almost always unclear, because only one[83] of the included studies had a study protocol available and conformity to the protocol was reported in only one study.[61] Furthermore, conducting a non-RCT or BA might induce confounding; often no correction for relevant confounders was applied. Future studies should aim to improve the standard on conducting research on the effectiveness of interventions in children with visual impairment and should adequately report on the results, preferably using one of the available reporting standards[34] and preregistering study protocol and expected outcomes.

4.3 Strengths and limitations of this systematic review

In contrast to previous systematic reviews[5,9,107], this review focuses specifically on children and included studies irrespective of study design, with the exception of single case studies or studies with less than 10 participants. We used a broad search strategy to get an overall view of all available evidence, employing multiple databases as well as searching the grey literature for relevant studies. Furthermore, we included all types of interventions aimed at increasing functioning, quality of life and/or participation, and/or skills and behaviors that determine these constructs. The broad search strategy resulted in finding a large number of studies, and 59 met the inclusion criteria. Moreover, effect sizes were calculated to investigate the relevance of the results with respect to changes within and between groups over time.

A number of limitations need to be acknowledged as well. Because of the small number of high quality studies, it is not possible to draw firm conclusions on the effectiveness of interventions to improve functioning, participation and quality of life in children with visual impairment. The large variety of intervention types and lack of uniformity in the outcome measures used (i.e. over 50 different outcome measures were reported) hinders comparison of the results. Therefore, it was not possible to pool the results of the included studies and perform a meta-analysis. Furthermore,

because of the intention to perform a meta-analysis, studies with less than 10 participants were not included, although large in number (at least 120 studies were counted performing a quick search among all excluded studies). The results of these studies are thus missing in this systematic review, and further research should indicate whether interventions investigated in these studies might be effective for improving quality of life, participation and functioning in children with visual impairment. Moreover, some articles were more experimental in nature, comparing for example two methods for visual search, and reporting on the results over time (e.g. [25,64]); however, these studies did not include information on pre-test data, and were therefore also omitted in this systematic review. In addition, studies not published in English, Dutch, French or German were excluded in this systematic review, because of the difficulties with interpretation of the results. Ten studies were excluded because of this reason: 5 from Russia, 2 from Japan and 3 from Spain (the other 24 studies in Figure 1 were not presenting original research, but for example presented research protocols, abstracts, systematic reviews, editorials or letters to the editor). Last, since we could not perform a meta-analysis, we have also not contacted the authors of the included studies to request additional information for calculating effect sizes. Hence, also risk of bias could not be always assessed and the relevance of some of the intervention effects remains uncertain.

5. Conclusions

Overall, the lack of high-quality, well-designed and adequately reported studies, limits the conclusions that can be drawn for the effectiveness of interventions to increase functioning, participation or quality of life in children with visual impairment. The included studies were all susceptible to bias, and reporting of the results was often substandard. There was hardly any consensus on the most suitable methods or instruments to measure the outcomes of interventions, which hindered study comparisons. Despite these limitations, the results of this review suggest that sports camps, prescription of low vision devices and oral hygiene programs might be effective in improving functioning or elements of participation and quality of life in children with visual impairment. In particular, sports camps were effective in improving physical performance and psychological outcomes, prescription of low vision devices in improving viewing behavior, and to a lesser extent reading skills, and oral hygiene programs in improving oral health. Further research is warranted in order to collect more evidence for the effectiveness of interventions to improve functioning, participation and quality of life in children with visual impairment. Moreover, for those interventions that already have been studied, it should be investigated what the underlying mechanisms for effectiveness are and whether these interventions are more effective for groups with certain demographic or clinical characteristics.

6. Recommendations for practice and future research

This systematic review supports the need for well-designed, high-quality studies on the effectiveness of interventions to increase functioning, participation and quality of life in children with visual impairment. Future studies should preferably adopt an RCT design using a control condition that is appropriate to the aim of the study; however, the limitations regarding the suitability for conducting an RCT should be acknowledged (e.g. ethical issues for denying or delaying a group access to care, lack of representativeness of daily health care practice which causes limited results when effective interventions are implemented in daily health care practice, and lack of appropriate interventions to be researched using an RCT), especially for this heterogeneous population.[116] Furthermore, future

studies should also ensure sufficient statistical power, proper randomization methods, longer follow-up measurements, blinded outcome assessment, trial registration and published research protocols. We recommend that results of future studies should be reported using one of the available reporting standards,[34] including a detailed description of what the intervention entailed.

Lack of homogeneity in interventions and outcome measures hinders the comparison of results. Therefore, consensus must be sought on what constructs or even outcome measures are most relevant for measuring the effects of interventions to increase functioning, participation and quality of life. Visual functioning is not sufficient to capture the effectiveness of an intervention on children's participation and quality of life; for that purpose, patient-reported outcome measures for functional status and quality of life should be recorded as well. In contrast to the measures available for adults with visual impairment (e.g.[37,45,49,67,68,100,123]), there has been a paucity of effort in the development and application of such measures for children; however, several instruments have recently been developed to target this specific population and are now available for use.[10,23,31,41,42,59,102,104] If future studies would incorporate measures for functional status and/or quality of life as secondary outcome measures, in addition to their primary outcome measures, it would facilitate comparison between studies using meta-analysis.

Although this review suggests that certain interventions might be effective in improving aspects of quality of life, participation and functioning in children with visual impairment, the effectiveness of many interventions offered by, for instance, low vision rehabilitation centers is still unclear. Further research is needed in order to determine which interventions are effective and to ensure maintenance of funding for low vision rehabilitation services in children.

7. Method of literature search

7.1 Search strategy

A review protocol was developed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)-statement (www.prisma-statement.org). A comprehensive search was performed in the bibliographic databases PubMed, Embase.com, EBSCO/PsycINFO, EBSCO/CINAHL, EBSCO/ERIC and Wiley/Cochrane Library from inception up to 21 February 2018, in collaboration with an experienced medical librarian. The following terms were used (including synonyms and closely related words) as index terms or free-text words: "Visually Impaired Persons", "Vision Disorders", "Children", "Infants", "Newborn", "Rehabilitation". The search was performed without date or language restriction. After deduplication all titles were screened and appropriate abstracts reviewed. The full search strategies for all databases can be found in the Supplementary file 2. Relevant articles were selected using 4 steps: 1) reviewing title, 2) reviewing title and abstract, 3) reading the full text of the articles and 4) quality assessment. All steps were performed by two researchers independently. Discrepancies were resolved by discussion and/or consultation of a third researcher. Reference lists of retrieved articles and identified reviews [5,9,17,18,29,38,80,107,117,125] were searched by hand to ensure all relevant studies were considered. Additional strategies were used to include relevant 'grey literature', i.e. abstracts from conference proceedings, which never have been published in scientific journals. For that purpose, conference proceedings of the 9th-12th International Conference on Low Vision, ARVO 2010-2017, ESLRR 2013-2015 and ICEVI 2013-2017 were searched by hand. Because of the large number of abstracts for ARVO, the search term 'child' was used in order to identify the most relevant abstracts. In the next phase, we searched for available full-text

articles with no limitations to year of publication. Studies that were not available in full text were requested through the Inter Library Loan service only if they were published after 1990.

7.2 Study criteria

The following criteria for inclusion were used: 1) original research in English, German, French or Dutch, 2) longitudinal research design with at least two measurements, 3) included participants have visual impairment according to the WHO criteria[118] and/or the guideline on visual impairments, rehabilitation and referral[115] and are not older than 18 years, having any gender, ethnicity, intellectual capacity or eye condition (if a study only had a few participants who were older than 18 years, but the majority was younger, the study was included), 4) sample size of at least 10 participants in order to be able to pool results in meta-analyses, 5) interventions aimed at improving functioning, quality of life and/or participation. Because quality of life and participation are often indirectly measured,[52,86] the main outcome measure might be a specific part of quality of life and/or participation, operationalized through various constructs (e.g. mobility skills or reading ability). Therefore, both quality of life and participation as well as skills and behaviors, that determine these constructs, were investigated in this study. Studies were excluded if they: 1) obtained results from simulated visual impairment, 2) were only reported as abstracts, 3) involved the assessment of surgical procedures or optometric interventions to correct for example squint, amblyopia and refractive disorders.

7.3 Data extraction

The following characteristics of included studies were extracted: 1) country and year of publication; 2) study design, duration of follow-up and setting; 3) participant characteristics at baseline (i.e. sample size, mean age, age range, proportion of females and drop-out rate); 4) the degree of vision impairment and the diagnosis of visual impairment; 5) the aspect of functioning, participation or quality of life measured; 6) description of the intervention for the intervention group; and 7) description of the intervention for the control group (if applicable).

7.4 Quality assessment

A distinction was made between RCTs, non-RCTs and before-after comparisons. The Cochrane Collaboration Risk of Bias Tool (CCRBT) was used to assess the quality of RCTs.[48] For non-RCTs and BAs, the Risk Of Bias In Non-randomized Studies - of Interventions Tool (ROBINS-I) was used.[101] The CCRBT has seven parameters: 1) random sequence generation (selection bias); 2) allocation concealment (selection bias); 3) blinding of participants and personnel (performance bias); 4) blinding of outcome assessment (detection bias); 5) incomplete outcome data (attrition bias); 6) selective reporting (reporting bias); and 7) other sources of bias, such as those introduced by baseline imbalances.[48] Each parameter was assessed as low risk, high risk or unclear risk. The ROBINS-I also has seven parameters: 1) bias due to confounding; 2) bias in selection of participants into the study; 3) bias in classification of interventions; 4) bias due to deviations from intended interventions; 5) bias due to missing data; 6) bias in measurement of outcomes; and 7) bias in selection of the reported results.[101] Each parameter was assessed as low risk, moderate risk, serious risk, critical risk or unclear risk. Assessment of study quality was done by two researchers independently. Discrepancies were resolved by discussion and/or consultation of a third researcher.

7.5 Evidence synthesis

Originally, we planned to conduct a meta-analyses to synthesize the evidence of included studies.

However, this was not possible because the outcome measures differed vastly in the included studies. Therefore, a narrative method was used to synthesize evidence from the included studies. To aid comparison of the outcomes of different studies and investigate whether the results were clinically meaningful, effect sizes were calculated when possible using Cohen's d method: effect size = mean change in outcome divided by the pooled standard deviation at baseline and follow up.[24] The effect size was classified using Cohen's categories: ≤ 0.49 represented a small effect, 0.5-0.79 a medium effect and ≥0.8 a large effect. For each outcome, the mean change from baseline to follow-up and the standard deviation of this mean change was extracted for the intervention group and the control group separately, if applicable. In some cases, the standard deviation was derived from the standard error. To compare differences in change between intervention and control group, differences in change scores between the groups were divided by the standard deviations of change.

8. Abbreviations

BA: before-after comparison
CCRBT: Cochrane Collaboration Risk of Bias Tool
ICF-CY: International Classification of Functioning, Disability and Health for Children and Youth
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis
RCT: randomized controlled trial
ROBINS-I: Risk Of Bias In Non-randomized Studies - of Interventions
WHO: World Health Organization

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Table 1. Characteristics of reviewed studies, arranged on outcome measure: 1) physical performance, 2) oral health, 3) psychological outcomes, 4) reading performance, 5) functioning & development, 6) social skills, 7) viewing behavior, and 8) mobility skills

Author (year, country)	Study design (follow-up, setting)	Sample: sample size, mean age (age range), % female, % drop-out	Sample: degree of vision impairment, diagnosis of visual impairment	Outcome measures	Arm 1	Arm 2
1. Physical performance						
Aki et al. (2007, Turkey)[1]	2-Arm non-RCT* (3 months, probably home)	N=40, 8.9 years (age-range not reported), 50% female, no drop-out	Severe visual impairment (VA ≤40/200), congenital cataract (47.5%), albinism (17.5%), rod/cone dystrophy (15%), optic atrophy (10%), retinopathy (7.5%), coloboma (2.5%)	Motor skills (BOT)	Training program guided by a physiotherapist (3 months, 3 times per week for 1 hour)	Home training program guided by parents (similar in dose and intensity)
Black (1978, USA)[11]	2-Arm non-RCT (30 days, residential camp)	N=30, average age not reported (14-17 years), gender not reported, no drop-out	Visual impairment (VA ≤20/200), diagnoses not reported	Dynamic balance (modified version of the Springfield Beam-Walking Test), spatial veering (UCLA Mobility Orientation Test for the blind)	Outdoor adventure program (12 days, 50 hours in total)	Program of traditional residential physical education activities and mobility training (30 days, 50 hours in total)
Blessing et al. (1993, USA)[12]	1-Arm BA (16 weeks, probably school)	N=30, 13.5 years (8-18 years), 36.7% female, no drop-out	Visual impairment (33.3% blind, 53.5% VA ≤ 20/200, 13.3% visual field ≤ 20°), cataract (26.6%), corneal disease (20%), retinal/chorodal disease (13.4%), glaucoma (6.7%), other (33.3%)	Cardiovascular fitness, body composition (height, weight, skinfold thickness)	Endurance training (16 weeks, 3 times per week for approximately 40 minutes)	No control group
Caliskan et al. (2011, Turkey)[16]	2-Arm RCT* (3 months, probably school)	N=46, 12.5 years (10-15 years), 43.5% female, no drop-out	Severe visual impairment (diagnosis not reported)	BMI, percent body fat	Goalball (3 days per week, 54 hours in total)	Movement education (similar in dose and intensity)
Chen & Lin (2011, Taiwan)[19]	2-Arm RCT (71 days, probably school)	N=16, 16.1 years (15-17 years), gender not reported, no drop-	Visual impairment (diagnosis not reported)	Physical fitness (BMI, sit-and-reach, sit-up, PACER)	Rope jumping (10 weeks, 3 days per week for 50 minutes)	No intervention

		out				
Jazi et al. (2012, Iran)[54]	2-Arm RCT (8 weeks, school)	N=19, 10.3 years (8-14 years), 36.8% female, no drop-out	Visual impairment (VA ≤20/70), diagnosis not reported	Dynamic balance (Modified Bass Test of Dynamic Balance)	Group-based balance training program (8 weeks, 2 times per week for 1 hour)	No intervention
Joseph (1984, USA)[56]	3-Arm RCT* (2 days, school)	N=50, 15.2 years (7.9-21.1 years), 56% female, no drop-out	Blind, ROP (42%), optic nerve degeneration (14%), glaucoma (8%), tapetoretinal degeneration (6%), microphthalmia (6%), macular dystrophy (4%), other (20%)	Motor skills	First arm received verbal information feedback with knowledge of results and performance (three sessions)	Second arm received verbal information feedback with knowledge of results (similar in dose and intensity) Third arm received verbal information feedback with knowledge of performance (similar in dose and intensity)
Mavrovouniotis et al. (2013, Greece)[69]	2-Arm RCT (8 weeks, school)	N=16, 15.9 years (age-range not reported), 43.8% female, 12.5% drop-out	Blind, diagnosis not reported	Balance (MABC-2, BOT-2)	Training program with Greek traditional dances and Pilates movements (8 weeks, 2 times a week for 45 minutes)	Physical education lessons (similar in dose and intensity)
McMahon (2013, USA)[71]	1-Arm BA (1 week, sports education camp)	N=671, average age not reported (9-18 years), gender not reported, no drop-out	Visual impairment, diagnosis not reported	Physical performance (SCEI)	Sports education camp (one week)	No control group
Mohanty et al. (2015, India)[74]	2-Arm non-RCT (16 weeks, probably school)	N=83, 12.2 years (9-18 years), 31.3% female, 3.6% drop-out	Visual impairment (22.5% blind, 77.5% visual impairment), diagnosis not reported	Muscle fitness (Kraus-Weber test)	Group-based yoga program (16 weeks, 5 days per week for 60 minutes)	Waiting list
Mohanty et al. (2016, India)[75]	2-Arm non-RCT (16 weeks, probably	N=83, 12.6 years (9-16 years), 30.1% female, 7.2% drop-out	Legal blindness (VA <20/200 or visual field ≤20°), diagnosis not reported	*Of interest:* motor speed (FTT). *Other outcomes:* upper extremity muscle strength (handheld	Group-based yoga program (16 weeks, 5 times per week for 1 hour)	Waiting list

	school)			dynamometer), pinch strength (pinch dynamometer)		
Pineio et al. (2017, Greece)[82]	2-Arm non-RCT (12 weeks, setting not reported)	N=24, average age not reported (6-14 years), gender not reported, no drop-out	Visual impairment, diagnosis not reported	Motor development (BOT-2)	Group-based exercise program (12 weeks, 3 times per week for 40 minutes)	No intervention
Ponchillia et al. (2005, USA)[84]	1-Arm BA (1 week, sports education camp)	N=321, 12.8 years (8-19 years), 45.1% female, no drop-out	Visual impairment, diagnosis not reported	*Of interest:* sports skills (SCEI). *Other outcomes:* attitudes, sports knowledge (SCEI)	Sports education camp (one week)	No control group
Reimer et al. (2011, The Netherlands)[89]	2-Arm non-RCT* (6 weeks, setting not reported)	N=22, 57 months (48-71 months), visual impairment, 36% female, no drop-out	Visual impairment (VA 20/400-20/67), albinism (36.4%), cong. cataract (17.4%), cong. nystagmus (13.6%), retinoschizis (13.6%), other (18.2%)	*Of interest:* fine motor skills (ManuVis, writing task of MABC). *Other outcomes:* Motoscopic data (head orientation, working distance)	Training in trail-following tasks using a stand magnifier (12 half-hour sessions during 6 weeks)	Training in trail-following tasks without a visual aid (similar in dose and intensity)
Robinson & Lieberman (2007, USA)[91]	1-Arm BA (6 weeks, home)	N=18, average age not reported (9-23 years), 38.9% female, no drop-out	Visual impairment, diagnosis not reported	Physical activity time	Parent resource manual	No control group
Shindo et al. (1987, Japan)[97]	1-Arm BA (6 weeks, probably school)	N=10, 17.7 years (16-22 years), 0% female, no drop-out	Visual impairment (60% visual impairment, 40% blind), diagnosis not reported	Physical and psychic symptoms (CMI), physical fitness	Endurance training (6 weeks, 3 times per week for 60 minutes)	No control group
Taskin (2016, Turkey)[105]	2-Arm non-RCT (8 weeks, setting not reported)	N=40, 15.5 years (age-range not reported), gender not reported, no drop-out	Visual impairment (blind 3 classification), diagnosis not reported	Auditory reaction time, maximal oxygen uptake	Aerobic training program (8 weeks, three times per week for 60-80 minutes)	No intervention
2. Oral health						
Arunakul et al. (2015, Thailand)[3]	3-Arm RCT (3 months, setting not reported)	N=75, 11.3 years (10-12 years), 46.7% female, no drop-out	Visual impairment, diagnosis not reported	Oral health status (plaque index, gingival index and Streptococcus mutans level)	First arm received brushing instructions, oral hygiene education kits and sodium fluoride	Third arm received brushing instructions

					mouth rinse Second arm received brushing instructions and oral hygiene education kits	
Chowdary et al. (2016, India)[20]	3-Arm non-RCT* (6 months, school)	N=120, 11 years (6-16 years), gender not reported, no drop-out	Legal blindness, diagnosis not reported	Oral health status (plaque index, gingival index)	First arm received a verbal + braille + tactile oral hygiene awareness intervention (2 weeks, 1 time per week)	Second arm received a verbal + tactile oral hygiene awareness intervention (similar in dose and intensity) Third arm received a verbal + braille oral hygiene awareness intervention (similar in dose and intensity)
Debnath et al. (2017, India)[28]	1-Arm BA (6 months, school)	N=40, average age not reported (9-18 years), 37.5% female, no drop-out	Visual impairment (VA ≤20/200), diagnosis not reported	Oral health status (plaque index), oral health knowledge	Oral health education module consisting of music based brushing technique, cast models and an oral health education talk and braille booklet (6 sessions at 1-month intervals)	No control group
Ganapathi et al. (2015, India)[39]	5-Arm RCT (8 weeks, school)	N=200, average age not reported (8-14 years), gender not reported, no drop-out	Totally blind, diagnosis not reported	Oral health status (Modified Quigley-Hein Plaque Index), oral health knowledge	First arm received oral health education by audio Second arm received oral health education by braille Third arm received oral health education by tooth models Fourth arm received oral health education by audio, braille and tooth	No intervention

					models (multisensory group)	
Hebbal & Ankola (2012, India)[46]	1-Arm BA (18 months, school)	N=110, average age not reported (6-18 years), 32% female, 12.7% drop-out	Visual impairment (69.8% partially, 30.2% totally), diagnosis not reported	Oral health status (plaque index), oral hygiene practice	Series of interactive sessions about the Audio Tactile Performance (ATP) technique (9 months)	No control group
Krishnakumar et al. (2016, India)[62]	2-Arm RCT* (4 months, school)	N=48, average age not reported, (6-18 years), 12.5% female, no drop-out	Visual impairment (fit into categories 3, 4 and 5 of the ICD), diagnosis not reported	Oral health status (plaque index)	Audio-tactile health education with the Audio Tactile Performance (ATP) technique (2 sessions at 2 months intervals)	Audio health education (similar in dose and intensity)
Qureshi et al. (2017, Pakistan)[85]	2-Arm RCT (30 days, school)	N=50, 12.4 years (10-15 years), 32% female, no drop-out	Visual impairment (75% partially, 25% totally), diagnosis not reported	Oral hygiene index	Guided tooth brushing program (2 sessions at 2-weeks intervals)	Verbal oral hygiene message (1 session)
Shetty et al. (2013, India)[96]	2-Arm non-RCT (3 months, school)	N=98, average age not reported (4-16 years), 46% female, no drop-out	Blind, diagnosis not reported	Oral health status (Modified Gingival Index, Modified Quigley-Hein Plaque Index, Streptococcus mutans colony count)	Oral health education program (1 month)	Oral health education program (2 weeks)
Smutkeeree et al. (2011, Thailand)[98]	2-Arm RCT* (6 months, school)	N=60, 11 years (10-12 years), visual impairment, 43.3% female, 5% drop-out	Visual impairment, diagnosis not reported	Oral health status (plaque index of Turesky Modification of Quigley-Hein, gingival index)	Verbal and tactile instructions on horizontal Scrub method of tooth brushing	Verbal and tactile instructions on modified Bass method of tooth brushing
Yalcinkaya & Atalay (2006, Turkey)[126]	1-Arm BA (9 months, school)	N=65, average age not reported (7-17 years), 41.5% female, no drop-out	Visual impairment (43.1% totally, 56.9% partially), diagnosis not reported	Oral health hygiene (plaque index, gingival index), oral health knowledge	Oral health education program (3 sessions at 2-month intervals)	No control group
3. Psychological outcomes						
Dursun et al. (2015, Turkey)[30]	1-Arm BA (3 months, ice-skating center)	N=20, 12.0 years (8-16 years), visual impairment, 40.0 % female, no drop-out	Visual impairment (VA ≤20/200), diagnosis not reported	Sleep quality (PSQI), self-concept (PHCSCS), behavioral and emotional states (SDQ)	Ice-skating program (3 months, 2 times per week for 1 hour)	No control group
Eniola &	2-Arm RCT* (6	N=32, average age	Visual impairment, diagnosis	Motivation to work (WVI)	Group-based motivation	Group-based motivation

Adebiyi (2007, Nigeria)[33]	weeks, training location: Conference Hall of Civil Service Commission)	not reported (age-range not reported), visual impairment, 56% female, no drop-out	not reported		skills intervention based on emotional intelligence (6 weeks, 2 sessions per week)	skills intervention based on goal setting (similar in dose and intensity)
Eniola & Ajobiewe (2013, Nigeria)[32]	3-Arm RCT (8 weeks, classroom)	N=120, average age not reported (12-21 years), 23% female, no drop-out	Visual impairment (75.8% totally, 24.2% partially), diagnosis not reported	Psychological wellbeing (AVRPWB)	First arm received group-based Emotional Intelligence Training (EIT) (8 weeks, 8 sessions of 2 hours) Second arm received group-based Locus of Control Training (LCT) (similar in dose and intensity)	No intervention
Johnson & Johnson (1991, USA)[55]	2-Arm non-RCT (4 weeks, setting not reported)	N=14, average age not reported (12-18 years), 28% female, no drop-out	Visual impairment, diagnosis not reported	Self-concept (TSCS), attitude towards blindness (AB scale), Locus of control (North Carolina Internal-External Scale: Short Form)	Group counseling activities (4 weeks, 12 sessions)	No intervention
Levin & Rotheram-Fuller (2011, USA)[65]	2-Arm non-RCT (4 months, classroom)	N=30, average age not reported (14-21), 43% female, no drop-out	Visual impairment, diagnosis not reported	Self-determination (AIR), self-concept (TSCS:2), self-esteem (subscale BASC-2)	Group-based empowered curriculum (15 weeks, 2 times per week for 45 minutes)	Waiting list
Locke & Gerler (1981, USA)[66]	4-Arm RCT (15 weeks, classroom)	N=42, average age not reported (age-range not reported), gender not reported, no drop-out	Visual impairment, diagnosis not reported	*Of interest:* self-image (Self-Appraisal Inventory-Primary Level). *Other outcomes:* attitude toward school (School Sentiment Index-Primary Level), classroom behavior (PBRS)	First arm received the group-based Human Development Program (HDP) (15 weeks, 3 times per week) Second arm received the group-based Developing Understanding of Self and Others (DUSO)	Third arm received a group-based comparison program in which they played games (similar in dose and intensity) Fourth arm received no intervention

					program (similar in dose and intensity)	
McMahon (2013, USA)[70]	1-Arm BA (1 week, sports education camp)	N=671, average age not reported (9-18 years), gender not reported, no drop-out	Visual impairment, diagnosis not reported	*Of interest:* self-perception (SCEI). *Other outcomes:* sports knowledge, BMI (SCEI)	Sports education camp (1 week)	No control group
Mohamed et al. (2011, Egypt)[73]	1-Arm BA (duration not reported, ophthalmology outpatient clinic and Research Institute of Ophthalmology)	N= 50, 15.9 years, (12-18 years), 40% female, no drop-out	Visual impairment, primary glaucoma (20%), secondary glaucoma (80%)	*Of interest:* anxiety (CMAS), depression (CDI), self-esteem (self-esteem inventory), activities of daily living. *Other outcomes:* knowledge about glaucoma, expectations (modified ECES)	Group-based educational program (15 sessions)	No control group
Shapiro et al. (2005, USA)[95]	1-Arm BA (1 week, summer sports camp)	N=43, 13.0 years (8-21 years), 37.2% female, no drop-out	Visual impairment (32.6% VA 20/200-20/400 or visual field 5-20°, 16.3% VA <20/400 or visual field <5°, 20.9% blind, 30.2% unknown), diagnosis not reported	Perception of competence (SPPC, SPPA)	Summer sports camp (1 week)	No control group
4. Functioning & development						
Al-Dababneh et al. (2015, Jordan)[2]	2-Arm non-RCT (3 months, school)	N=41, average age not reported (9-10 years), 65% female, no drop-out	Visual impairment, diagnosis not reported	Creativity (creativity questionnaire)	Training program aimed at developing creative abilities (3 months, 2 times per week for 45 minutes)	No intervention
Beelmann & Brambring (1998, Germany)[6]	2-Arm non-RCT (24 months on average, home)	N=50, average age not reported (9.5-36 months), 42% female, no drop-out	Congenital blindness, ROP (42%), optic atrophy (18%), other (40%)	Development (BEB-KV)	Home-based early intervention (1 time per 2 weeks)	Usual care
Behl et al. (1993, USA)[7]	2-Arm RCT (3 years, home)	N=35, 13.8 months (2-30 months), 51.3%	Visual impairment (~66.7% VA 20/200-20/800, ~33.3% VA	Child functioning (BDI), family functioning (PSI,	Individualized home-based intervention	Parent group meetings (average of 20.1

		female, 31.4% drop-out	20/900-20/2400), diagnosis not reported	FSS, FRS, FILE, FACES III)	(average of 19.6 months, 1 time per week for 1 hour)	months, 12 times per year)
Çalik et al. (2012, Turkey)[15]	2-Arm non-RCT (6 weeks, probably school)	N=20, 9.85 years (7-12 years), gender not reported, no drop-out	Visual impairment (20% VA 40/200, 25% VA 20/200, 35% VA 10/200, 20% VA 2/200), diagnosis not reported	Cognition (modified child MMSE), activities of daily living (NPI), quality of life (LVQOL)	Educational attention training program (Pay Attention©) (6 weeks, 3 times per week for 30 minutes)	No intervention
Christy (2012, India)[21]	4-Arm RCT* (9 months, rehabilitation center/home)	N=89, 11.7 years (8-15 years), 35% female, 7.9% drop-out	Visual impairment (VA 6/12-light perception, or visual field <20°, 38% VA 6/12-6/18, 36% VA 6/18-6/60, 26% VA <6/60), retinal degeneration (25%), retinal dystrophy (16%), refractive error (12%), whole globe (11%), cornea (7%), albinism (6%), optic nerve disorders (5%), glaucoma (5%), other (11%)	Impact of vision impairment (IVI)	First arm received center-based low vision service delivery (3 consecutive days of initial training for 4-6 hours, and 6-12 days of follow-up training for 2-5 hours at 15 days intervals) Second arm received community-based low vision service delivery (3 consecutive days of initial training for 4-6 hours, and 6-12 days of follow-up training for 2-5 hours at 15 days intervals, and ongoing training and support by the community) Third arm received center-based and community-based low vision service delivery (3 consecutive days of initial training for 4-6 hours, and 6-12 days of follow-up training for 4-6	Fourth arm received center-based low vision service delivery with non-interventional follow-up (3 consecutive days of initial training for 4-6 hours, and 6-12 days of non-interventional follow-up at 15 days intervals)

					hours at 15 days intervals, and ongoing training and support by the community)	
Ganesh et al. (2013, India)[40]	1-Arm BA (2 months, rehabilitation center)	N=35, 10.5 years (6-15 years), 20% female, no drop-out	Visual impairment (inclusion in the category of visually impaired according to the WHO criteria for low vision), retinal dystrophy (37.1%), amblyopia (22.9%), albinism (17.2%), congenital developmental defects (14.2%), congenital idiopathic nystagmus (8.6%)	Functional vision (LVP-FVQ)	Prescription of low vision devices + training in use of low vision devices	No control group
Gothwal et al. (2015, India)[43]	1-Arm BA (3-4 months, rehabilitation center)	N=397, 11.9 years (8-16 years), 43% female, 54% drop-out	Visual impairment (1.6% VA ≥20/40 with visual field restriction, 6% VA 20/40-20/60, 76.5% VA 20/60-20/200, 16% VA <20/200), retinal cause (incl. cone dystrophy, rod monochromatism, retinitis pigmentosa, Stargardt's macular dystrophy, and heredomacular degeneration, 55%), non-retinal cause (incl. Steven-Johnson syndrome, uveal coloboma, optic atrophy, amblyopia associated with congenital cataract surgery, and congenital glaucoma, 45%)	Functional vision (LVP-FVQ II)	Prescription of low vision devices + training in use of low vision devices, orientation and mobility, computer use, and activities of daily living	No control group
Platje et al. (2018, the	2-Arm RCT (~14 months,	N=86, 3.3 years (1-5 years), 42% female,	Visual impairment, diagnosis not reported	Parental sensitivity and quality of parent-child	Attachment-based video-feedback	Care as usual

Netherlands)[83]	rehabilitation center/home)	10.47% drop-out		interaction (NICHHDS), Parenting self-efficacy (self-efficacy subscale NRQ), parenting stress (PSI)	parenting intervention (VIPP-V) (5 sessions of 1.5 hour every 2-3 weeks, and 2 booster sessions of 1.5 hour every 4-5 weeks) in combination with care as usual	
Williams (1985, UK)[122]	1-Arm BA (duration not reported, residential care unit)	N=29, 8.3 years (2.7-13.11 years), gender not reported, 48.3% drop-out	Visual impairment, diagnosis not reported	Development (subscales Reynell-Zinkin Scales)	Admission to the care unit	No control group
5. Reading performance						
Corn et al. (2002, USA)[26]	1-Arm BA (~6 months, school)	N=185, 10.5 years (age-range not reported), 34% female, no drop-out	Visual impairment (15.2% VA 20/32-30/63, 37.5% VA 20/80-20/180, 39.1% VA 20/200-20/400, 8.2% 20/500-20/1000), albinism (21.2%), macular impairment (18.4%), ROP 10.3%), coloboma (7.6%), nystagmus (7.6%), other (35.1%)	Reading speed and comprehension rates (Informal Reading Inventory)	Prescription of optical devices and training in their use	No control group
Farmer & Morse (2007, USA)[35]	2-Arm non-RCT (~8 months, classroom)	N=16, average age not reported (age-range not reported), gender not reported, no drop out	Visual impairment (VA ≤20/70), diagnosis not reported	Reading skills (BRI)	Individualized Education Program and classroom assistance in magnifier use + six additional sessions in magnifier training	Individualized Education Program and classroom assistance in large print use
Heber et al. (1967, USA)[47]	2-Arm RCT (2 years, school)	N=54, average age not reported (age-range not reported), gender not reported, no drop-out	Visual impairment (VA ≤20/200), diagnosis not reported	Braille reading (Traditional Braille Reading Tasks, Braille Configuration Recognition Task, Ammons Wide Range Vocabulary Test)	Braille Tape Reader training (2 years, 3 times per week for 50 minutes; 14 weeks during the first year (n=30 in total), 27 weeks during the second	Traditional braille materials (similar in dose and intensity)

					year (n=54 in total))	
Howell (1977, UK)[50]	3-Arm RCT (5 weeks, school)	N=24, average age not reported (10-21 years), 50% female, no drop-out	Legal blindness, diagnosis not reported	*Of interest: b*raille reading rate and comprehension (DRT). *Other outcomes:* brain wave patterns (EEG)	First arm received rapid reading training in braille using the freehand method (5 weeks, 5 times per week) Second arm received rapid reading training in braille using the pacing method (similar in dose and intensity)	No intervention
Huurneman et al. (2016, The Netherlands)[51]	2-Arm non-RCT (5-9 weeks, setting not reported)	N=35, 9.3 years (age-range not reported), gender not reported, no drop-out	Visual impairment (VA 20/31-20/400), infantile nystagmus (48.6% albinism and infantile nystagmus, 51.4% idiopathic infantile nystagmus)	*Of interest:* maximum reading speed, critical print size, reading acuity, acuity reserve. *Other outcomes:* crowded distance visual acuity, distance crowding extent, reading acuity	Crowded training (5 weeks, 2 times per week)	Uncrowded training (similar in dose and intensity)
Kederis et al. (1964, USA)[57]	2-Arm RCT (~3 months, school)	N=30, average age not reported (age-range not reported), 70% female, no drop-out	Visual impairment, diagnosis not reported	Braille reading (Gates Basic Reading Test)	Group-based practice under conditions of successively reduced exposed times (22 sessions, 5 times per week)	No intervention
Kederis et al. (1964, USA)[58]	2-Arm RCT (2.5 months, school)	N=32, average age not reported (age-range not reported), 50% female, 6.3% drop-out	Visual impairment, diagnosis not reported	Braille reading (Gates Basic Reading Test)	Pacing training (20 sessions, 5 times per week for 1.5 hour)	No intervention
Uysal & Düger (2012, Turkey)[113]	1-Arm BA (3 months, school)	N=35, 10.9 years (age-range not reported), 51.4% female, no drop-out	Visual impairment (satisfying criteria for low vision according to ICD-10-CM, 34.3% VA 20/80-20/150, 65.7% VA 20/200-20/400), diagnosis not reported	*Of interest:* writing speed (Jebsen-Taylor Hand function Test), legibility of writing, reading speed. *Other outcomes:* preferred font size and type	Writing and reading training with optical adaptations (3 months, 2 times per week for 45 minutes)	No control group

6. Social skills						
Bieber-Schut (1991, Canada)[8]	1-Arm BA (4 days, rehabilitation center)	N=12, average age not reported (13-18 years), 50% female, 25% drop-out	Visual impairment (8.3% VA 20/100, 33.3 % VA <20/200-light perception, 58.3% blind), no diagnosis reported	Social skills (SSI)	Developmental drama workshop (4 days)	No control group
Grumpelt & Rubin (1972, USA)[44]	2-Arm non-RCT (duration not reported, school)	N=66, average age not reported (15-19 years), gender not reported, no drop-out	Blindness, diagnosis not reported	Speed listening skills	Speed listening training at 275-300 words per minute	Speed listening training at the standard 175 words per minute
Kim (2003, USA)[61]	2-Arm RCT (12 weeks, school)	N=26, 16.1 years (13-19 years), 46.2% female, 11.5% drop-out	Visual impairment (7.7% VA >20/200 with visual field restriction, 30.8% VA 20/200, 19.2% VA 20/400, 3.8% 20/600, 3.8% count fingers, 15.4% light perception, 19.2% no light perception), ROP (19.2%), optic nerve hypoplasia (19.2%), aniridia (11.5%), retinal detachment (7.7%), myopia (7.7%), optic atrophy (7.7%), other (26.9%)	Social skills (SSRS), assertiveness (MRAS), self-criticism and helplessness (subscales MCDS), assertive behavior (RPT)	Group-based assertiveness training (12 weeks, 1 session per week)	No intervention
McConnell (1994, USA)[72]	2-Arm RCT (5 weeks, home)	N=20, 16.7 years (15-18 years), 50% female, no drop-out	Visual impairment, optic atrophy (15%). Stargardt's maculopathy 10%), nystagmus (10%), other (65%)	*Of interest:* adolescent-parent communication (PAC). *Other outcomes*: career certainty and indecision (CDS), importance of work (CSS)	The Partner's Program (5 weeks)	No intervention
Sacks & Gaylord-Ross (1989, USA)[93]	3-Arm RCT (4 weeks, school)	N=15, 9.7 years (7-12 years), 40% female, no drop-out	Legal blindness (20% VA 20/200, 33.3% VA 20/400, 13.3% VA 20/800, 6.7% light perception, 26.7% no light perception), optic nerve (40%), ROP (13.3%), glaucoma (13.3%), albinism (13.3%),	Social skills (behavioral measures), social competence (PCSC), social validation (Peer questionnaire, Teacher Observation Checklist)	First arm received peer-mediated social skills training (4 weeks, 3 times per week for 40 minutes) Second arm received teacher-directed social	Third arm received no intervention

			other (20%)		skills training (similar in dose and intensity)	
Uysal & Düger (2012, Turkey)[114]	2-Arm RCT (3 months, school)	N=40, 10.9 years (age-range not reported), 42.5% female, no drop-out	Visual impairment (fitting into the low vision category according to the ICD-10-CM), diagnosis not reported	*Of interest:* social skills (SSAT-VI), activity performance (COPM). *Other outcomes:* visual perception (MVPT)	Visual perception training with computer (3 months, 2 days per week for 45 minutes)	Visual perception training with paper and pen (similar in dose and intensity)
Yildiz & Duy (2013, Turkey)[127]	2-Arm RCT (4 months, probably school)	N=16, 13.5 years (age-range not reported), 37% female, no drop-out	Visual impairment, diagnosis not reported	Empathic skills (Child and Adolescent KA-SI Empathic Tendency Scale), communication skills (Communication Skills Scale)	Group-based psycho-education program (9 sessions)	No intervention
7. Viewing behavior						
Boonstra et al. (2012, The Netherlands)[13]	2-Arm RCT* (6 weeks, probably rehabilitation center)	N=21, 4.7 years (3-6.5 years), 33% female, no drop-out	Visual impairment (VA ≤20/50, 26.3% VA ≤20/200, 26.3% VA 20/200-20/100, 47.4% VA 20/100-20/50), albinism (38.1%), nystagmus (19.0%), cong. cataract (9.5%), retinoschizis (9.5%), other (23.8%)	Viewing behavior (duration of observation, viewing distance)	Training with a magnifier (6 weeks, 2 times per week or 30 minutes)	Training without a magnifier (similar in dose and intensity)
Cox et al. (2009, The Netherlands)[27]	2-Arm non-RCT* (8 weeks, home or school)	N=42, 4.7 years (age-range not reported), 36.4% female, 21.4% drop-out	Visual impairment (VA ≤20/50, 33.3% VA ≤20/200, 48.5% VA 20/200-20/100, 18.2% VA 20/100-20/50), albinism (36.4%), cataract (15.2%), nystagmus (12.1%), retinoschizis (9.1%), aniridia (6.1%), other (21.2%)	Task performance (number of trails followed, number of trails followed correctly)	Training with magnifier use (6 weeks, 12 30-minute sessions)	Training without magnifier (similar in dose and intensity)
Nyquist et al. (2016, USA)[78]	3-Arm RCT (~2.5 weeks, probably school)	N=24, 14.2 years (9-18 years), gender not reported, no drop-out	Visual impairment (VA 20/60-20/800 and visual field ≥35°, 12.5% VA 20/800, 20.8% VA 20/400, 4.2% VA 20/300, 58.3% VA 20/200, 4.2% VA 20/60), albinism (33.3%),	Visual functioning (foveal motion perception, single target motion discrimination, multi-target direction comparisons, visual	First arm received an action video game (AVG) (10 sessions of 40-50 minutes, 3-5 times per week) Second arm received	A control video game similar to Tetris (similar in dose and intensity)

			stargardt's macular dystrophy (16.7%), ROP (12.5%), cong. cataract (8.3%), other (29.2%)	crowding, and visual search)	modified attentional tracking (MAT) (similar in dose and intensity)	
Ritchie et al. (1989, India)[90]	1-Arm BA (6 weeks, rehabilitation center)	N=48, average age not reported (1.5-6 year), gender not reported, 37.5% drop-out	Severe visual impairment (50% partially sighted, 50% blind), cong. cataract (16.7%), albinism (13.3%), Leber's amaurosis (13.3%), other (56.7%)	Visual functioning (responding correctly to questions about a set of visual material)	Training in use of a visual aid (6 weeks)	No control group
8. Mobility skills						
Ungar et al. (1997, UK)[111]	1-Arm BA (3 weeks, setting not reported)	N=26, 8.5 years (5-11.9 years), visual impairment, gender not reported, no drop-out	Visual impairment (38.5% congenitally blind, 61.5% residual vision), diagnosis not reported	Performance in estimating distances	Training in the use of an effective strategy to work out distances from a map (30 minutes)	No control group
Wood (1978, USA)[124]	3-Arm RCT (16 weeks, classroom)	N=42, 10.6 years (5.1-9.7 years), gender not reported, 14.3% drop-out	Severe visual impairment (light perception or less), diagnosis not reported	Motor, sensory, concept and mobility skills (PMS)	First arm received programmed orientation and mobility instruction materials (16 weeks, 5 times per week for 40 minutes per day)	Second arm was a distal control group that received a regular educational program Third arm was an onsite control group that received a regular educational program

* No intervention or control group were reported in the article, and no hypotheses on which of the groups would be superior were made

AB Scale: Attitudes Toward Blindness Scale; AIR: AIR Self-Determination Scale; AVRPWB: Adapted Version of Ryff Scale of Psychological Well-being; BASC: Behavior Assessment System for Children; BDI: Battelle Developmental Inventory; BEB-KV: Bielefeld Developmental Test for Blind Infants and Preschoolers; BMI: Body Mass Index; BOT: Bruininks-Oseretsky Test of Motor Proficiency Short Form; BRI: Basic Reading Inventory; CDI: Children Depression Inventory; CDS: Career Decision Scale; CMAS: Children Manifest Anxiety Scale; CMI: Cornell Medical Index; COPM: Canadian Occupational Performance Measure; DRT: Diagnostic Reading Test; CSS: Career Salience Scale; ECES: Eye Care Expectations Survey; EEG: electroencephalograph; FACES: Family Adaptability and Cohesion Evaluation Scales; FILE: Family Inventory of Life Events and Changes; FSS: Family Support Scale; FRS: Family Resource Scale; FTT: Finger Tapping Test; LVP-FVQ: LV Prasad-Functional Vision Questionnaire; LVQOL: Low Vision Quality of Life questionnaire; MABC: Movement Assessment Battery for Children; ManuVis: manual skills test for children (6-12 years) with visual impairment; MCDS: Modified Cognitive Distortion Scales; MMSE: Mini-Mental State Examination; Movement ABC: movement assessment for children; MRAS: Modified Rathus Assertiveness Schedule; MVPT: Motor Free Visual Perception Test; NICHHDS: National Institute of Child Health and Human Development Scales; NPI: Northwick Park Index of Independence; NRQ: Nurturing Role Questionnaire; PAC: Parent-Adolescent Communication Scale; PACER: Progressive Aerobic Cardiovascular Endurance Run; PBRS: Pupil Behavior Rating Scale; PCSC: Perceived Competence Scale for Children; PHCSCS: Piers-Harris Children's Self-Concept Scale; PMS: Peabody Mobility Scale; PSI: Parenting

Stress Inventory; PSQI: Pittsburgh Sleep Quality Index; RCT: Randomized Controlled Trial; RPT: Role Play Test; SCEI: sports camp evaluation instrument; SDQ: Strengths and Difficulties Questionnaire; SPPA: Self-Perception Profile for Adolescents; SPPC: Self-Perception Profile for Children; SSAT-VI: Social Skills Assessment Tool for Children with Visual Impairments; SSI: Social Skills Inventory; SSRS: Social Skills Rating System; TSCS: Tennessee Self-Concept Scale; WVI: Work Value Inventory

Table 2. Risk of bias overview for RCTs based on the Cochrane Collaboration Risk of Bias Tool (CCRBT)

	Random sequence generation: selection bias	Allocation concealment: selection bias	Blinding of participants and personnel: performance bias	Blinding of outcome assessment: detection bias	Incomplete outcome data: attrition bias	Selective reporting: reporting bias	Other sources of bias
Arunakul et al. (2015, Thailand)[3]	?	?	-	?	+	?	+
Behl et al. (1993, USA)[7]	+	?	-	+	+	?	+
Boonstra et al. (2012, The Netherlands)[13]	?	?	-	+	?	?	?
Caliskan et al. (2011, Turkey)[16]	?	?	-	?	+	?	+
Chen & Lin (2011, Taiwan)[19]	?	?	-	?	+	?	?
Christy (2012, India)[21]	+	+	-	?	+	+	?
Eniola & Adebiyi (2007, Nigeria)[33]	?	?	-	?	+	?	?
Eniola & Ajobiewe (2013, Nigeria)[32]	?	?	-	?	+	?	?
Ganapathi et al. (2015, India)[39]	?	?	-	+	+	-	?
Heber et al. (1967, USA)[47]	?	?	-	+	+	?	?
Howell (1977, UK)[50]	+	?	-	?	+	?	?
Jazi et al. (2012, Iran)[54]	?	?	-	?	+	?	?
Joseph (1984, USA)[56]	?	?	-	?	+	?	?
Kederis et al. (1964, USA)[57]	?	?	-	?	+	?	?
Kederis et al. (1964, USA)[58]	?	?	-	?	+	?	?
Kim (2003, USA)[61]	+	?	-	+	+	?	+
Krishnakumar et al. (2016, India)[62]	?	?	-	?	+	?	?
Locke & Gerler (1981, USA)[66]	?	?	-	?	+	?	?
Mavrovouniotis et al. (2013, Greece)[69]	?	?	-	?	+	?	+
McConnell (1994, USA)[72]	+	?	-	?	+	?	?
Nyquist et al. (2016, USA)[78]	+	?	-	+	+	?	+
Platje et al. (2018, the Netherlands)[83]	+	?	-	+	+	+	+
Qureshi et al. (2017, Pakistan)[85]	+	+	-	+	+	?	+

Smutkeeree et al. (2011, Thailand)[98]	+	?	-	?	+	?	?
Sacks & Gaylord-Ross (1989, USA)[93]	?	?	-	-	+	?	?
Uysal & Düger (2012, Turkey)[114]	+	?	-	?	+	?	?
Wood (1978, USA)[124]	?	?	-	?	+	?	?
Yildiz & Duy (2013, Turkey)[127]	?	?	-	?	+	?	?

?: unclear risk of bias; -: high risk of bias; +: low risk of bias

Table 3. Risk of bias overview for non-RCTs and BAs based on the Risk Of Bias In Non-randomized Studies - of Interventions Tool (ROBINS-I)

	Bias due to confounding	**Bias in selection of participants**	**Bias in classification of interventions**	**Bias due to deviations from intended interventions**	**Bias due to missing data**	**Bias in measurement of outcomes**	**Bias in selection of reported results**	**Overall risk of bias**
Aki et al. (2007, Turkey)[1]	++	++++	++++	++++	++++	?	+++	++
Al-Dababneh et al. (2015, Jordan)[2]	++	++++	++++	++++	++++	++	+++	++
Beelmann & Brambring (1998, Germany)[6]	+++	+++	++++	++++	++++	++	+++	++
Bieber-Schut (1991, Canada)[8]	++	++++	N/A	++++	?	++	+++	++
Black (1983, USA)[11]	++	++++	++++	++++	++++	++	+++	++
Blessing et al. (1993, USA)[12]	++	++++	N/A	++++	++++	+++	+++	++
Çalik et al. (2012, Turkey)[15]	++	+++	++++	++++	++++	++	+++	++
Chowdary et al. (2016, India)[20]	++	++++	++++	++++	++++	+++	+++	++
Corn et al. (2002, USA)[26]	++	++++	N/A	++++	++++	+++	+++	++
Cox et al. (2009, The Netherlands)[27]	++	+++	++++	++++	?	++++	+++	++
Debnath et al. (2017, India)[28]	++	++++	N/A	++++	++++	+++	+++	++
Dursun et al. (2015, Turkey)[30]	++	++++	N/A	++++	++++	++	+++	++
Farmer & Morse (2007, USA)[35]	++	++++	++++	++++	++++	+++	+++	++
Ganesh et al. (2013, India)[40]	++	+++	N/A	++++	++++	++	+++	++
Gothwal et al. (2015, India)[43]	++	+++	N/A	++++	++++	++	++	++
Grumpelt & Rubin (1968, USA)[44]	+++	++++	++++	++++	++++	+++	+++	+++
Hebbal & Ankola (2012,	++	++++	N/A	++++	++++	+++	+++	++

India)[46]								
Huurneman et al. (2016, The Netherlands)[51]	++	++++	++++	++++	++++	+++	+++	++
Johnson & Johnson (1991, USA)[55]	+++	++++	++++	++++	++++	++	+++	++
Levin & Rotheram-Fuller (2011, USA)[65]	++	++++	++++	++++	++++	++	+++	++
McMahon (2013, USA)[70]	++	++++	N/A	++++	++++	++	+++	++
McMahon (2013, USA)[71]	++	++++	N/A	++++	++++	+++	+++	++
Mohamed et al. (2011, Egypt)[73]	++	++++	N/A	++++	++++	++	+++	++
Mohanty et al.(2015, India)[74]	++	++++	++++	++++	++++	++++	+++	++
Mohanty et al. (2016, India)[75]	+++	++++	++++	++++	++++	++++	+++	+++
Pineio et al. (2017, Greece)[82]	+++	++++	++++	++++	++++	+++	+++	+++
Ponchillia et al. (2005, USA)[84]	++	++++	N/A	++++	++++	++	+++	++
Reimer et al. (2011, The Netherlands)[89]	++	++++	++++	++++	++++	+++	+++	++
Ritchie et al. (1989, India)[90]	++	++++	N/A	++++	?	+++	+++	++
Robinson & Lieberman (2008, USA)[91]	++	+++	N/A	++++	++++	++	+++	++
Shapiro et al. (2005, USA)[95]	++	++++	N/A	++++	++++	++	+++	++
Shetty et al. (2013, India)[96]	++	++++	++++	++++	++++	++	+++	++
Shindo et al. (1987, Japan)[97]	++	++++	N/A	++++	++++	+++	+++	++
Taskin (2016, Turkey)[105]	++	++++	++++	++++	++++	+++	+++	++
Ungar et al. (1997, UK)[111]	++	++++	N/A	++++	++++	+++	+++	++
Uysal & Düger (2012, Turkey)[113]	++	++++	N/A	++++	++++	+++	+++	++
Williams (1985, UK)[122]	++	++++	N/A	++++	?	++	+++	++

Yalcinkaya & Atalay (2006, Turkey)[126]	++	++++	N/A	++++	++++	+++	+++	++

?: unclear risk of bias; +: critical risk of bias; ++: serious risk of bias; +++: moderate risk of bias; ++++: low risk of bi

Table 4. Characteristics of reviewed studies, divided into study focus: 1) physical performance, 2) oral health, 3) psychological outcomes, 4) reading performance, 5) functioning & development, 6) social skills, 7) viewing behavior, and 8) mobility skills

Author (year, country)	Outcome per intervention group baseline versus follow-up	Results and effect size baseline versus follow-up	Outcome per intervention group versus comparator	Results and effect size per intervention group versus comparator
1. Physical performance				
Aki et al. (2007, Turkey, 2-arm non-RCT)[1]	Pre-test vs. post-test for a) intervention group motor skills b) control group motor skills	a) significant improvement (ES: -1.501) b) significant improvement (ES: -0.408)	Intervention vs. control group at a) post-test motor skills b) gain motor skills	a) significant differences on various subtests in favor of intervention group b) intervention group gained more (ES: 1.083)
Black (1978, USA, 2-arm non-RCT)[11]	Pre-test vs. post-test for a) intervention group dynamic balance b) intervention group spatial veering c) control group dynamic balance d) control group spatial veering	a) significant improvement b) significant improvement c) no significant results d) no significant results	Intervention vs. control group at a) pre-test dynamic balance b) pre-test spatial veering c) post-test dynamic balance d) post-test spatial veering e) gain spatial veering	a) no significant difference b) no significant difference c) significant difference in favor of intervention group d) significant difference in favor of intervention group e) intervention group gained significantly more
Blessing et al. (1993, USA, 1-arm BA)[12]	Pre-test vs. post-test for a) weight b) skinfold thickness c) cardiovascular variables	a) significant increase (ES: -0.116) b) significant improvement (ES: 0.134) c) significant improvements (ES: 0.339; 0.787)	N/A	N/A
Caliskan et al. (2011, Turkey, 2-arm RCT)[16]	Pre-test vs. post-test for a) intervention group BMI b) intervention group percent body fat c) control group BMI d) control group percent body fat	a) significant decrease (ES: 0.111) b) significant decrease (ES: 0.480) c) non-significant increase (ES: -0.169) d) non-significant decrease (ES: 0.272)	Intervention vs. control group at a) gain BMI b) gain percent body fat	a) intervention group decreased more (ES: -0.282) b) intervention group decreased more (ES: -0.088)
Chen & Lin (2011, Taiwan, 2-arm RCT)[19]	Pre-test vs. post-test for a) intervention group BMI b) intervention group sit-and-reach c) intervention group sit-up d) intervention group PACER e) control group BMI	a) non-significant decrease (ES: 0.070) b) significant improvement (ES: -0.751) c) non-significant improvement (ES: -0.015)	Intervention vs. control group at a) gain BMI b) gain sit-and-reach c) gain sit-up d) gain PACER	a) intervention group decreased more (not significant) (ES: -0.051) b) intervention group gained significantly more (ES: 0.583) c) intervention group gained more (not significant) (ES: 0.031)

	f) control group sit-and-reach g) control group sit-up h) control group PACER	d) significant improvement (ES: -0.649) e) non-significant decrease (ES: 0.010) f) non-significant deterioration (ES: 0.007) g) non-significant deterioration (ES: 0.015) h) non-significant improvement (ES: -0.102)		d) intervention group gained significantly more (ES: 0.433)
Jazi et al. (2012, Iran, 2-arm RCT)[54]	Pre-test vs. post-test for a) intervention group dynamic balance b) control group dynamic balance	a) significant improvement b) non-significant deterioration	Intervention vs. control group at a) pre-test dynamic balance b) post-test dynamic balance c) gain dynamic balance	a) no significant difference b) significant difference in favor of intervention group c) intervention group gained more
Joseph (1984, USA, 3-arm RCT)[56]	Pre-test vs. post-tests for a) intervention group motor skills b) knowledge of results control group motor skills c) knowledge of performance motor skills	a) significant gradual improvement (ES: -0.701; -0.299), deterioration at post-test 3 (ES: 0.676) b) significant gradual improvement (ES: -0.725; -0.405), deterioration at post-test 3 (ES: 0.729) c) significant gradual improvement (ES: -0.349; -0.219), deterioration at post-test 3 (ES: 0.855)	Intervention vs. control groups at a) gain intervention vs. knowledge of results motor skills b) gain intervention vs. knowledge of performance motor skills c) gain knowledge of performance vs. knowledge of results motor skills	a) similar gain at post-test 2, similar deterioration at post-test 3 (ES: 0.000; 0.093) b) intervention group gained more and deteriorated less (ES: -0.401; -0.094) c) knowledge of results gained more and deteriorated less (ES: -0.408; -0.100)
Mavrovouniotis et al. (2013, Greece, 2-arm RCT)[69]	Pre-test vs. post-test for a) intervention group MABC-2 b) intervention group BOT-2 c) control group MABC-2 d) control group BOT-2	a) significant improvements (ES: -0.953; -3.278) b) significant improvements (ES: -0.982; -1.291) c) non-significant improvements/deteriorations (ES: -0.240; 0.693) d) non-significant improvements (ES: -0.353; 0)	Intervention vs. control group at a) pre-test MABC-2 b) pre-test BOT-2 c) post-test MABC-2 d) post-test BOT-2 e) gain MABC-2 f) gain BOT-2	a) no significant differences b) no significant differences c) significant differences in favor of intervention group d) significant differences in favor of intervention group e) intervention group gained more (ES: 1.337; 2.306) f) intervention group gained more (ES: 0.939; 1.398)
McMahon (2013, USA, 1-arm BA)[71]	Pre-test vs. post-test for a) standing long jump b) overarm throw	a) significant improvement (ES: -0.213) b) significant improvement	N/A	N/A

	c) underarm throw d) throwing speed	(ES: -0.075) c) significant improvement (ES: -0.243) d) non-significant deterioration (ES: 0.156)		
Mohanty et al. (2015, India, 2-arm non-RCT)[74]	Pre-test vs. post-test for intervention group muscle fitness	Significant improvement	Intervention vs. control group at a) pre-test muscle fitness b) post-test muscle fitness	a) no significant difference b) significant difference in favor of intervention group
Mohanty et al. (2016, India, 2-arm non-RCT)[75]	Pre-test vs. post-test for a) intervention group motor speed b) control group motor speed	a) significant improvement (ES: -0.578; -0.678) b) non-significant improvement (ES: -0.057; -0.100)	Intervention vs. control group at a) gain motor speed	a) intervention group gained significantly more (ES: 0.461; 0.634)
Pineio et al. (2017, Greece, 2-arm non-RCT)[82]	Pre-test vs. post-test for a) intervention group motor development b) control group motor development	a) significant improvement (ES: -4.788) b) no difference (ES: -0.016)	Intervention vs. control group at gain motor development	Intervention group gained more (ES: 1.363)
Ponchillia et al. (2005, USA, 1-arm BA)[84]	Pre-test vs. post-test sport skills	Participants significantly increased performance in sport skills	N/A	N/A
Reimer et al. (2011, The Netherlands, 2-arm non-RCT)[89]	Pre-test vs. post-test for a) intervention group ManuVis b) intervention group Movement ABC c) control group ManuVis d) control group Movement ABC	a) improvement (ES: 0.836) b) improvement (ES: 0.626) c) improvement (ES: 0.733) d) improvement (ES: 1.351)	Intervention vs. control group at a) pre-test ManuVis b) post-test ManuVis c) post-test Movement ABC d) gain ManuVis e) gain Movement ABC	a) no significant differences b) significant differences in favor of intervention group c) no significant differences d) control group gained more (ES: -0.414) e) control group gained more (ES: -0.991)
Robinson & Lieberman (2007, USA, 1-arm BA)[91]	Pre-test vs. post-test physical activity time	Boys significantly increased their physical activity time, but girls did not; physical activity time for the total group decreased	N/A	N/A
Shindo et al. (1987, Japan, 1-	Pre-test vs. post-test for a) CMI	a) improvement b) significant improvement in 7/22	N/A	N/A

arm BA)[97]	b) physical fitness tests	variables (ES maximal oxygen uptake: -0.896; 0.957; ES maximal heart rate: -0.348; ES maximal ventilation: -0.533)		
Taskin (2016, Turkey, 2-arm non-RCT)[105]	Pre-test vs. post-test for a) intervention group auditory reaction time b) intervention group maximal oxygen uptake c) control group auditory reaction time d) control group maximal oxygen uptake	a) significant improvement (ES: 0.888) b) significant improvement (ES: -2.404) c) no difference (ES: 0.000) d) no difference (ES: 0.000)	Intervention vs. control group at a) gain auditory reaction time b) gain maximal oxygen uptake	a) intervention group gained more (ES: 0.848) b) intervention group gained more (ES: 2.720)
2. Oral health				
Arunakul et al. (2015, Thailand, 3-arm RCT)[3]	Pre-test vs. post-test for a) mouth rinse+OHE intervention group plaque index b) mouth rinse+OHE intervention group gingival index c) mouth rinse+OHE intervention group Streptococcus mutans level d) OHE intervention group plaque index e) OHE intervention group gingival index f) OHE intervention group Streptococcus mutans level g) control group plaque index h) control group gingival index i) control group Streptococcus mutans level	a) significant improvement (ES: 7.048) b) significant improvement (ES: 3.959) c) significant improvement (ES: 0.868) d) significant improvement (ES: 7.048) e) significant improvement (ES: 4.025) f) significant improvement (ES: 0.662) g) significant improvement (ES: 1.643) h) significant improvement (ES: 2.190) i) non-significant improvement (ES: 0.563)	Intervention vs. control groups at a) gain mouth rinse+OHE vs. OHE plaque index b) gain mouth rinse+OHE vs. OHE gingival index c) gain mouth rinse+OHE vs. OHE Streptococcus mutans level d) OHE vs. control plaque index e) OHE vs. control gingival index f) OHE vs. control Streptococcus mutans level g) gain mouth rinse+OHE vs. control plaque index h) gain mouth rinse+OHE vs. control gingival index i) gain mouth rinse+OHE vs. control Streptococcus mutans level	a) mouth rinse+OHE gained significantly more (ES: 0.000) b) no significant difference (ES: 0.073) c) mouth rinse+OHE gained more (ES: 0.117) d) OHE gained significantly more (ES: 0.515) e) OHE gained significantly more (ES: 1.379) f) OHE gained more (ES: 0.383) g) mouth rinse+OHE gained significantly more (ES: 0.515) h) mouth rinse+OHE gained significantly more (ES: 0.426) i) mouth rinse+OHE gained more (ES: 0.519)
Chowdary et al. (2016, India, 3-arm non-RCT)[20]	Pre-test vs. post-tests for a) intervention group plaque index b) intervention group gingival index c) verbal+tactile control group	a) gradual significant improvement (ES: 2.562; 4.271) b) gradual significant improvement (ES: 2.121; 3.729)	Intervention vs. control groups at a) gain intervention vs. verbal+tactile plaque index b) gain intervention vs.	a) intervention group gained gradually significantly more (ES: -0.872; -1.288) b) intervention group gained

	plaque index d) verbal+tactile control group gingival index e) verbal+braille control group plaque index f) verbal+braille control group gingival index	c) gradual significant improvement (ES: 1.027; 1.967) d) gradual significant improvement (ES: 1.001; 1.729) e) gradual significant improvement (ES: 1.754; 3.258) f) gradual significant improvement (ES: 0.923; 3.432)	verbal+tactile gingival index c) gain intervention vs. verbal+braille plaque index d) gain intervention vs. verbal+braille gingival index e) gain verbal+tactile vs. verbal+braille plaque index f) gain verbal+tactile vs. verbal+braille gingival index	significantly more at three months follow-up (other time-points not significant) (ES: -0.371; -0.664) c) intervention group gained significantly more (max. at 3 months) (ES: -0.795; -1.784) d) intervention group gained more at 1 month follow-up, control group gained more at 3 and 6 months follow-up (not significant) (ES: -0.405; 0.608) e) verbal+braille gained more at 1 and 6 months follow-up, verbal+tactile gained more at 3 months follow-up (not significant) (ES: -0.459; 0.250) f) verbal+tactile gained more at 1 month follow-up (not significant), verbal+braille gained significantly more at 3 and 6 months follow-up (ES: -1.038; 0.038)
Debnath et al. (2017, India, 1-arm BA)[28]	Pre-test vs. post-test for a) knowledge, attitude and practices regarding oral health b) plaque index	a) significant improvement b) significant improvement	N/A	N/A
Ganapathi et al. (2015, India, 5-arm RCT)[39]	Pre-test vs. post-test for a) audio intervention group oral health knowledge b) audio intervention group oral health status c) braille intervention group oral health knowledge d) braille intervention group oral health status e) tooth models intervention group oral health knowledge	a) significant improvement (ES: -3.881) b) significant improvement (ES: 1.223) c) significant improvement (ES: -2.163) d) significant improvement (ES: 0.563) e) significant improvement (ES: -4.076) f) significant improvement	Intervention vs. control groups at a) gain audio vs. braille oral health knowledge b) gain audio vs. braille oral health status c) gain audio vs. tooth models oral health knowledge d) gain audio vs. tooth models oral health status e) gain audio vs. multisensory oral health knowledge	a) audio gained significantly more (ES: -2.080) b) audio gained significantly more (ES: 0.589) c) tooth models gained more (not significant) (ES: 0.119) d) audio gained more (not significant) (ES: 0.196) e) multisensory gained significantly more (ES: 0.795) f) audio gained more (not

	f) tooth models intervention group oral health status g) multisensory intervention group oral health knowledge h) multisensory intervention group oral health status	(ES: 1.098) g) significant improvement (ES: -5.456) h) significant improvement (ES: 1.329)	f) gain audio vs. multisensory oral health status g) gain braille vs. tooth models oral health knowledge h) gain braille vs. tooth models oral health status i) gain braille vs. multisensory oral health knowledge j) gain braille vs. multisensory oral health status k) gain tooth models vs. multisensory oral health knowledge l) gain tooth models vs. multisensory oral health status	significant) (ES: 0.116) g) tooth models gained significantly more (ES: 2.008) h) tooth models gained significantly more (ES: -0.430) i) multisensory gained significantly more (ES: 2.710) j) multisensory gained significantly more (ES: -0.536) k) multisensory gained significantly more (ES: 0.622) l) multisensory gained more (not significant) (ES: -0.092)
Hebbal & Ankola (2012, India, 1-arm BA)[46]	Pre-test vs. post-test for a) oral health status b) oral hygiene practice	a) significant improvement (ES: 1.578) b) non-significant improvement	N/A	N/A
Krishnakumar et al. (2016, India, 2-arm RCT)[62]	Pre-test vs. post-test for a) intervention group plaque index b) control group plaque index	a) significant improvement (ES: 1.054) b) no difference (ES: 0.051)	Intervention vs. control group at a) gain plaque index	a) intervention group gained more (ES: 1.227)
Qureshi et al. (2017, Pakistan, 2-arm RCT)[85]	Pre-test vs. post-test for a) intervention group oral hygiene index b) control group oral hygiene index	a) significant improvement (ES: 1.432) b) non-significant improvement (ES: 0.318)	Intervention vs. control group at a) pre-test oral hygiene index b) post-test oral hygiene index c) gain oral hygiene index	a) no significant difference b) no significant difference c) intervention group gained more (ES: 0.566)
Shetty et al. (2013, India, 2-arm non-RCT)[96]	Pre-test vs. post-tests for a) intervention group plaque index b) intervention group gingival index c) intervention group Streptococcus mutans count d) control group plaque index e) control group gingival index f) control group Streptococcus mutans count	a) gradual significant improvement (ES: 1.061; 1.846) b) gradual significant improvement (ES: 1.346; 1.962) c) gradual significant improvement d) gradual significant improvement (ES: 0.413; 0.873) e) gradual significant improvement (ES: 0.709; 1.131) f) significant improvement at 3	Intervention vs. control group at a) gain post-test 1 plaque index b) gain post-test 1 gingival index c) gain post-test 2 plaque index d) gain post-test 2 gingival index	a) intervention group gained significantly more (ES: -1.237) b) intervention group gained significantly more (ES: -1.052) c) intervention group gained significantly more (ES: -1.188) d) intervention group gained significantly more (ES: -1.027)

		months follow-up		
Smutkeeree et al. (2011, Thailand, 2-arm RCT)[98]	Pre-test vs. post-test 1 for a) intervention group plaque index b) intervention group gingival index c) control group plaque index d) control group gingival index Pre-test vs. post-test 2 for e) intervention group plaque index f) intervention group gingival index g) control group plaque index h) control group gingival index	a) significant improvement (ES: 0.972) b) significant improvement (ES: 1.412) c) significant improvement (ES: 1.485) d) significant improvement (ES: 1.153) e) significant improvement (ES: 1.083) f) significant improvement (ES: 0.882) g) significant improvement (ES: 0.971)	Intervention vs. control group at a) pre-test plaque index b) pre-test gingival index c) post-test 1 plaque index d) post-test 1 gingival index e) post-test 2 plaque index f) post-test 2 gingival index g) gain post-test 1 plaque index h) gain post-test 1 gingival index i) gain post-test 2 plaque index j) gain post-test 2 gingival index	a) no significant difference b) no significant difference c) no significant difference d) no significant difference e) no significant difference f) no significant difference g) control group gained more (ES: 0.433) h) control group gained more (ES: 0.290) i) control group gained more (ES: 0.044) j) control group gained more (ES: 0.383)
Yalcinkaya & Atalay (2006, Turkey, 1-arm BA)[126]	Pre-test vs. post-tests for a) plaque index b) gingival index c) oral health knowledge	a) gradual significant improvement (ES: 0.435; 1.044) b) gradual significant improvement (ES: 0.520; 1.000) c) significant improvement on all items except for importance of tooth brushing	N/A	N/A
3. Psychological outcomes				
Dursun et al. (2015, Turkey, 1-arm BA)[30]	Pre-test vs. post-test for a) sleep quality b) self-concept c) behavioral and emotional states	a) significant improvement (ES: 0.784) b) significant deterioration (ES: 1.991) c) mixed results (ES: -0.684; 1.473)	N/A	N/A
Eniola & Adebiyi (2007, Nigeria, 2-arm RCT)[33]	Pre-test vs. post-test for a) intervention group motivation to work b) control group motivation to work	a) significant improvement (ES: -4.510) b) significant improvement (ES: -4.045)	Intervention vs. control group at a) gain motivation to work	a) intervention group gained more (ES: 4.352)
Eniola & Ajobiewe (2013, Nigeria, 3-arm RCT)[32]	Pre-test vs. post-test for a) EIT intervention group psychological well-being b) LCT intervention group	a) significant improvement b) significant improvement c) significant improvement	Intervention vs. control groups at a) post-test psychological well-being	a) EIT intervention group had the highest post-test adjusted mean score, followed by the LCT intervention group and last the

	psychological well-being c) control group psychological well-being			control group
Johnson & Johnson (1991, USA, 2-arm non-RCT)[55]	N/A	N/A	Intervention vs. control group at a) pre-test self-concept b) pre-test attitude towards blindness c) pre-test locus of control d) gain self-concept e) gain attitude towards blindness f) gain locus of control	a) no significant differences b) no significant difference c) no significant difference d) intervention group gained significantly more e) intervention group gained significantly more f) intervention group gained significantly more
Levin & Rotheram-Fuller (2011, USA, 2-arm non-RCT)[65]	Pre-test vs. post-test for a) intervention group self-determination b) intervention group self-concept c) intervention group self-esteem d) control group self-determination e) control group self-concept f) control group self-esteem	a) no significant results (ES: -0.266; 0.239 b) no significant results (ES: -0.008) c) no significant results (ES: 0.435) d) no significant results (ES: -0.392; 0.297) e) no significant results (ES: -0.104) f) no significant results (ES: 0.017)	Intervention vs. control group at a) pre-test self-determination b) pre-test self-concept c) pre-test self-esteem d) gain self-determination e) gain self-concept f) gain self-esteem	a) no significant differences b) no significant difference c) no significant difference d) no significant differences (ES: -0.149; 0.464) e) control group gained more (ES: 0.098) f) control group deteriorated less (ES: 0.342)
Locke & Gerler (1981, USA, 4-arm RCT)[66]	Pre-test vs. post-test for a) HDP intervention group self-image b) DUSO intervention group self-image c) play control group self-image d) control group self-image	a) non-significant improvement (ES: -0.573) b) non-significant improvement (ES: -0.430) c) non-significant improvement (ES: -0.213) d) non-significant improvement (ES: -0.253)	Intervention vs. control groups at a) gain HDP vs. play control self-image b) gain HDP vs. control self-image c) gain DUSO vs. play control self-image d) gain DUSO vs. control self-image	a) HDP gained more (ES: 0.438) b) HDP gained more (ES: 0.537) c) DUSO gained more (ES: 0.208) d) DUSO gained more (ES: 0.322)
McMahon (2013, USA, 1-arm BA)[70]	Pre-test vs. post-test for self-perception	Significant improvement (ES: 0.518; 1.099)	N/A	N/A
Mohamed et al. (2011, Egypt, 1-	Pre-test vs. post-test for a) anxiety	a) significant improvement (ES: 1.584)	N/A	N/A

arm BA)[73]	b) depression c) self-esteem d) activities of daily living	b) significant improvement (ES: 0.486) c) significant improvement (ES: -1.980) d) significant improvements		
Shapiro et al. (2005, USA, 1-arm BA)[95]	Pre-test vs. post-test for a) social acceptance b) athletic competence c) physical appearance	a) improvement (ES: -0.212) b) improvement (ES: -0.271) c) improvement (ES: -0.186)	N/A	N/A
4. Functioning and development				
Al-Dababneh et al. (2015, Jordan, 2-arm non-RCT)[2]	N/A	N/A	Intervention vs. control group at gain in creativity	Intervention group gained significantly more at all scale dimensions
Beelmann & Brambring (1998, Germany, 2-arm non-RCT)[6]	N/A	N/A	Intervention vs. control group at a) full-term children various developmental ages b) pre-term children at various developmental ages	a) significant difference in favor of intervention group at age 30 months (ES: 1.348); mixed results for other ages (ES: -0.196; 0.821) b) mixed results (ES: -0.722; 0.249)
Behl et al. (1993, USA, 2-arm RCT)[7]	Pre-test vs. post-test 1 for a) intervention group child functioning b) intervention group family functioning c) control group child functioning d) control group family functioning Pre-test vs. post-test 2 for e) intervention group child functioning f) intervention group family functioning g) control group child functioning h) control group family functioning Pre-test vs. post-test 3 for i) intervention group child functioning	a) improvement (ES: -1.240) b) mixed results (ES: -0.465; 0.203) c) improvement (ES: -1.352) d) mixed results (ES: -0.248; 0.276) e) improvement (ES: -2.175) f) mixed results (ES: -0.782; 0.663) g) improvement (ES: -2.729) h) mixed results (E: -0.262; 0.276) i) improvement (ES: -2.428) j) mixed results (ES: -0.783; 0.017) k) improvement (ES: -2.975) l) mixed results (ES: -0.504; 0.602)	Intervention vs. control group at a) pre-test child functioning b) pre-test family functioning c) post-test 1 child functioning d) post-test 1 family functioning e) post-test 2 child functioning f) post-test 2 family functioning g) post-test 3 child functioning h) post-test 3 family functioning i) gain post-test 1 child functioning j) gain post-test 1 family functioning k) gain post-test 2 child functioning l) gain post-test 2 family functioning m) gain post-test 3 child functioning n) gain post-test 3 family functioning	a) no significant difference b) significant difference in FRS in favor of control group c) no significant difference d) no significant differences e) no significant difference f) no significant differences g) no significant difference h) no significant differences i) control group gained more (ES: -0.193) j) mixed results (ES: -0.617; 0.255) k) control group gained more (ES: -0.311) l) mixed results (ES: -0.358; 0.873) m) control group gained more (ES: -0.389)

	j) intervention group family functioning k) control group child functioning l) control group family functioning			n) intervention group gained more (ES: 0.129; 1.119)
Çalik et al. (2012, Turkey, 2-arm non-RCT)[15]	Pre-test vs. post-test for a) intervention group cognition b) intervention group activities of daily living c) intervention group quality of life d) control group cognition e) control group activities of daily living f) control group quality of life	a) significant improvement (ES: -1.084) b) significant improvement (ES: -1.081) c) significant improvement (ES: -0.385) d) non-significant improvement (ES: -0.118) e) non-significant improvement (ES: -0.100) f) no difference (ES: 0.007)	Intervention vs. control group at a) pre-test cognition b) pre-test activities of daily living c) pre-test quality of life d) post-test cognition e) post-test activities of daily living f) post-test quality of life g) gain cognition h) gain activities of daily living i) gain quality of life	a) no significant difference b) no significant difference c) no significant difference d) significant difference in favor of intervention group e) significant difference in favor of intervention group f) significant difference in favor of intervention group g) intervention group gained more (ES: -0.373) h) intervention group gained more (ES: -0.991) i) intervention group gained more (ES: -0.359)
Christy (2012, India, 4-arm RCT)[21]	Pre-test vs. post-test for a) center-based impact of vision impairment b) community-based impact of vision impairment c) center- and community-based impact of vision impairment d) non-interventional center-based impact of vision impairment	a) significant improvement (ES: 0.558) b) significant improvement (ES: 0.726) c) significant improvement (ES: 1.156) d) significant improvement (ES: 0.292)	Intervention vs. control groups at a) gain center vs. community impact of vision impairment b) gain center vs. center and community impact of vision impairment c) gain center vs. center non-interventional impact of vision impairment d) gain community vs. center and community impact of vision impairment e) gain community vs. center non-interventional impact of vision impairment f) gain center and community vs. center non-interventional impact of	a) community gained more (ES: -0.162) b) center and community gained significantly more (ES: -0.686) c) center gained more (ES: 0.135) d) center and community gained significantly more (ES: -0.538) e) community gained more (ES: 0.272) f) center and community gained significantly more (ES: 0.727)

			vision impairment	
Ganesh et al. (2013, India, 1-arm BA)[40]	Pre-test vs. post-test functional vision	Significantly less often answer 4 of the LVP-FVQ (unable to do activity due to visual reasons) was chosen for the items 'copying from the blackboard', 'reading textbook at arm's length', 'writing along a straight line', 'applying paste on a tooth brush', and 'making out whether someone is calling you by waving his/her hand from across the road'	N/A	N/A
Gothwal et al. (2015, India, 1-arm BA)[43]	Pre-test vs. post-test functional vision	Significant improvement (ES: -0.69)	N/A	N/A
Platje et al. (2018, the Netherlands, 2-arm RCT)[83]	Pre-test vs. post-test 1 for a) intervention group parental sensitivity b) intervention group parent-child interaction c) intervention group parenting stress d) intervention group parenting self-efficacy e) control group parental sensitivity f) control group parent-child interaction g) control group parenting stress h) control group parenting self-efficacy Pre-test vs. post-test 2 for i) intervention group parental sensitivity j) intervention group parent-child interaction k) intervention group parenting	a) improvement (ES: -0.162) b) improvement (ES: -0.465) c) improvement (ES: 0.297) d) improvement (ES: -0.239) e) improvement (ES: -0.038) f) improvement (ES: -0.127) g) deterioration (ES: -0.051) h) improvement (ES: -0.179) i) improvement (ES: -0.051) j) improvement (ES: -0.303) k) improvement (ES: 0.204) l) improvement (ES: -0.359) m) improvement (ES: -0.110) n) improvement (ES: -0.052) o) no difference (ES: 0.000) p) improvement (ES: -0.013)	Intervention vs. control group at a) gain post-test 1 parental sensitivity b) gain post-test 1 parent-child interaction c) gain post-test 1 parenting stress d) gain post-test 1 parenting self-efficacy e) gain post-test 2 parental sensitivity f) gain post-test 2 parent-child interaction g) gain post-test 2 parenting stress h) gain post-test 2 parenting self-efficacy	a) intervention group gained more (ES: 0.123) b) intervention group gained more (ES: 0.370) c) intervention group gained more (ES: -0.360) d) intervention group gained more (ES: 0.097) e) control group gained more (ES: -0.063) f) intervention group gained more (ES: 0.257) g) intervention group gained more (ES: -0.216) h) intervention group gained more (ES: 0.373)

	stress l) intervention group parenting self-efficacy m) control group parental sensitivity n) control group parent-child interaction o) control group parenting stress p) control group parenting self-efficacy			
Williams (1985, UK, 1-arm BA)[122]	Pre-test vs. post-test for a) social adaptation b) sensorimotor understanding c) exploration of the environment d) response to sound and verbal comprehension e) expressive language	a) significant improvement b) significant improvement c) non-significant improvement d) no difference e) no difference	N/A	N/A
5. Reading performance				
Corn et al. (2002, USA, 1-arm BA)[26]	Pre-test vs. post-test for a) silent comprehension b) oral comprehension c) silent reading speed d) oral reading speed	a) significant improvement (ES: -0.487) b) non-significant improvement (ES: -0.257) c) significant improvement (ES: -1.305) d) non-significant improvement (ES: -0.142)	N/A	N/A
Farmer & Morse (2007, USA, 2-arm non-RCT)[35]	Pre-test vs. post-test for a) intervention group type size b) intervention group reading rate c) intervention group comprehension d) control group type size e) control group reading rate f) control group comprehension	a) improvements b) improvements c) improvements d) no differences e) improvements f) no differences	N/A	N/A
Heber et al. (1967, USA, 2-	N/A	N/A	Intervention group vs. control group at	a) intervention group gained more b) no difference

arm RCT)[47]			a) gain post-test 1 reading rate b) gain post-test 2 reading rate	
Howell (1977, UK, 3-arm RCT)[50]	Pre-test vs. post-test for a) freehand intervention group comprehension b) pacing intervention group comprehension c) control group comprehension	a) no difference b) no difference c) no difference	Intervention vs. control groups at a) gain freehand vs. control reading rate b) gain pacing vs. control reading rate c) gain freehand vs. pacing reading rate	a) freehand gained significantly more b) pacing gained significantly more c) no difference
Huurneman et al. (2016, The Netherlands, 2-arm non-RCT)[51]	Pre-test vs. post-test for a) intervention group reading speed b) intervention group critical print size c) intervention group reading acuity d) intervention group acuity reserve e) control group reading speed f) control group critical print size g) control group reading acuity h) control group acuity reserve	a) no difference (ES: -0.024) b) significant improvements (ES: 0.526) c) significant improvements (ES: 0.537) d) no difference (ES: 0) e) no difference (ES: 0.032) f) significant improvements (ES: 0.166) g) significant improvements (ES: 0.422) h) no difference (ES: -0.243)	Intervention vs. control group at a) gain reading speed b) gain critical print size c) gain reading acuity d) gain acuity reserve	a) intervention group gained more (ES: 0.054) b) intervention group gained more (ES: 0.341) c) intervention group gained more (ES: 0.115) d) control group gained more (ES: -0.246)
Kederis et al. (1964, USA, 2-arm RCT)[57]	Pre-test vs. post-test for a) intervention group reading time b) intervention group comprehension c) control group reading time d) control group comprehension	a) significant improvements (ES: 0.631; 0.729) b) non-significant deteriorations (ES: 0.000; 0.131) c) significant improvements (ES: 0.768; 1.060) d) non-significant deteriorations (ES: 0.340; 0.870)	Intervention vs. control group at a) gain reading time b) gain comprehension	a) control group gained more (ES: -0.270; -0.093) b) intervention group gained more (ES: -0.877; -0.239)
Kederis et al. (1964, USA, 2-arm RCT)[58]	Pre-test vs. post-test for a) reading time b) comprehension	a) significant improvements (ES: 0.348; 1.323) b) non-significant deteriorations (ES: 0.136; 0.379)	Intervention vs. control group at a) gain reading time	a) intervention group gained more (not significant)
Uysal & Düger	Pre-test vs. post-test for	a) significant improvement	N/A	N/A

(2012, Turkey, 1-arm BA)[113]	a) writing speed b) legibility of writing c) reading speed	(ES: 0.321) b) non-significant improvement (ES: -0.049) c) significant improvement (-0.418)		
6. Social skills				
Bieber-Schut (1991, Canada, 1-arm BA)[8]	Pre-test vs. post-test for social skills	Significant improvement	N/A	N/A
Grumpelt & Rubin (1972, USA, 2-arm non-RCT)[44]	Pre-test vs. post-test for a) intervention group speed listening skills b) control group speed listening skills	a) significant deterioration b) significant deterioration	Intervention vs. control group at a) pre-test speed listening skills b) post-test speed listening skills c) gain speed-listening skills	a) no significant difference b) significant difference in favor of intervention group c) intervention group deteriorated significantly less
Kim (2003, USA, 2-arm RCT)[61]	Pre-test vs. post-test for a) intervention group social skills students b) intervention group social skills teachers c) intervention group assertiveness students d) intervention group cognitive distortion e) intervention group assertiveness observers f) control group social skills students g) control group social skills teachers h) control group assertiveness students i) control group cognitive distortion j) control group assertiveness observers	a) improvement (ES: -0.143) b) improvement (ES: -0.210) c) improvement (ES: -0.012) d) improvement (ES: 0.139) e) improvement (ES: -0.333) f) improvement (ES: -0.379) g) improvement (ES: -0.105) h) deterioration (ES: 0.505) i) improvement (ES: 0.220) j) improvement (ES: -0.389)	Intervention vs. control group at a) gain social skills students b) gain social skills teachers c) gain assertiveness students d) gain cognitive distortion e) gain assertiveness observers	a) control group gained more (not significant; ES: 0.160) b) intervention group gained more (not significant; ES: 0.088) c) intervention group gained more (not significant; ES: 0.488) d) intervention group gained more (not significant; ES: -0.044) e) no difference (ES: 0.000)
McConnell (1994, USA, 2-arm RCT)[72]	Pre-test vs. post-test for a) intervention group parent communication	a) no difference (ES: 0.016) b) no difference (ES: 0.099) c) no difference (ES: 0.035)	Intervention vs. control group at a) gain parent communication b) gain adolescent communication	a) intervention group deteriorated less (ES: 0.027) b) intervention group deteriorated

	b) intervention group adolescent communication c) control group parent communication d) control group adolescent communication	d) deterioration (ES: 0.359)		less (ES: 0.291)
Sacks & Gaylord-Ross (1989, USA, 3-arm RCT)[93]	Pre-test vs. post-tests for a) peer-mediated intervention group social skills b) peer-mediated intervention group social validation c) teacher-directed intervention group social skills d) teacher-directed intervention group social validation e) control group social skills f) control group social validation	a) significant improvement in 5/7 behaviors at post-test 1, 7/7 behaviors at post-test 2, 6/7 behaviors post-test 3 b) significant improvement on 3/7 items completed by peers and 7/8 items completed by teachers c) significant improvement in 7/7 behaviors at post-test 1, no difference at post-test 2 and significant improvement in 1/7 behaviors at post-test 3 d) significant improvement on 2/7 items completed by peers and 2/8 items completed by teachers e) no significant difference at post-test 1 and 3, significant improvement in 2/7 behaviors at post-test 2 f) no significant difference at items completed by peers and teachers	Intervention vs. control groups at a) gain peer-mediated vs. control social competence b) gain teacher-directed vs. control social competence c) gain peer-mediated vs. teacher directed social competence	a) peer-mediated gained significantly more b) teacher-directed gained significantly more c) peer-mediated gained more (not significant)
Uysal & Düger (2012, Turkey, 2-arm RCT)[114]	Pre-test vs. post-test for a) intervention group social skills b) intervention group activity performance c) control group social skills d) control group activity performance	a) significant improvement (ES: -0.681) b) significant improvement (ES: 1.229) c) significant improvement (ES: -0.443) d) significant improvement (ES: 1.076)	Intervention vs. control group at a) gain social skills b) gain activity performance	a) intervention group gained more (ES: 0.024) b) control group gained more (ES: -0.134)
Yildiz & Duy	Pre-test vs. post-test for	a) significant improvement	Intervention vs. control group at	a) intervention group gained

(2013, Turkey, 2-arm RCT)[127]	a) intervention group empathic skills b) intervention group communication skills c) control group empathic skills d) control group communication skills	b) significant improvement c) significant improvement d) significant improvement	a) gain empathic skills b) gain communication skills	significantly more b) intervention group gained significantly more
7. Viewing behavior				
Boonstra et al. (2012, The Netherlands, 2-arm RCT)[13]	Pre-test vs. post-test for a) viewing behavior LH chart near vision test single b) viewing behavior LH chart near vision line c) duration of observation	a) significant improvement (ES: 0.685) b) significant improvement (ES: 0.663) c) significant improvement	Intervention vs. control group at a) gain viewing behavior LH chart near vision test single b) gain viewing behavior LH chart near vision line c) gain duration of observation	a) no difference b) no difference c) no difference
Cox et al. (2009, The Netherlands, 2-arm non-RCT)[27]	Pre-test vs. post-test for a) intervention group number of trails followed b) control group number of trails followed c) pooled groups number of trails followed	a) improvement (ES: -0.975) b) improvement (ES: -1.670) c) significant improvement (ES: 2.608)	Intervention vs. control group at gain proportion of trails followed correct	Intervention group gained significantly more
Nyquist et al. (2016, USA, 3-arm RCT)[78]	Pre-test vs. post-test for a) AVG intervention group foveal motion perception b) AVG intervention group single target motion direction discrimination c) AVG intervention group multi-target direction comparisons d) AVG intervention group visual crowding e) AVG intervention group visual search f) MAT intervention group foveal motion perception g) MAT intervention group single	a) no significant difference b) significant improvement c) non-significant improvement d) significant improvement e) significant improvement f) no significant difference g) significant improvement h) significant improvement i) significant improvement j) significant improvement k) no significant difference l) no significant difference m) no significant difference n) no significant difference o) significant improvement	Intervention vs. control groups at a) gain AVG vs. control foveal motion perception b) gain AVG vs. control single target motion direction discrimination c) gain AVG vs. control multi-target direction comparisons d) gain AVG vs. control visual crowding e) gain AVG vs. control visual search f) gain MAT vs. control foveal motion perception g) gain MAT vs. control single target motion direction discrimination h) gain MAT vs. control multi-target	a) no difference b) AVG gained more (not significant) c) AVG gained more (not significant) d) AVG gained significantly more e) AVG gained more (not significant) f) no difference g) MAT gained significantly more h) MAT gained more (not significant) i) MAT gained more (not significant) j) MAT gained more (not significant) k) no difference l) MAT gained more (not significant) m) MAT gained more (not significant)

	target motion direction discrimination h) MAT intervention group multi-target direction comparisons i) MAT intervention group visual crowding j) MAT intervention group visual search k) control group foveal motion perception l) control group single target motion direction discrimination m) control group multi-target direction comparisons n) control group visual crowding o) control group visual search		direction comparisons i) gain MAT vs. control visual crowding j) gain MAT vs. control visual search k) gain MAT vs. AVG foveal motion perception l) gain MAT vs. AVG single target motion direction discrimination m) gain MAT vs. AVG multi-target direction comparisons n) gain MAT vs. AVG visual crowding o) gain MAT vs. AVG visual search	n) MAT gained more (not significant) o) MAT gained more (not significant)
Ritchie et al. (1989, India, 1-arm BA)[90]	Pre-test vs. posttest for visual functioning	50% of the children improved		
8. Mobility skills				
Ungar et al. (1997, UK, 1-arm BA)[111]	Pre-test vs. post-test for performance in estimating distances	Improvement	N/A	N/A
Wood (1978, USA, 3-arm RCT)[124]	N/A	N/A	Intervention vs. control groups at gain PMS	Intervention group gained significantly more

AVG: Action Video Game; BOT: Bruininks-Oseretsky Test of Motor Proficiency Short Form; CMI: Cornell Medical Index; DUSO: Developing Understanding of Self and Others; EIT: Emotional Intelligence Training; ES: Effect size; HDP: Human Development Program; LCT: Locus of Control Training; LVP-FVQ: LV Prasad-Functional Vision Questionnaire; MABC: Movement Assessment Battery for Children; ManuVis: manual skills test for children (6-12 years) with visual impairment; MAT: Modified Attentional Tracking; Movement ABC: movement assessment for children; N/A: Not applicable; OHE: oral hygiene education; PACER: Progressive Aerobic Cardiovascular Endurance Run; PMS: Peabody Mobility Scale

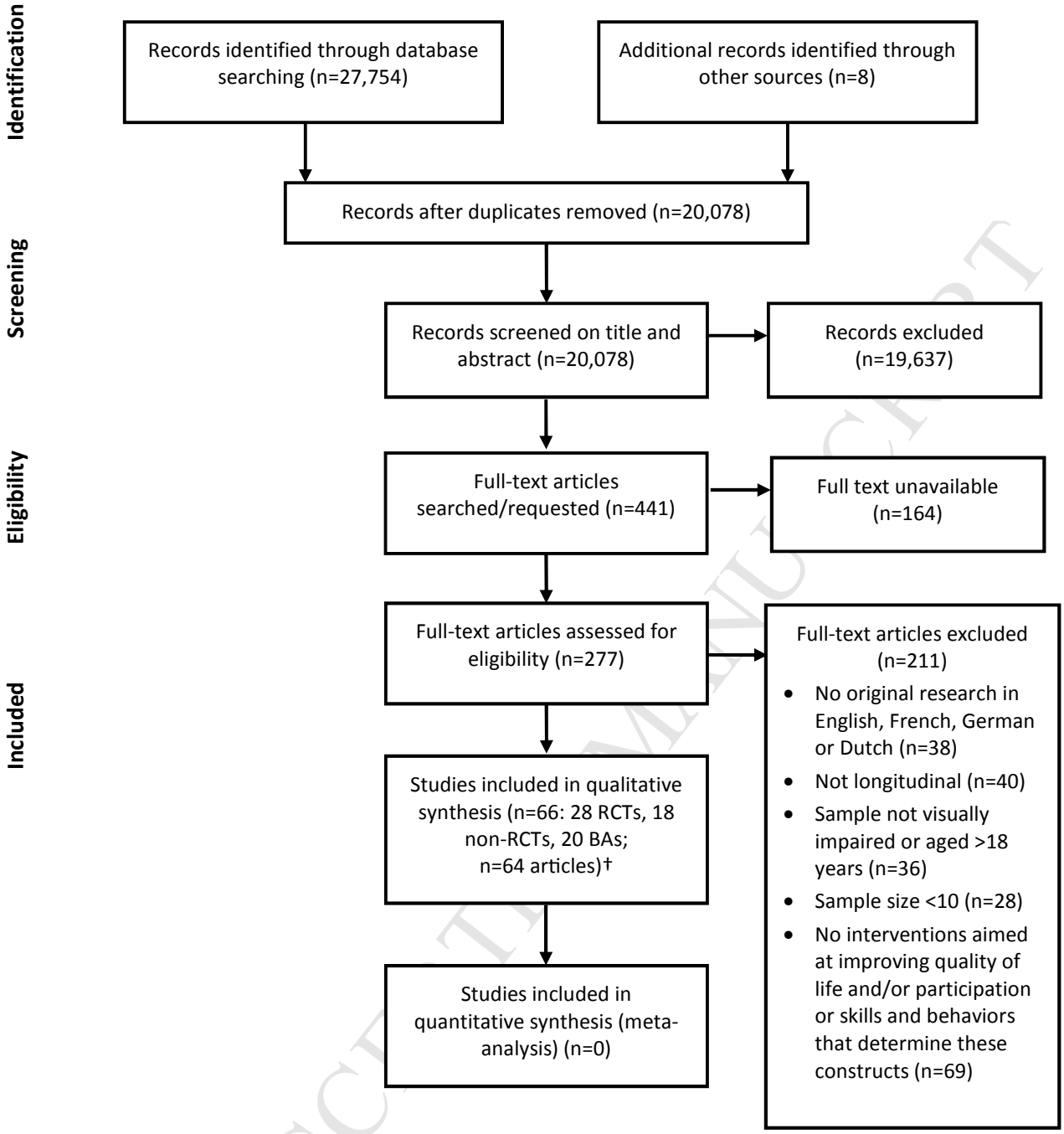
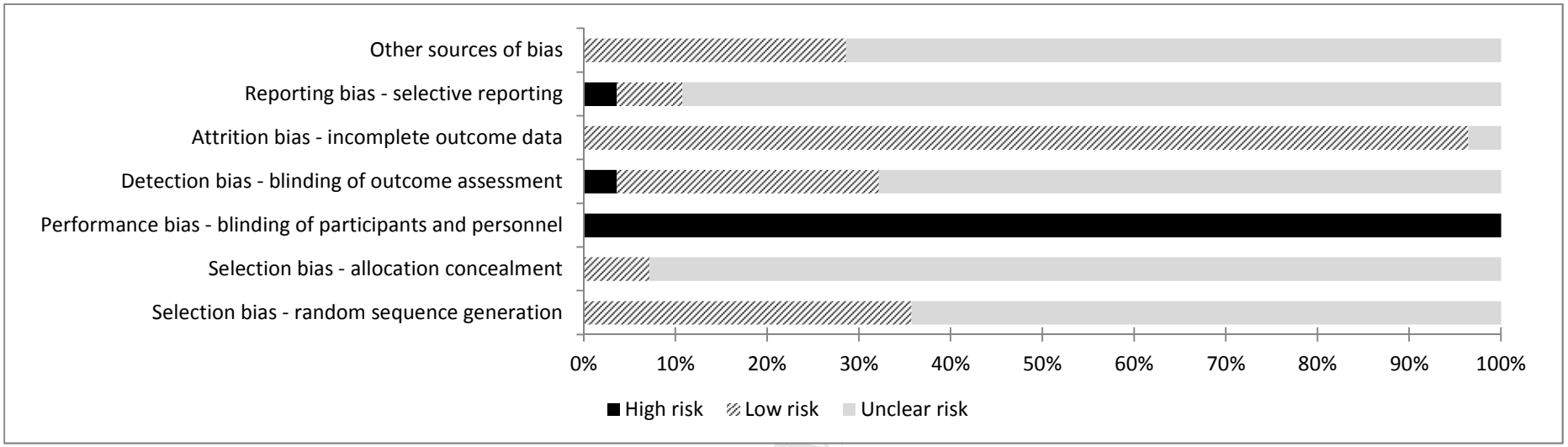
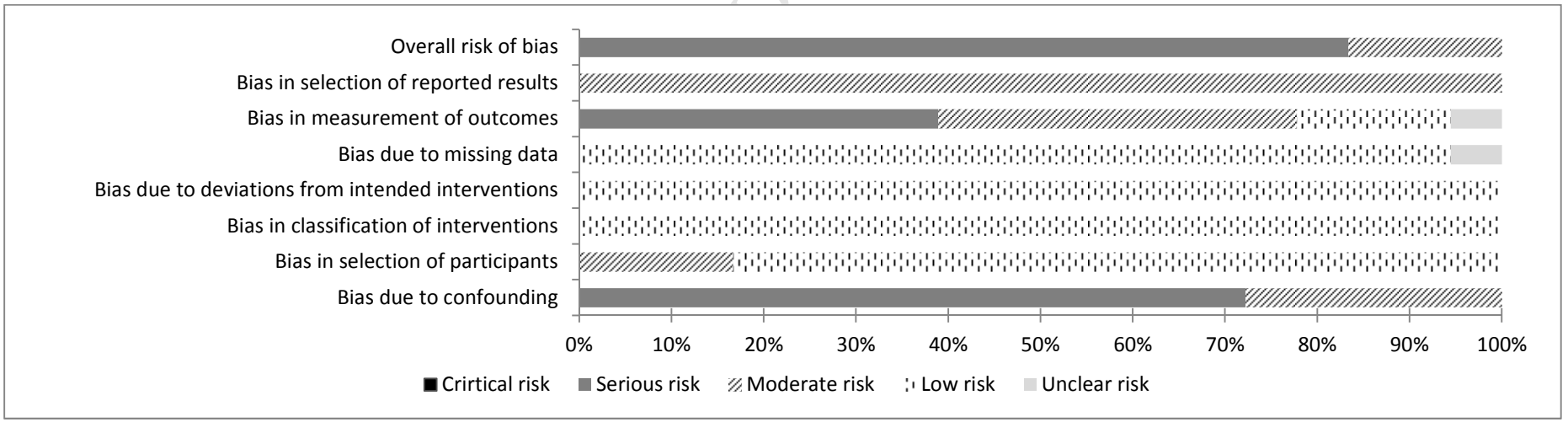


Figure 1. Flow-diagram of study inclusion process

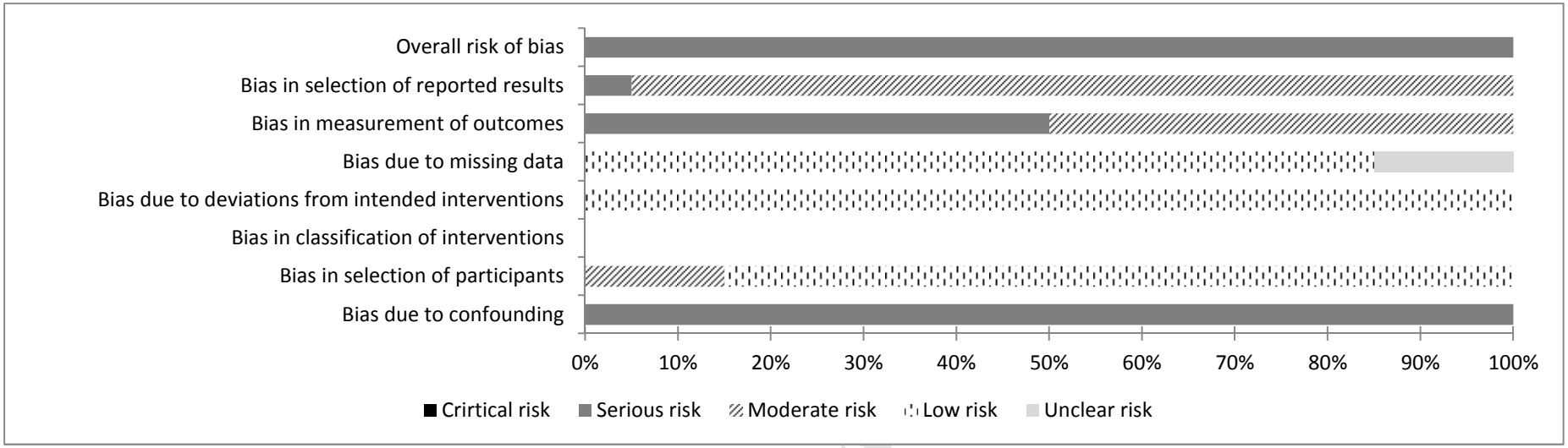
† The articles of McMahon and Kederis described two different studies.[57,58,70,71]



a. Risk of bias graph for RCTs



b. Risk of bias graph for non-RCTs



c. Risk of bias graph for BAs

Figure 2. Risk of bias graphs for a) RCTs; b) non-RCTs; and c) BAs: review authors' judgements about each risk of bias parameter presented as percentages across all included studies