Does Health-Related Physical Fitness Differ Amongst Visually Impaired and Fully Sighted Young People?

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ABSTRACT

Introduction: Visual impairment is said to pose a barrier to everyday tasks, including physical activity. Physical activity can promote teamwork, socialisation and improve health and skill-related physical fitness. Fitness is important when participating in sport and exercise and is also a key facilitator in completing everyday tasks with ease. There are five components of health-related fitness: cardiorespiratory fitness, muscular strength, muscular endurance, body composition and flexibility. The aim of this systematic review was to determine the difference, if any, in health-related physical fitness levels of children and adolescents with a visual impairment when compared to fully sighted children and adolescents.

Methods: Comprehensive database searches of CINAHL, Embase and MEDLINE were undertaken to identify studies relating to the aim outlined above. Quantitative data was sought in relation to each of the five components of health-related fitness. Data was critically appraised, and bias addressed. A narrative synthesis, without meta-analysis was performed.

Results: Of the 342 studies screened, six were deemed eligible for inclusion. No conclusion was drawn with regards to muscular strength/endurance, body composition or flexibility due to the small amount of data collected. There were positive correlations found with regards to cardiorespiratory fitness and level of vision, with most studies indicating poorer fitness amongst the visually impaired groups. The heterogeneous nature of these findings did not allow for conclusiveness. Limitations of the included studies and this review were explored.

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Discussion: Overall, despite consistent patterns in the findings, further study is needed to determine the difference in each of the health-related fitness components amongst the two groups.

Keywords: visual impairment, fitness, systematic review

INTRODUCTION

The World Health Organization (WHO) includes both low vision and blindness in the definition of visual impairment (VI).[1] Whilst there is some discrepancy amongst definitions, WHO recognises blindness as having a visual acuity (VA) of 'less than 3/60, or a corresponding visual field loss to less than 10°, in the better eye with the best possible correction'. Low vision is subsequently defined as VA 'of less than 6/18 but equal to or better than 3/60, or a corresponding visual field loss to less than 20°, in the better eye with the best possible correction'.[2] Vision in sporting environments is usually classified according to International Blind Sports criteria B1, B2 or B3: B1 – VA less than LogMAR 2.60; B2 – VA between LogMAR 1.50 and 2.60 and/or a visual field less than 10°; B3 – VA between LogMAR 1.40 and 1.0 and/or a visual field less than 40°.[3] VI is said to pose a potential barrier to everyday tasks, including but not solely, physical activity.[4] Greguol et al[4] found lack of security, information relating to available programs and lack of motivation to be amongst the most significant barriers perceived by young individuals with a visual impairment. Physical activity is considered as any energy-expending activity produced by skeletal muscles, above resting levels.[5] Sedentary behaviour has been noted as a modifiable risk factor for an array of diseases including cardiovascular and osteopathic disease, diabetes mellitus and depression.[6] Physical activity, particularly in children can promote socialisation, teamwork, 'fair play, leadership, decision-making, trust'.[7] Social factors such as these could well prevent the social isolation that may arise as a result of VI.[8]

Physical fitness can be defined as 'a set of attributes that people have or achieve that relates to the ability to perform physical activity'.[9] There are five health-related components of physical fitness that can attribute to its measurement: cardiorespiratory fitness, muscular endurance, muscular strength, body composition and flexibility.[9]

Depending on level of vision, participation in sporting or exercise programs may be limited due to lack of appropriate programs and equipment, lack of peers to train with and limited knowledge of how to include young people with VI in sports.[10] Adaptations to current activities may be necessary to allow for greater level of involvement, such as the use of tactile or auditory equipment or an increase in the contrast of equipment.[11,12] When implementing changes, it is important to consider the gross motor skills, such as walking, running or jumping, of the individual to allow for optimal post-adaptation performance. There is a positive correlation between level of physical fitness and motor competence.[13]

The aim of this review was to determine the difference, if any, in health-related physical fitness levels between children and adolescents with VI when compared to their fully sighted peers during participation in physical fitness tests. Societally, many recreational sporting programs are targeted to a younger demographic and so the focus of this review will be amongst children and adolescents. There is currently no systematic review relating solely to this specific topic.

METHODS

Eligibility criteria

The following study designs were eligible for inclusion: non-randomised control trials, cross-sectional studies, cohort studies and case-control studies. Only papers in the English language with results relating to human subjects aged 1 to 18 years were included. Participants were classified as having a visual impairment, either blind or low vision, without comorbidities, and the control group as fully sighted. Any unpublished results were excluded. Results of included articles were required to contain objective quantitative results relating to one or more health-related physical fitness component.

Participants: The review included children and adolescents aged 1 to 18 years with a visual impairment and matched fully sighted controls.

Exposure: Participants were exposed to tests of health-related physical fitness, including cardiorespiratory testing, body composition, muscular strength and endurance, and flexibility.

Outcomes: The outcome of interest was the difference in health-related physical fitness levels between visually impaired children when compared to their fully sighted peers. Outcome measures included at least one of the five health-related components of physical fitness: cardiorespiratory fitness, including maximum oxygen uptake (VO2 max), heart rate and breath rate/respiratory rate; body composition, including body fat percentage and skinfold; muscular strength; muscular endurance; and flexibility.

Identification of studies

Electronic searches of the following online databases were conducted: CINAHL, Embase and MEDLINE, with searches inclusive of all articles, 28th September 2018 and prior. Search terms included a combination of 'vis* impair*' and 'physical* activ*' or sport* or exercis* or fitness*. No restrictions were placed on date of publication, however searches were limited to human subjects and English language. Limitations were placed on age group with MEDLINE and CINAHL limited to 2 – 18 years and Embase limited to 1 – 17 years, owing to varying database subcategories.

Study selection

Two authors (RS and MV) independently reviewed the titles and abstracts identified in the search; irrelevant articles were excluded. Remaining articles were then collated, and duplicates identified and removed. The remaining articles were screened, and exclusions were made based on the eligibility criteria. Articles were obtained directly from database links and if necessary, via a university library document delivery. Articles were referenced and sorted using Endnote X9 (Clarivate Analytics).

Data extraction and critical appraisal

A comprehensive pre-developed data extraction form was used to analyse and extract relevant data. The items in the data extraction form included:

- Study design (and relevant reference details)
- Participant characteristics (age, gender, level of vision)
- Specific exposure type (specific fitness test and location undertaken)
- Outcome measures
- Methods used to analyse data
- Results of study relating to outcome measures
- Inclusion/exclusion

The key findings are detailed in Table 1.

Following the completion of the study selection, appraisal of the remaining studies was performed using the Joanna Briggs Institute (JBI) critical appraisal tools.[14,15] The tools assessed the relevance of the articles with regards to the established eligibility criteria, as well as the validity and reliability of the articles. Depending on the type of study, the relevant checklist was utilised. Quality was assessed based on the validity of study results.

Data synthesis/analysis

For the outcome of interest, objective measurements were sought. Quantitative results were compared against age-matched counterparts. Results were subdivided into the five relevant health-related physical fitness components. Where possible, analysis was isolated according to age, gender and level of vision. In most instances, a narrative synthesis was adapted from analysis of statistical significance (p value). Statistical pooling of results was not possible in this review due to the heterogeneity of results.

RESULTS

Search results

The total number of articles produced from the three database searches was 342. Following screening of title and abstract and removal of duplicates, 50 articles were identified as potentially eligible for inclusion. Following closer investigation of these articles, six were identified as being eligible for inclusion in the review, based on the established eligibility criteria. Total numbers and justifications were documented in a flowchart based on the principles of the PRISMA flow diagram (Figure 1).[16]

Study characteristics

Of the final six studies, a total of 593 participants were included, with ages ranging from 6 to 18 years (one study including only elementary school and junior high school students). Of these 593 participants, 270 were fully sighted and 323 were visually impaired, specific vision classifications utilised in each study are highlighted in Table 1. Publication dates spanned from 1982 to 2010. Studies were undertaken globally, in Canada, India, Netherlands, New Zealand, Poland and USA. Each study measured at least one component of health-related physical fitness, with many using various tests of fitness to do so (Table 1).

Study quality

Critical appraisal of the included studies was undertaken, according to the JBI critical appraisal tools for cohort and cross-sectional studies.[14,15] The study by Telles and Srinivas[17] followed a cohort study design. The respective JBI cohort appraisal tool was utilised.[14] Following the checklist, the study was found to be of good quality with a low risk of bias. Of particular interest in this study was the efficiency and completion of follow-up, reducing the risk of bias.

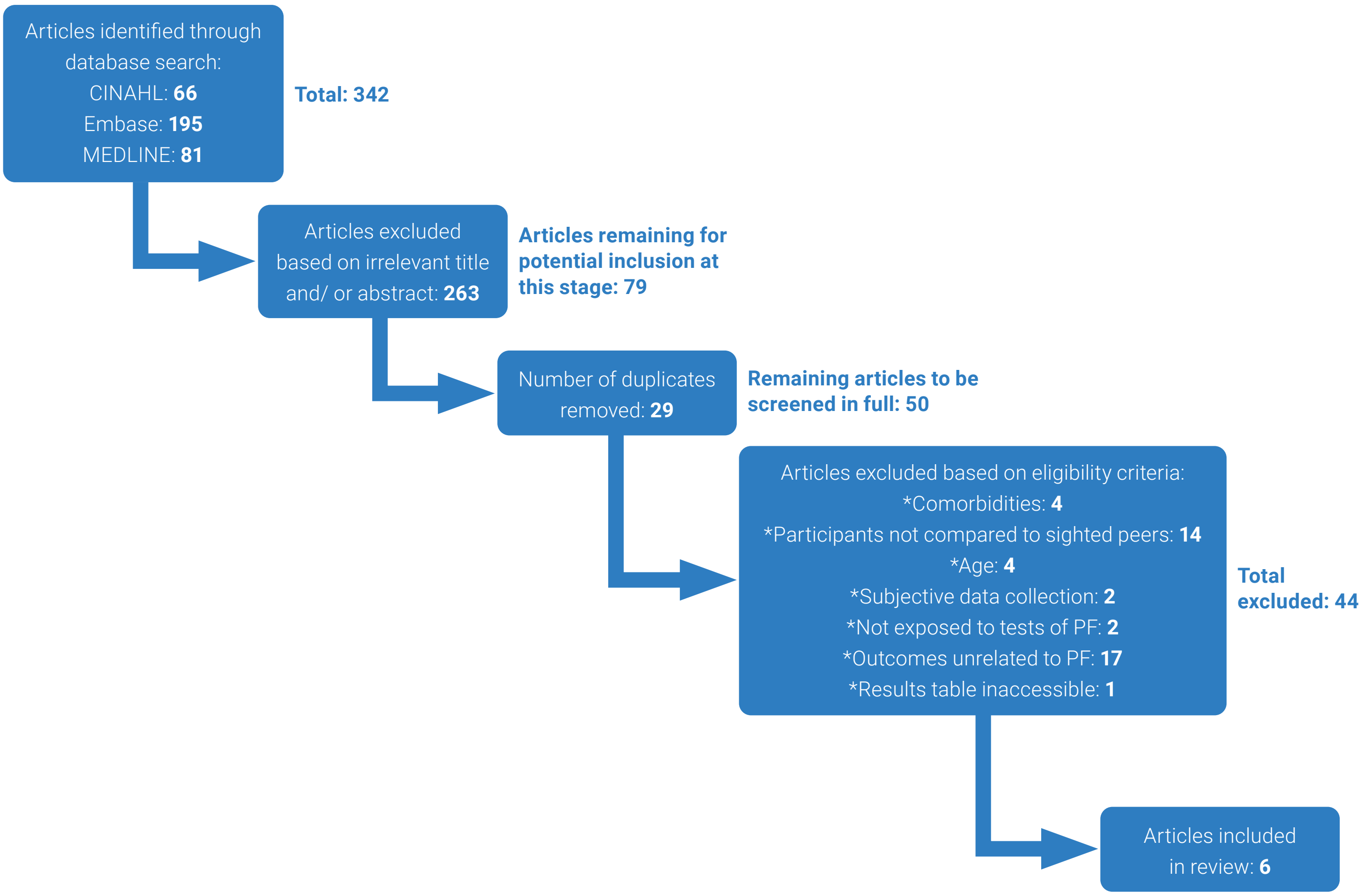

Figure 1. Study selection process.

The remaining five studies were assessed according to the JBI cross-sectional study tool.[15] Of these five studies, two were found to be under the influence of bias. The study by Zebrowska et al[19] was found to be of fair quality with a moderate risk of bias. The study by Seelye[20] was found to be of poor quality with a high risk of bias. Justifications are highlighted in Table 1.

Meta-analysis

The highly heterogeneous nature of the included studies, with varying outcome measures and physical fitness tests administered, prevented the undertaking of a meta-analysis. Statistical analysis of the pooled data is likely to have compromised the validity of the review with unreliable extrapolation of data, particularly since the number of included studies, and subsequent participants was small.

DISCUSSION

Findings

Upon analysis of the six included studies, no definite conclusion could be drawn as to whether children and adolescents with a visual impairment have lower levels of health-related physical fitness than their fully sighted peers. Whilst the majority of results showed that participants with VI achieved lower scores across the five components of health-related physical fitness, these results were obtained from small sample sizes and the outcome measures and fitness tests were not consistent across the studies.

Cardiorespiratory fitness

Five studies measured various aspects of cardiorespiratory fitness.

VO2 max: Kobberling et al[18] and Zebrowska et al[19] measured VO2 max on a cycle ergometer (maximal and submaximal) and treadmill (maximal), respectively. Both studies found that sighted males had significantly higher uptake when compared to VI males. Hopkins et al[21] also measured maximal oxygen uptake on a treadmill, finding fully sighted participants as having higher VO2 max compared to their peers with VI, particularly those classified as B1. Whilst not stating a specific physiological indicator, Houwen et al[22] measured overall cardiorespiratory fitness during the 20-MST (20 Meter Endurance Shuttle Run Test). It was found that sighted participants performed noticeably better than those with VI. This maximal test is an estimate of VO2 max.

Heart rate: Hopkins et al[21] measured heart rate using the Canadian Home Fitness Stepping test (submaximal). Fully sighted individuals had significantly lower heart rates than those with B1, B2 and B3 visual impairment, with lower submaximal heart rate indicative of greater fitness. Kobberling et al[18] found heart rate pre-exercise, as well as during running (submaximal), to be considerably higher in both male and female participants with VI. Heart rate during walking (submaximal) was significantly higher amongst males with VI compared to their fully sighted counterparts. Whilst the measured maximal heart rate was lower in the VI groups, it was not statistically significant. Similarly, Telles and Srinivas[17] also found resting heart rate to be significantly higher in participants with VI.

Breath rate/respiratory rate: Telles and Srinivas[17] found resting breath rate to be significantly higher in VI participants.

Cardiorespiratory fitness was the most commonly assessed aspect of fitness. Whilst the results do indicate a possible pattern of children with VI having lower levels of cardiorespiratory fitness than their fully sighted peers, the evidence cannot be considered conclusive. The data in some instances varied based on gender, and the measurement types (VO2 max, heart rate or breath rate) were not consistent across all studies. Given that all studies measuring this component favoured fully sighted participants in terms of greater fitness, it prompts further study in this specific area to reach a definite conclusion.

Body composition

Three studies measured body composition using the included outcome measures. Kobberling et al[18] measured body fat percentage, with the outcomes deemed insignificant amongst the VI and fully sighted groups. Houwen et al[22] also conducted assessment of percentage body fat finding fully sighted participants to be statistically lower. Hopkins et al[21] found an inverse correlation between level of vision and skinfold thickness, with participants categorised as B1 having a significantly higher average thickness compared to fully sighted, B2 and B3 participants. The varying measurement types, limited number of studies and conflicting results suggest further research is needed. Consistent measurement types are necessary to reach a definitive conclusion as to whether there is a clinically inverse correlation between level of vision and body composition.

Muscular strength

Three studies measured muscular strength. Using the ‘partial sit up’ and ‘sit up’ test, Hopkins et al[21] and Houwen et al[22] found no correlation between level of VA and abdominal muscular strength. Houwen et al[22] found the difference in hand strength between persons with VI and fully sighted persons to be insignificant when tested with a hand grip dynamometer. Despite not being classified as statistically significant it is important to note however, that the fully sighted group averaged an extra four kilograms on muscular contraction than the VI group. Seelye[20] measured abdominal and back strength as part of the Kraus-Weber Minimum Physical Fitness test. The study compared three participant groups. Whilst the fully sighted and partially sighted groups had similar pass rates (95%, 85%, respectively), the legally blind group had a lower rate of 45%. These results

Table 1. Summary of findings

Study	Group demographics	Physical fitness component tested and results Statistical significance p<0.05	Quality (Q) and Risk of Bias (RoB) within study
Hopkins et al, 1987[21] New Zealand (cross- sectional study)	**Experimental group** 27 participants (13 M, 14 F) *B1 (11), B2 (7), B3 (9)* **Control group** 27 participants (13M, 14F) **Age range** 7-17 years	**Cardiorespiratory fitness** FS lower HR (p<0.001) FS higher VO2 max (p<0.001) **Body composition** B1 higher skinfold (p<0.01) B2/B3 insignificant **Flexibility** Insignificant **Muscular strength/endurance** Insignificant	Q: good RoB: low
Houwen et al, 2010[22] Netherlands (cross- sectional study)	**Experimental group** 60 participants (40M, 20F) *20/400<BCVA<20/200 (16)* *20/60<BCVA<20/200 (44)* *Slight peripheral VF loss (4)* *Slight central VF loss (7)* *No VF loss (49)* **Control group** 60 participants (40M, 20F) **Age range** 6-12 years	**Cardiorespiratory fitness** FS performed better (p=0.03) **Muscular endurance**_ Insignificant **Muscular strength** FS jumped further (p=0.01) Grip strength insignificant **Flexibility** Insignificant **Body composition** FS % body fat lower (p=0.02)	Q: good RoB: low
Kobberling et al, 1989[18] Canada (cross-sectional study)	**Experimental group** 30 participants (20M, 10F) *B1 (9), B2 (7), B3 (14)* **Control group** 30 participants (20M, 10F) **Age range** 12-16 years	**Cardiorespiratory fitness** M VI lower VO2 max (p<0.05) M & F VI higher rest and running HR (p<0.05) M VI higher walking HR (p<0.05) **Body composition** Insignificant	Q: good RoB: low
Seelye, 1983[20] USA (cross- sectional study)	**Experimental group** 74 participants *LB (37), PS (37)* **Control group** 37 participants **Age range** Elementary and junior high school students	**Muscular strength** Pass rates FS- 95%, PS- 85%, LB- 45% **Flexibility** Pass rates FS- 95%, PS- 73%, LB- 49%	Q: poor RoB: high (specific vision classifications not identified, single author, limited data regarding participant recruitment, gender breakdown not mentioned, conclusions based on visual inspection of data rather than statistical analysis)
Telles & Srinivas, 1998[17] India (cohort study)	**Experimental group** 28 participants *Grade 0: NPL* *Grade 1: PL* *Grade 2: HM* *Grade 3: CF* **Control group** 28 participants **Age range** 12-17 years	**Cardiorespiratory fitness** VI higher resting HR (p<0.05) VI higher resting BR (p<0.01)	Q: good RoB: low (gender breakdown not mentioned)
Zebrowska et al, 2007[19] Poland (cross- sectional study)	**Experimental group** 104 participants **Control group** 88 participants **Age range** 10-18 years	**Cardiorespiratory fitness** FS M higher VO2 max (p<0.01)	Q: fair RoB: moderate (inconsistent participant tallying throughout, specific vision classifications not identified, unequal group sizes)

Note: M = male, F = female, FS = fully sighted, BCVA = best corrected visual acuity, LB = legally blind, PS = partially sighted, NPL = no light perception, PL = light perception, HM = hand movements, CF = count fingers, HR = heart rate, BR = breath rate.

may indicate lower strength rates amongst visually impaired children and adolescents, with a possible positive correlation between level of vision and muscular strength. Conflicting data and small sample sizes measuring different areas of the body highlight the need for further study in this area.

Muscular endurance

Two studies tested muscular endurance using the 'partial sit up' test (the latter differing in name: 'sit up' test).[21,22] The sit up tests are a measure of both muscular strength and endurance, and as such , results are according to those above. Hopkins et al[21] found no correlation between level of vision and muscular endurance. Houwen et al[22] found the difference in muscular endurance of the abdominal muscles to be statistically insignificant between the two groups. Whilst similar findings were obtained, data cannot be generalised on the basis of two studies, with small sample sizes.

Flexibility

Two studies tested flexibility using the 'sit and reach' test.[21,22] One study simply stated that flexibility did not correlate with level of vision, and the second yielded identical results between both groups. A third study tested flexibility with the 'toe touch' test. This test made up one fifth of the Kraus-Weber Minimum Physical Fitness test.[20] These researchers reported a difference between the three groups with a pass rate of 95% in fully sighted, 73% in partially sighted and 49% in legally blind participants. From this, despite the studies administering similar test types, the conflicting result from the respective third study suggests that more research is needed in measuring flexibility levels amongst youths with VI to confirm whether or not there is a positive correlation between level of vision and flexibility.

Strengths/limitations:

The results found and collated in this review were influenced by initial database limitations. Restriction of non-English publications and the searching of only three databases may have excluded potential articles for inclusion in the review. A key inclusion criterion was the comparison of persons with VI to fully sighted participants. Whilst this did ensure reliability of comparison between the two groups, given rigorous matching and identical testing environment, it may have prevented a greater volume of credible evidence comparing VI to standardised age norms.

None of the included study designs were that of a randomised control trial, therefore the studies were susceptible to participant recruitment bias. All the included reviews did however contain control and experimental groups, obtained by matching according to age and anthropometric characteristics allowing for greater comparative reliability. Inclusion of only six studies, each with only a small number of participants, may limit the ability of the data to be applied into practice as it may not be representative of the general population. Health-related physical fitness contains five varying components, each with various valid measurements. The included studies, in most instances, utilised different measures of fitness components and used varying fitness tests to establish these measurements, leading to inconsistent data that could not be reliably pooled. It is recommended that future studies narrow the searches to individual components, such as cardiorespiratory fitness only, and their specific measurements within each component, ie VO2 max. Whilst most of the articles were of good quality with low bias, articles by Seelye,[20] and Zebrowska et al[19] contained potential biases, affecting their quality. These potential biases have been highlighted in Table 1.

Contextualisation of findings

There is suggestion in the literature that children with VI participate in less physical activity than the recommended age-related norms.[21,23] Greguol et al[4] found factors contributing to lower levels of participation to include lack of motivation and information regarding available programs, as well as security. Given the findings in this review, there may be evidence to suggest that children and adolescents with VI also have lower levels of cardiorespiratory fitness than their fully sighted peers. Whilst the results of the other four components of physical fitness were not extensive and easily comparable, individual results were generally favoured towards the fully sighted groups in terms of greater performance. If indicative of the greater population, this lesser participation in physical activity may have resulted in lower levels of physical fitness, due to limited opportunities to train and improve fitness levels. Participating in general activities such as rope jumping[24] or specific blindsports such as goalball for example[25] can have the capacity to improve physical fitness levels amongst VI children and adolescents. Enhanced engagement of this particular demographic in existing physical activity programs or further implementation of blindsports programs may be beneficial in improving participation levels and therefore health-related physical fitness levels. Improving these levels and promoting a healthy, active lifestyle at a young age could reduce chronic health conditions later in life and promote social development at a young age.

It is important also to note findings in the study by Kobberling et al[18] regarding oxygen consumption and energy expenditure. Both male and female participants with VI were found to use more oxygen whilst walking and running than the fully sighted participants. The suggestion from previous authors was that individuals with VI took a higher frequency of steps, with each being of shorter stride length, thus requiring more oxygen and perhaps leading to an earlier onset of fatigue.[26-28] Adapting activities based on gait and motor competence could be a useful tool in sparing oxygen use and delaying fatigue and improving one's physical fitness levels. Telles and Srinivas[17] found an increase in diastolic blood pressure, resting heart rate and resting breath rate in individuals with VI. Factors such as fear of falling and injury may be responsible for these findings.[23,29] From this, it can be deduced that factors such as fear and biomechanics may also be responsible for poorer physical fitness outcomes upon testing. In addition to generally addressing lack of participation, it is also recommended that future studies address concerns regarding physical activity on an individual level and personalising adaptations.

CONCLUSION

The findings of this review indicate the necessity of further research into the effects of VI on muscular strength/endurance, body composition and flexibility. The results regarding cardiorespiratory fitness highlight that there may be a positive correlation between level of vision and this particular health-related fitness component. If further research is to confirm this correlation, conducting further studies measuring both participation in physical activity and consequent physical fitness levels of the respective individuals may also be recommended. Whilst a growing number of blindsports opportunities have been noted in community sport settings, these findings may be further cause to implement additional programs or enhance these current opportunities.

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