Chapter 13| Exercise, Physical Activity, and Older Adults

Amy E. Burton

Staffordshire University

ORCiD

000-0002-3698-0712

Abstract:

The worldwide population is ageing, however as we live longer these extra years are not always spent in good health. Physical activity is an important component of facilitating good health in later life with value for both physical and psychological outcomes, however experiencing visual impairment can negatively impact the ability to engage in this behavior. Interventions have been developed and trialed to increase physical activity in older adults with visual impairment, frequently with a focus on reducing falls risk. This chapter discusses the literature relating to exercise and physical activity in older adults with visual impairment, overviews the evidence for interventions designed to increase this behavior, and makes suggestions for future research and practice.

Introduction

The worldwide population is ageing, meaning there is both an increase in the average age of the population and a growing proportion falling within the older age brackets. By 2050 it is predicted that two billion people will be aged 60 years or above worldwide and there will be 434 million aged over 80 (World Health Organization, 2020a). While life expectancy has been steadily increasing over time, the level of 'healthy' life expectancy has not consistently improved at the same rate and the likelihood of older adulthood being spent in good health varies greatly between countries (World Health Organization, 2020b). The World Health Organization defines healthy ageing as 'the process of developing and maintaining the functional ability that enables well-being in older age' (p.28 World Health Organization, 2015). Health in later life is therefore not just the absence of disease or disability and there are several factors that can contribute to the experience of good health in old age. One important factor is physical activity.

The World Health Organization (2010) categorizes physical activity for persons over 65 to include leisure time, transportation, occupational activities, household chores, games and sports. Activity recommendations (see table 13.1) are based on optimal levels to reduce disease risk, depression and cognitive decline and to improve cardiorespiratory and muscular fitness, bone and functional health. However, a substantial proportion of the world's population do not achieve the WHO guidelines after age 60 (Bauman et al., 2016), with 50% of those over 80 not meeting minimum activity thresholds for health (Bauman et al., 2016). Furthermore, evidence suggests that older adults sit for 9+ hours a day with levels of sedentary behavior increasing with age (Harvey et al., 2015).

The low uptake of physical activity in this age group is concerning for several reasons. Individuals who are physically active throughout the life course have reduced mortality, with

those engaging in recommended levels experiencing a 31% lower risk (Arem et al., 2015). Health benefits are not just the case for vigorous exercise, as even those who engage in 'mild' physical activities, such as laundry or home repairs, experience reduced mortality (Hamer, De Oliveira, et al., 2014). Furthermore, these benefits continue to apply even when individuals take up physical activity relatively later in life (Hamer, Lavoie, et al., 2014). Engaging in physical activity in later life can improve social outcomes, psychological outcomes and wellbeing, and enhance functional status (Bauman et al., 2016), as well as providing protective effects for a range of conditions, for example reducing the risk of developing dementia (Norton et al., 2014), coronary heart disease and stroke (Li & Siegrist, 2012), and reducing cases of falls, hip fractures and musculoskeletal symptoms (Bauman et al., 2016).

Ageing and Visual Impairment

Engaging in physical activity can be particularly challenging for those with co-morbid conditions, such as vision loss (Burton et al., 2016). As we age we are more likely to experience visual impairment (Bourne et al., 2013). This is caused by several age-related changes that occur within the eye including: changes in the curvature and internal structure of the cornea; changes to the dilation and constriction of the pupil; reduced elasticity in the eye lid; reduced elasticity and increased opacity of the lens, and reduced functioning of the retina (Schieber, 2006). In addition to these age-related structural changes in the visual system, eye diseases become more prevalent including age-related macular degeneration (AMD), glaucoma, cataract, and diabetic retinopathy (DR).

Age-related macular degeneration

AMD is the most common vision disorder in later life with an estimated global prevalence of 196 million (Wong et al., 2014). AMD is a chronic progressive disease of the

retina and vision loss occurs as a result of one of two processes: neovascular ("wet") AMD and geographic atrophy ("dry") AMD (Lim et al., 2012). The disease is experienced as a progressive loss of central vision often with associated functional limitations, challenges with adaptation and independence, concerns about the future, dissatisfaction with interactions with health services, barriers to social engagement, and negative emotions (Bennion et al., 2012). There are currently no treatments for the "dry" form of the condition, however early "wet" AMD can be treated with injections to the eye (Brown et al., 2006)

Glaucoma

Glaucoma is a leading cause of irreversible blindness with an estimated global prevalence of 76 million (Tham et al., 2014). Glaucoma is an umbrella term for various condition subtypes that cause structural damage to the optic nerve and patterns of visual field loss often due to increased intraocular pressure (Davis et al., 2016). There are two main subtypes, open-angle and angle-closure, each of which can be further divided into primary disease, with no distinguishable pathological cause, and secondary disease, where a pathological cause can be identified (Casson et al., 2012). Glaucoma is experienced as gradual peripheral vision loss leading to tunnel vision, and often results in uncertainty about treatment and concerns around illness prognosis (Wu et al., 2011). The extent to which glaucoma impacts on functioning varies, however emotional and physical challenges are reported for some patients (Glen & Crabb, 2015). Treatment varies dependent on glaucoma type and primarily aims to reduce intraocular pressure via medication, laser treatment, or surgery.

Cataract

Cataract is opacification or clouding of the lens caused by chemical changes to lens proteins (National Eye Institute, 2019a). The worldwide prevalence of cataract is estimated to be

around 95 million (Liu et al., 2017), however prevalence of age-related cataract specifically is unknown due to the absence of a uniform grading system for cataract opacity and the influence of co-existing conditions contributing to vision loss (Asbell et al., 2005). Despite this, cataracts are reported to be the most common cause of reversible vision loss in later life with over two thirds of cases being in those aged over 70 years (Nagaratnam et al., 2016). Cataracts are experienced as a gradual blurring or misting of vision, issues with glare, challenges seeing in low light, double vision, and colors appearing faded (National Eye Institute, 2019a) and can be corrected and vision restored using surgery, viscoelastics or intraocular lenses (Asbell et al., 2005). The correction of cataracts has been shown to improve function and health related quality of life in older adults (Owsley et al., 2007)

Diabetic retinopathy

Diabetic retinopathy (DR) is a complication of diabetes mellitus caused by high blood sugar levels damaging the blood vessels that supply the retina. Estimates of global prevalence for diabetic retinopathy vary, however numbers living with vision threatening DR could be as high as 28 million (Yau et al., 2012). DR can fluctuate from day to day and is experienced as general blurred or double vision, vision distortion, floaters in the visual field and changes in refractive error (National Eye Institute, 2019b). Loss of vision caused by DR can be traumatic for some patients and result in loss of independence and roles and increased social isolation (Devenney & Neill, 2011). DR can also impact on patients' ability to engage in important diabetic care activities (Coyne et al., 2004). For example, physical activity can be particularly difficult for those with DR who may adopt a fatalistic attitude towards their condition and develop a fear of going out alone (Devenney & Neill, 2011). In the early stages of DR treatment is not offered but patients are regularly monitored; in the later stages treatment can be offered in the form on

injections, laser treatment, and surgery to prevent further deterioration (National Eye Institute, 2019b).

Research Overview

Evidence suggests that older adults with visual impairment engage in physical activities less than those without visual impairment (Alma et al., 2011; Christ et al., 2014) and this reduced ability is associated with increased mortality risk (Zhang et al., 2016). There are a number of reasons why this group may be less physically active then their sighted peers including increased risk and fear of falling (Saftari & Kwon, 2018; Van Landingham et al., 2014), impacts on balance and gait (Kotecha et al., 2012; Wood et al., 2009), psychological perspectives that prioritize independence over supported participation (Burton et al., 2018; McGrath et al., 2016), and the dynamic interaction between health, functional abilities and environment (Steinman et al., 2011).

Burton, Clancy and Cowap (2018) explored perceptions of physical activity from the perspectives of older adults themselves, highlighting the existence of barriers to participation at the individual psychological level, community level, and broader societal level. From a psychological perspective, barriers to engagement include perceptions of incapability, fear, and holding the stereotypical belief that physical activity is only important for young people. From a physical community perspective, the closure of services and inaccessibility of exercise environments were perceived to prevent engagement. When considering social communities, interaction with immediate social networks, and interpersonal relationships could lead to the formation of dependency scripts due to unintentional restriction of activities by family members. For example, Burton et al (2018) highlighted accounts of family members providing unnecessary levels of personal assistance and therefore creating an expectance of dependence, such as helping

older adults in and out of the car and doing their seatbelt or taking responsibility for activities like gardening in order to get these tasks completed more quickly. On a broader societal level, town and environmental planning can fail to consider the needs of those with vision impairment effectively, for example participants highlighted how signage in a recently built bus station was too high for them to access confidently. Furthermore, a lack of public awareness of the needs of those with sight loss resulted in pavements littered with tables and chairs or uncut hedges being unexpected barricades to mobility. This lack of societal awareness also fosters negative cultural attitudes, beliefs and social norms leading to a cycle of internalized negativity towards physical activity in this population (Burton et al., 2018).

Poor visual acuity has been shown to contribute to reduced physical activity in older adults over and above other health-related factors (Swanson et al., 2012) and therefore work to understand the causes of reduced activity, and interventions to overcome these barriers, are essential to increase physical activity participation and improve the health of this population.

Interventions to improve physical activity in later life

Very few interventions have been trialed for increasing physical activity in older adults with visual impairment. A Cochrane review in 2013 was unable to draw conclusions about the value or effectiveness of behavioral or environmental interventions due to the absence of randomized controlled trials (RCT) or quasi-RCTs to increase physical activity in older adults with sight loss (Skelton et al., 2013).

However, interventions with physical activity components and a key focus of falls prevention have been conducted. Reduced visual acuity, poor contrast sensitivity, poorer depth perception and field restriction all contribute to older adults with visual impairment being at

particular risk of falls leading to fractures and hospital admissions (Waterman et al., 2016). The most frequently reported falls prevention program is the Otago exercise programme (Gardner et al., 2001) which has been evaluated in New Zealand (Campbell et al., 2005; La Grow et al., 2006), England (Waterman et al., 2016) and Hungary (Kovács et al., 2012), and in both community (Campbell et al., 2005; La Grow et al., 2006; Waterman et al., 2016) and residential settings (Kovács et al., 2012) .

The standard Otago exercise protocol involves physiotherapist or occupational therapist home visits to devise and assist with individually prescribed exercises (Gardner et al., 2001). The program is adapted to be appropriate for those with visual impairment through audio description of exercises, manual demonstration and large font written guidance (Campbell et al., 2005). Exercises are undertaken for at least 30 minutes three times a week and supplemented by a twice weekly walking plan. Strength exercises focus on lower limbs to encourage postural control and balance exercises are closely related to everyday activities. Participants are also usually supported by phone calls to discuss motivation and challenges, and prescribed vitamin D supplementation (Campbell et al., 2005; Kovács et al., 2012; La Grow et al., 2006; Waterman et al., 2016).

There is very little evidence to suggest modified versions of the Otago program are effective for falls reduction (Campbell et al., 2005; Kovács et al., 2012; La Grow et al., 2006; Waterman et al., 2016). In addition, concern has been raised about the safety of the program with reports of a 15% increase in falls in community dwelling older adults with visual impairment randomized to the Otago program when compared to a control group (Campbell et al., 2005). Reported compliance is also variable and frequently poor (Campbell et al., 2005; La Grow et al., 2006; Waterman et al., 2016), lack of compliance may explain falls risk with one study reporting

a 77% lower falls rate in those who were compliant with the program and exercising at least three times a week (Campbell et al., 2005). Caution should therefore be used when further adapting this program for this population as adherence to the program content is essential to ensure participant safety.

Pilot and feasibility studies have been conducted for several other forms of falls reduction intervention. Hackney et al (2015) compared the effectiveness of two interventions aimed at reducing fall risk in American older adults (>50 years) with diagnosed eye pathology and best corrected visual acuity less than 20/60 in the best eye. The first intervention was an adapted Tango class including a warmup and gradually increasing difficulty of steps each week. The second intervention was based on an existing falls prevention program for older adults called FallProof (Rose, 2011). The program involved activities of increasing complexity (e.g. performance of tasks sitting, then standing, then walking) and balance was tested over time by altering visual and/or somatosensory input and challenging the vestibular system. Both class types lasted 1.5 hours twice a week for 10-12 weeks. Participants in both groups showed improvement in balance over the course of the intervention and at one-month post intervention. Mobility also improved for both interventions, but this improvement was only maintained at one month for the Tango group. As a pilot study the participant sample was small (n=32), however both options present potentially effective rehabilitation strategies for older adults with visual impairment.

Kingston (2018) evaluated the adaptation of an American nationally recognized evidence-based falls prevention program called A Matter of Balance for people with vision impairment. Older adults (>60) received eight two-hour sessions delivered by a trained facilitator as part of an in-patient program. The sessions focused on teaching individuals to view falls as

controllable, goal setting for increased physical activity, identifying and making changes to address fall risk, and education on exercises to increase strength and balance. Participants also received standard care including orientation and mobility training and access to tools and technologies to improve accessibility and health. Evaluation was completed using falls and balance assessments and gait assessment before and after the intervention. No significant improvements in falls risk or balance and gait were reported when compared to usual care, however the sample size of 24 participants meant the research was underpowered to identify such an effect. Despite this, the findings were suggestive of a trend towards improvement in these areas and informal feedback from both participants and trainers indicated that the intervention was well received and thought to be effective.

Adams et al (2018) conducted a feasibility study to explore the adaptation of an existing group based falls management exercise intervention to be suitable for community dwelling older adults (>60 years) with vision impairment in the United Kingdom. The Visually Impaired Older Adults Exercise Program (VIOLET) consisted of group one-hour weekly exercise sessions for up to 10 participants over 12 weeks and took place in community venues. To aid attendance participants were offered taxi transport and permitted to bring a companion for support if they wished. A range of individually tailored exercises were included aimed at improving balance, strength, endurance, flexibility, gait, falls avoidance, and ability to get down and up from the floor. In addition, participants completed floor and adapted Tai Chi exercises becoming progressively more challenging as weeks progressed. Participants were also encouraged to complete exercises daily at home and guidance was provided in large text booklets, DVD or audio format. In order to prompt engagement, the exercises were linked to daily tasks (e.g. heel raises whilst waiting for the kettle to boil). Adams et al (2018) concluded that adaptation of the

sighted exercise program was possible, reporting high adherence and low attrition in their sample. However, little difference in the key outcome measure of fear of falling was found when compared to a control population. This may result from participants being at low risk of falling at baseline and therefore having little capacity to improve. Alternatively, the finding may reflect a sub-optimal dose of exercise for most participants. The intervention aimed to deliver the recommended 36 hours of exercise over 12 weeks for optimal falls prevention (Power & Clifford, 2013), however participants spent only 50 minutes on average engaging in exercise at home illustrating that adherence to this type of task can be a challenge for older adults with sight loss. No follow up RCT of this program has yet been published.

Other interventions have focused on improving balance and mobility with an end goal of reducing falls risk. Gleeson et al (2015) explored the effectiveness of the Alexander Technique to improve balance and mobility in older adults (aged 50-90 years) with visual impairment in Sydney, Australia. The Alexander Technique involves the use of verbal and manual guidance in ordered to teach awareness of previously unnoticed tension. The intervention was delivered as individual one-to-one sessions in the participants' own home by an accredited Alexander Technique teacher and participants received weekly 30-minute Alexander Technique lessons over a period of 12 weeks. Each lesson focused on everyday activities (e.g. walking, climbing stairs and carrying everyday articles), and subsequent lessons were based on prior progress. When compared to a control group, receiving usual care from Guide Dogs, there were no significant differences between the control and Alexander Technique group in terms of physical outcomes at three or 12 months. However, sub-group analysis did indicate that the Alexander Technique was more effective for those who had experienced multiple falls in the past with

improved gait and step length at three months post intervention and chair stand at 12 months post intervention.

Two studies have explored interventions for residential care home residents with vision impairment in Hong Kong (Chen et al., 2012; Cheung et al., 2008). Chen et al (2012) explored the effects of a Tai Chi intervention on balance control for older adults (>65 years). The program consisted of 1.5 hour long sessions three times a week for 16 weeks. Using verbal cuing and physical guidance the participants were taught a Tai Chi routine with a focus on weight shifting, head and trunk rotation and awareness of body alignment. The program was shown to be cost-effective and improvements were recorded in knee proprioception and balance control.

Cheung (2008) developed an intervention to improve balance and ambulation confidence. Female older adults (>65) with either no light perception or best corrected visual acuity in the better eye of 6/120 or poorer were recruited. The intervention was designed by a physiotherapist and included an individually tailored exercise program delivered for 45 minutes three times a week for 12 weeks alongside standard care of group physical activity. Standard care involved three sessions of 45-50 minutes each week of general exercise activities (mobilization of limbs, shoulder pulley and floor bike exercises). Intervention exercises were designed to improve functional balance and muscle strength and included stretching exercises for upper and lower limbs, balance exercises (stool stepping, tandem standing and single leg standing), and cool down stretches and mobility exercises. All exercises were progressed based on the participant's needs. Verbal and manual guidance was used to assist in completion of the exercises. Findings indicated that the intervention significantly improved balance and was particularly beneficial for those with weaker balance at baseline. While no falls were reported during the study for any

participants the intervention was suggested to have the potential to reduce falls due to improvements in balance.

Focus on functional gain such as falls reduction, balance and mobility has been at the expense of exploring participants experience and enjoyment of physical activity. Only one study has been conducted with this focus. Green and Miyahara (2008) collected case study data exploring the experience of a walking group for older adults with visual impairment in New Zealand. The group was a recreational fortnightly event organized by The Royal New Zealand Foundation of the Blind. Group members spent 3-4 hours walking with others and socializing during a lunch break. The group had between four and eleven participants during the study and walkers were supported by sighted volunteers on a ratio of either 1:1 or 1:2 during each walk. Six group members aged between 53-70 years wore a pedometer and kept a diary of their physical activities during the six-week study period. They then took part in open ended semi structured interviews about their experiences lasting between 30 minutes and two hours. The data were analyzed on a case study basis and indicated that participants tended to be more active during weeks when the walking group took place. The participants, who had a variety of types and severity of visual impairment, reported social benefits of the group and felt it was a valuable opportunity to be physically active when they may otherwise not be able to do so.

Future Research Directions and Implications for Practice

This review of the literature has illustrated that, in interventions delivered to date, the evidence of value for reducing actual falls risk is lacking. Furthermore, evidence of engagement and compliance with prescribed physical activity of this type is limited. One potential explanation for this failure to deliver successful interventions may be in their design. Focus has been on changing the behavior and functional ability of the individual with little attention paid to

the psychological, community and societal barriers that have been identified as important contributors to physical activity in this population (Burton et al., 2018).

The focus on reducing falls risk specifically overlooks other valuable features of physical activity for both mental and physical health. Interventions illustrating improvements in falls risk, mobility and balance are to be commended, however if engagement and adherence to these programs is poor their value for wider populations is questionable. Exploratory research such as that by Green and Miyahara (2008) highlights that social motivators for engagement in physical activity programs may be of more value to individuals with visual impairment than the promotion of functional benefits or falls reduction. This finding is in line with research exploring the motivators for physical activity in older adults more generally (Devereux-Fitzgerald et al., 2016) illustrating the need for future research to design and evaluate interventions that emphasize social connection and fun in order to promote intrinsic motivation for engagement.

Another limitation of interventions to date is a focus only on the individual. While some interventions have included peer support (Waterman et al., 2016), none of the published studies considered participants immediate social context such as engagement by friends or family. Evidence suggests that interventions that are delivered to older adults alongside their partner lead to increased physical activity levels (Gellert et al., 2011). Exercising together may be particularly important for those with visual impairment (Green & Miyahara, 2008) and therefore interventions that involve an individual's wider social circle should be developed and evaluated for this group.

Finally, given that physical activity has been shown to impact on psychological outcomes (Bauman et al., 2016; Norton et al., 2014) in addition to physical function, future research should consider broader outcome measures than those focused on function and reduction in falls risk.

The understanding of outcomes relating to a broader definition of health and wellbeing need to be explored to fully capture the effectiveness and value of interventions of this type.

Conclusion

The worldwide population is ageing, and physical activity can make an important contribution to ensuring good health in old age through reducing mortality, improving function, protecting from ill health and falls, and providing social, psychological and wellbeing benefits. However, very few older adults achieve the recommended levels of physical activity and uptake is particularly low for those with visual impairment. Challenges at psychological, community and societal level exacerbate the barriers experienced by this group, however interventions to date have mainly focused on falls reduction, improving function and facilitating balance. Future research and practice should explore the value of promoting the social benefits of exercise in order to enhance physical activity participation in addition to evaluating the potential for interventions to improve broader physical and psychological outcomes. Interventions must also be devised that acknowledge that an individual's level of physical activity may be constrained by community factors and that these must be addressed if interventions are to successfully change behavior long term.

References

Adams, N., Skelton, D. A., Howel, D., Bailey, C., Lampitt, R., Fouweather, T., Gray, J., Coe, D., Wilkinson, J., Gawler, S., De Jong, L. D., Waterman, H., Deary, V., Clarke, M., & Parry, S. W. (2018). Feasibility of trial procedures for a randomised controlled trial of a community based group exercise intervention for falls prevention for visually impaired older people: The VIOLET study. *BMC Geriatrics*, *18*(1), 1–15. https://doi.org/10.1186/s12877-018-0998-6

Alma, M. A., van der Mei, S. F., Melis-Dankers, B. J. M., van Tilburg, T. G., Groothoff, J. W., & Suurmeijer, T. P. B. M. (2011). Participation of the elderly after vision loss. *Disability and Rehabilitation*, *33*(1), 63–72. https://doi.org/10.3109/09638288.2010.488711

Arem, H., Moore, S. C., Patel, A., Hartge, P., Berrington de Gonzalez, A., Visvanathan, K., T., C. P., Freedman, M., Weiderpass, E., Olov Adami, H., Linet, M. S., Lee, I.-M., & Matthews, C. E. (2015). Leisure time physical activity and mortality: A detailed pooled analysis of the dose-response relationship. *JAMA Internal Medicine*, *175*(12), 959–967. https://doi.org/doi:10.1001/jamainternmed.2015.0533

Asbell, P. A., Dualan, I., Mindel, J., Brocks, D., Ahmad, M., & Epstein, S. (2005). Age-related cataract. *Lancet*, 599–609.

Bauman, A., Merom, D., Bull, F. C., Buchner, D. M., & Fiatarone Singh, M. A. (2016). Updating the Evidence for Physical Activity: Summative Reviews of the Epidemiological Evidence, Prevalence, and Interventions to Promote "active Aging." *Gerontologist*, *56*, S268–S280. https://doi.org/10.1093/geront/gnw031

Bennion, A. E., Shaw, R. L., & Gibson, J. M. (2012). What do we know about the experience of age related macular degeneration? A systematic review and meta-synthesis of qualitative

research. *Social Science and Medicine*, *75*(6), 976–985.

Bourne, R. R. A., Stevens, G. A., White, R. A., Smith, J. L., Flaxman, S. R., Price, H., Jonas, J. B., Keeffe, J., Leasher, J., Naidoo, K., Pesudovs, K., Resnikoff, S., & Taylor, H. R. (2013). Causes of vision loss worldwide, 1990-2010: A systematic analysis. *The Lancet Global Health*, *1*(6), 339–349.

Brown, D. M., Kaiser, P. K., Michels, M., Soubrane, G., Heier, J. S., Kim, R. Y., Sy, J. P., & Schneider, S. (2006). Ranibizumab versus verteporfin for neovascular age-related macular degeneration. *The New England Journal of Medicine*, *355*(14), 1432–1444.

Burton, A. E., Clancy, L., & Cowap, L. (2018). Exploring the facilitators and barriers to physical activity in older people with sight loss. *Journal of Aging and Physical Activity*, *26*, 25–33. https://doi.org/10.1123/japa.2016-0123

Burton, A. E., Gibson, J. M., & Shaw, R. L. (2016). How do older people with sight loss manage their general health ? A qualitative study. *Disability and Rehabilitation*, *14*(23), 1-9 [Epud ahead of print]. https://doi.org/10.3109/09638288.2015.1123310

Campbell, A. J., Robertson, M. C., La Grow, S. J., Kerse, N. M., Sanderson, G. F., Jacobs, R. J., Sharp, D. M., & Hale, L. A. (2005). Randomised controlled trial of prevention of falls in people aged ≥75 with severe visual impairment: The VIP trial. *British Medical Journal*, *331*(7520), 817–820. https://doi.org/10.1136/bmj.38601.447731.55

Casson, R. J., Chidlow, G., Wood, J. P. M., Crowston, J. G., & Goldberg, I. (2012). Definition of glaucoma: Clinical and experimental concepts. *Clinical and Experimental Ophthalmology*, *40*(4), 341–349. https://doi.org/10.1111/j.1442-9071.2012.02773.x

Chen, E. W., Fu, A. S. N., Chan, K. M., & Tsang, W. W. N. (2012). The effects of Tai Chi on the balance control of elderly persons with visual impairment: A randomised clinical trial. *Age*

and Ageing, *41*(2), 254–259. https://doi.org/10.1093/ageing/afr146

Cheung, K. K. W., Au, K. Y., Lam, W. W. S., & Jones, A. Y. M. (2008). Effects of a structured exercise programme on functional balance in visually impaired elderly living in a residential setting. *Hong Kong Physiotherapy Journal*, *26*(1), 45–50. https://doi.org/10.1016/S1013-7025(09)70007-7

Christ, S. L., Zheng, D. D., Swenor, B. K., Lam, B. L., West, S. K., Tannenbaum, S. L., Muñoz, B. E., & Lee, D. J. (2014). Longitudinal Relationships Among Visual Acuity, Daily Functional Status, and Mortality: The Salisbury Eye Evaluation Study. *JAMA Ophthalmology*, *2055*(12), 1–7.

Coyne, K. S., Margolis, M. K., Kennedy-Martin, T., Baker, T. M., Klein, R., Paul, M. D., & Revicki, D. A. (2004). The impact of diabetic retinopathy: Perspectives from patient focus groups. *Family Practice*, *21*(4), 447–453.

Davis, B. M., Crawley, L., Pahlitzsch, M., Javaid, F., & Cordeiro, M. F. (2016). Glaucoma: the retina and beyond. *Acta Neuropathologica*, *132*(6), 807–826. https://doi.org/10.1007/s00401-016-1609-2

Devenney, R., & Neill, S. (2011). The experience of diabetic retinopathy: A qualitative study. *British Journal of Health Psychology*, *16*(4), 707–721. https://doi.org/10.1111/j.2044-8287.2010.02008.x

Devereux-Fitzgerald, A., Powell, R., Dewhurst, A., & French, D. P. (2016). The acceptability of physical activity interventions to older adults: A systematic review and meta-synthesis. *Social Science and Medicine*, *158*, 14–23. https://doi.org/10.1016/j.socscimed.2016.04.006

Gardner, M. M., Buchner, D. M., Robertson, C., & John Campbell, A. (2001). Practical implementation of an exercise-based falls prevention programme. *Age and Ageing*, *30*, 77–

83.

Gellert, P., Ziegelmann, J. P., Warner, L. M., & Schwarzer, R. (2011). Physical activity intervention in older adults: Does a participating partner make a difference? *European Journal of Ageing*, *8*(3), 211–219. https://doi.org/10.1007/s10433-011-0193-5

Gleeson, M., Sherrington, C., Lo, S., & Keay, L. (2015). Can the alexander technique improve balance and mobility in older adults with visual impairments? A randomized controlled trial. *Clinical Rehabilitation*, *29*(3), 244–260. https://doi.org/10.1177/0269215514542636

Glen, F. C., & Crabb, D. P. (2015). Living with glaucoma: A qualitative study of functional implications and patients' coping behaviours. *BMC Ophthalmology*, *15*(1), 1–15. https://doi.org/10.1186/s12886-015-0119-7

Green, C., & Miyahara, M. (2008). Older Adults With Visual Impairment: Lived Experiences and a Walking Group. *RE:View: Rehabilitation and Education for Blindness and Visual Impairment*, *39*(3), 91–112. https://doi.org/10.3200/revu.39.3.91-112

Hackney, M. E., Hall, C. D., Echt, K. V., & Wolf, S. L. (2015). Multimodal exercise benefits mobility in older adults with visual impairment: A preliminary study. *Journal of Aging and Physical Activity*, *23*(4), 630–639. https://doi.org/10.1123/japa.2014-0008

Hamer, M., De Oliveira, C., & Demakakos, P. (2014). Non-exercise physical activity and survival: English Longitudinal Study of Ageing. *American Journal of Preventive Medicine*, *47*(4), 452–460. https://doi.org/10.1016/j.amepre.2014.05.044

Hamer, M., Lavoie, K. L., & Bacon, S. L. (2014). Taking up physical activity in later life and healthy ageing: the English longitudinal study of ageing. *British Journal of Sports Medicine*, *48*(3), 239–243. https://doi.org/10.1136/bjsports-2013-092993

Harvey, J. A., Chastin, S. F. M., & Skelton, D. A. (2015). How sedentary are older people? A

systematic review of the amount of sedentary behavior. *Journal of Aging and Physical Activity*, *23*(3), 471–487. https://doi.org/10.1123/japa.2014-0164

Kingston, J. T. (2018). Visual impairment and falls: Outcomes of two fall risk assessments after a four-week fall prevention program. *Journal of Visual Impairment and Blindness*, *112*(4), 411–415. https://doi.org/10.1177/0145482X1811200408

Kotecha, A., Richardson, G., Chopra, R., Fahy, R. T. A., Garway-Heath, D. F., & Rubin, G. S. (2012). Balance control in glaucoma. *Investigative Ophthalmology and Visual Science*, *53*(12), 7795–7801. https://doi.org/10.1167/iovs.12-10866

Kovács, É., Tóth, K., Dénes, L., Valasek, T., Hazafi, K., Molnár, G., & Fehér-Kiss, A. (2012). Effects of exercise programs on balance in older women with age-related visual problems: A pilot study. *Archives of Gerontology and Geriatrics*, *55*(2), 446–452. https://doi.org/10.1016/j.archger.2012.01.009

La Grow, S. J., Robertson, M. C., Campbell, A. J., Clarke, G. A., & Kerse, N. M. (2006). Reducing hazard related falls in people 75 years and older with significant visual impairment: How did a successful program work? *Injury Prevention*, *12*(5), 296–301. https://doi.org/10.1136/ip.2006.012252

Li, J., & Siegrist, J. (2012). Physical activity and risk of cardiovascular disease-a meta-analysis of prospective cohort studies. *International Journal of Environmental Research and Public Health*, *9*(2), 391–407. https://doi.org/10.3390/ijerph9020391

Lim, L. A., Mitchell, P., Seddon, J. M., Holz, F. G., & Wong, Y. T. (2012). Age-related macular degeneration. *The Lancet*, *379*, 1728–1738.

Liu, Y. C., Wilkins, M., Kim, T., Malyugin, B., & Mehta, J. S. (2017). Cataracts. *The Lancet*, *390*(10094), 600–612. https://doi.org/10.1016/S0140-6736(17)30544-5

McGrath, C., Laliberte Rudman, D., Polgar, J., Spafford, M. M., & Trentham, B. (2016). Negotiating “positive” aging in the presence of age-related vision loss (ARVL): The shaping and perpetuation of disability. *Journal of Aging Studies*, *39*, 1–10. http://0-ovidsp.ovid.com.lib.exeter.ac.uk/ovidweb.cgi?T=JS&PAGE=reference&D=prem&NEWS=N&AN=27912847

Nagaratnam, N., Nagaratnam, K., & Cheuk, G. (2016). Low and loss of vision in the elderly. In *Diseases in the Elderly: Age-related changes and pathophysiology* (pp. 343–355). Springer.

National Eye Institute. (2019a). *Cataracts*. https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/cataracts

National Eye Institute. (2019b). *Diabetic Retinopathy*. https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/diabetic-retinopathy

Norton, S., Matthews, F. E., Barnes, D. E., Yaffe, K., & Brayne, C. (2014). Potential for primary prevention of Alzheimer’s disease: An analysis of population-based data. *The Lancet Neurology*, *13*(8), 788–794. https://doi.org/10.1016/S1474-4422(14)70136-X

Owsley, C., McGwin, G., Scilley, K., Meek, G. C., Seker, D., & Dyer, A. (2007). Impact of cataract surgery on health-related quality of life in nursing home residents. *British Journal of Ophthalmology*, *91*(10), 1359–1363. https://doi.org/10.1136/bjo.2007.118547

Power, V., & Clifford, A. M. (2013). Characteristics of optimum falls prevention exercise programmes for community-dwelling older adults using the FITT principle. *European Review of Aging and Physical Activity*, *10*(2), 95–106. https://doi.org/10.1007/s11556-012-0108-2

Rose, D. J. (2011). Reducing the risk of falls among older adults: The fallproof balance and mobility program. *Current Sports Medicine Reports*, *10*(3), 151–156.

https://doi.org/10.1249/JSR.0b013e31821b1984

Saftari, L. N., & Kwon, O. S. (2018). Ageing vision and falls: A review. *Journal of Physiological Anthropology*, *37*(1), 1–14. https://doi.org/10.1186/s40101-018-0170-1

Schieber, F. (2006). Vision and aging. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (6th ed., pp. 129–132). Elsevier.

Skelton, D. A., Howe, T. E., Ballinger, C., Neil, F., Palmer, S., & Gray, L. (2013). Environmental and behavioural interventions for reducing physical activity limitation in community-dwelling visually impaired older people. *The Cochrane Database of Systematic Reviews*, *6*, CD009233. https://doi.org/10.1002/14651858.CD009233.pub2

Steinman, B. A., Nguyen, A. Q. D., Pynoos, J., & Leland, N. E. (2011). Falls-prevention interventions for persons who are blind or visually impaired. *Insight: Research and Practice in Visual Impairment and Blindness*, *4*(2), 83–91.

Swanson, M. W., Bodner, E., Sawyer, P., & Allman, R. M. (2012). Visual acuity's association with levels of leisure-time physical activity in community-dwelling older adults. *Journal of Aging and Physical Activity*, *20*(1), 1–14.

Tham, Y. C., Li, X., Wong, T. Y., Quigley, H. A., Aung, T., & Cheng, C. Y. (2014). Global prevalence of glaucoma and projections of glaucoma burden through 2040: A systematic review and meta-analysis. *Ophthalmology*, *121*(11), 2081–2090. https://doi.org/10.1016/j.ophtha.2014.05.013

Van Landingham, S. W., Massof, R. W., Chan, E., Friedman, D. S., & Ramulu, P. Y. (2014). Fear of falling in age-related macular degeneration. *BMC Ophthalmology*, *14*(1), 1–9. https://doi.org/10.1186/1471-2415-14-10

Waterman, H., Ballinger, C., Brundle, C., Chastin, S., Gage, H., Harper, R., Henson, D.,

Laventure, B., McEvoy, L., Pilling, M., Olleveant, N., Skelton, D. A., Stanford, P., & Todd, C. (2016). A feasibility study to prevent falls in older people who are sight impaired: The VIP2UK randomised controlled trial. *Trials*, *17*(1), 1–14. https://doi.org/10.1186/s13063-016-1565-0

Wong, W. L., Su, X., Li, X., Cheung, C. M. G., Klein, R., Cheng, C. Y., & Wong, T. Y. (2014). Global prevalence of age-related macular degeneration and disease burden projection for 2020 and 2040: A systematic review and meta-analysis. *The Lancet Global Health*, *2*(2), 106–116. https://doi.org/10.1016/S2214-109X(13)70145-1

Wood, J. M., Lacherez, P. F., Black, A. A., Cole, M. H., Boon, M. Y., & Kerr, G. K. (2009). Postural stability and gait among older adults with age-related maculopathy. *Investigative Ophthalmology and Visual Science*, *50*(1), 482–487. https://doi.org/10.1167/iovs.08-1942

World Health Organization. (2010). *Global recommendations on physical activity for health.*

World Health Organization. (2015). *World report on ageing and health*.

World Health Organization. (2020a). *Ageing and health*. Key Facts. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

World Health Organization. (2020b). *World Health Statistics 2020: Monitoring health for the SDGs, sustainable development goals*.

Wu, P. X., Guo, W. Y., Xia, H. O., Lu, H. J., & Xi, S. X. (2011). Patients' experience of living with glaucoma: A phenomenological study. *Journal of Advanced Nursing*, *67*(4), 800–810. https://doi.org/10.1111/j.1365-2648.2010.05541.x

Yau, J. W. Y., Rogers, S. L., Kawasaki, R., Lamoureux, E. L., Kowalski, J. W., Bek, T., Chen, S. J., Dekker, J. M., Fletcher, A., Grauslund, J., Haffner, S., Hamman, R. F., Ikram, M. K., Kayama, T., Klein, B. E. K., Klein, R., Krishnaiah, S., Mayurasakorn, K., O'Hare, J. P., …

Wong, T. Y. (2012). Global prevalence and major risk factors of diabetic retinopathy. *Diabetes Care*, *35*(3), 556–564. https://doi.org/10.2337/dc11-1909

Zhang, T., Jiang, W., Song, X., & Zhang, D. (2016). The association between visual impairment and the risk of mortality: a meta-analysis of prospective studies. *Journal of Epidemiology and Community Health*, *70*(8), 836–842.