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Review Article / Derleme

Exercise programming for individuals with vision loss

Görme kaybı olan bireyler için egzersiz programlama

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ABSTRACT

For individuals with vision loss (IWVL), exercise is of primary importance to optimize their functional mobility, functionality and activities of daily living. Enhancing aerobic capacity and muscle strength through exercise prescribing can help improve independent living and quality of life for IWVL. The aim of this review is to emphasize the importance of aerobic and strength exercises for underserved IWVL population by summarizing the information that will guide the basic exercise programs to improve living conditions. General guidelines for aerobic and strength exercise training for the IWVL are outlined with relevant images to contribute to build an effective exercise prescription.

Keywords: *Visual impairment, vision loss, adapted physical activity, exercise, physical fitness*

ÖZ

Egzersiz görme kaybı olan bireylerin fonksiyonel mobilitelerini, işlevselliklerini ve günlük yaşam aktivitelerini optimal hale getirmek için birincil öneme sahiptir. Egzersiz reçetesi ile aerobik kapasiteyi ve kas kuvvetini artırmak görme kaybı olan bireylerin bağımsız yaşamlarını geliştirmeye ve yaşam kalitelerini artırmaya yardımcı olabilir. Bu derlemenin amacı, yaşam koşullarını iyileştirmek için temel egzersiz programlarına rehberlik edecek bilgileri özetleyerek, yetersiz hizmet alan görme kaybı olan bireyler için aerobik ve kuvvet egzersizlerinin önemini vurgulamaktır. Görme kaybı olan bireyler içingenel aerobik ve kuvvet egzersiz antrenman ilkeleri, etkili bir egzersiz reçetesi oluşturmaya katkıda bulunmak için ilgili görsellerle özetlenmiştir.

Anahtar Sözcükler: *Görme bozukluğu, görme kaybı, uyarlanmış fiziksel aktivite, egzersiz, fiziksel uygunluk*

INTRODUCTION

Vision is a multifaceted sensory function that requires the hierarchal participation of receptors, transmission and processing structures to transform captured visual information into meaningful senses and damage along with the visual pathway results in vision loss or blindness (1). Vision impairment, also known as visual impairment (VI), is an umbrella term to describe any kind of vision loss. As seen in Table 1., the International Classification of Diseases 11 (2018) classifies VI into two core categories; distance and near presenting VI (2, 3). The prevalence of distance VI in low-and middle-income regions is estimated to be four times higher than in high-income regions (2). Accordingly, near VI prevalence is estimated to be greater in low-income regions than high-income regions (4). The growth and ageing of the world's population are causing a significant increase in the number of people affected from VI (2). Most causes of VI are associated with ageing; however, loss of vision occurs before or at birth (congenital), during childhood, or later in life (adventitious) (5). Global prevalence of VI is 2.2 billion approximately and the leading causes of VI are uncorrected refractive errors (88.4 million), cataract (94 million), glaucoma (7.7 million), diabetic retinopathy (3.9 million), corneal opacity (4.2 million), trachoma (2 million), unaddressed presbyopia (826 million) and age-related macular degeneration (2).

VI may affect physical, cognitive, and psychological and social functioning, all important contributors to successful ageing (6). It is reported that individuals with vision loss (IWVL) demonstrate less developed motor skills, their quality of life and physical fitness levels tend to be lower than their sighted peers (7-12). They also have tendency to be overweight or obese and these problems are associated with a sedentary lifestyle (12). Reduced vision in older individuals is associated with falls and reduced performance in gait. Visual field impairment from glaucoma, contrast sensitivity, self-reported poor vision, impaired depth perception, presence of cataract and poor visual acuity are considerably related to falls, may affect gait and reduce mobility

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(13-17). Alternative training modalities such as virtual reality training programs are shown to be effective in improving balance and functional mobility in older individuals (18). These alternative training approaches can be tailored for IWVL. Circadian disorders are frequent in the blind especially in those who have no light perception (19, 20). This may lead disturbances in sleep/wake behaviours, alertness, mood and performance (21). Proper and well-established fitness programs can be beneficial for improvements in quality of life (e.g., increased sleep efficiency, enhancing physical and psychosocial functioning) and contribute to motor skill proficiency as well as activity of daily living (ADL) for IWVL.

Table 1. Categories of vision impairment with corresponding visual acuity

	Presenting visual acuity* in the better eye
Distance Vision Impairment	
· **Mild**	Visual acuity worse than 6/12 to 6/18
· **Moderate**	Visual acuity worse than 6/18 to 6/30
· **Severe**	Visual acuity worse than 6/60 to 3/60
· **Blindness**	Visual acuity worse than 3/60
Near Vision Impairment	
· **Presbyopia**	Visual acuity worse than N6 or M.08 at 40 cm

*Snellen visual acuity or the equivalent calculated from published logarithm of the minimum angle of resolution values.

Benefits of Exercise

Aerobic training

It is recommended that adult individuals should engage in moderate-intensity aerobic exercise for ≥30 min.d^{-1} on ≥5 d.wk^{-1} for a total of ≥150 min.wk^{-1}, vigorous intensity aerobic exercise for ≥20 min.d^{-1} on ≥3 d.wk^{-1} or a combination of moderate-and-vigorous-intensity aerobic exercise to achieve a total energy expenditure of ≥500-1000 MET.min.wk.$^{-1}$(22). This is not only significant for general population but for IWVL as well, because aerobic exercise contributes to cardiovascular fitness and helps to reduce attaining the secondary health conditions. It is reported that blindness is associated with reduced mechanical efficiency which leads to higher energy consumption and increase in fatigue during ambulation (23, 24). Aerobic capacity depends on type and intensity of exercise which may be temporarily related to the onset of blindness and VI degree (25). Limited studies showed that blind adolescent girls aged 10-18 showed similar peak oxygen intake with their sighted counterparts (23, 24), whereas sighted adolescent boys aged 12-18 had significantly higher aerobic capacity than that of the blind boys (23). When gender was taken into consideration, aerobic capacity of blind boys was higher than blind girls and difference in aerobic capacity between congenital and non-congenital blind individuals was not statistically significant (25). It was found that children with VI had lower cardiovascular endurance than their sighted peers (26) and irrespective of gender; youth with VI had lower aerobic fitness levels (27, 28). In contrast, peak oxygen uptake (VO_{2peak}) of blind soccer players was 51.8± 5.8 ml/kg/min and this finding suggests that blind individuals can improve their aerobic fitness regardless of their VI (29). Indeed, a unique study conducted by Saishoji and Nakata revealed that 20-min rope-guided walking (RG-walking) training increased VO_{2peak} of IWVL by 12.4% from 30.6±10.7 ml/kg/min to 34.4±10.4 ml/kg/min by the fourth week of training (30). Based on their findings RG-walking can be recommended as an effective exercise in increasing the aerobic capacity of IWVL (Figure 1). In addition, study by Chen and Lin (32) has shown that ten weeks of rope jumping exercise improved the aerobic capacity of adolescents with VI (31).

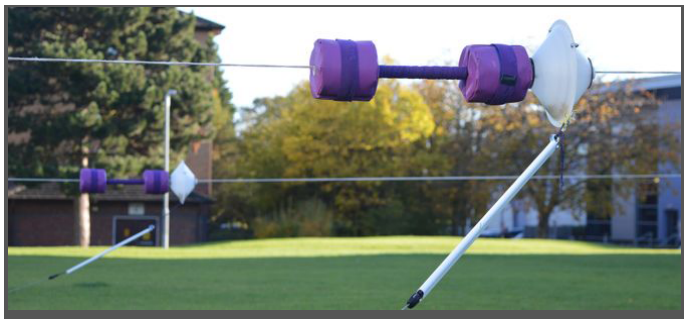

Figure 1. Running line (Image is credited to 'Loughborough University' and permission is obtained)

Strength training

The American Colleague of Sports Medicine (ACSM) recommends that adults should perform strength exercises for each of the major muscle groups for 2-3d.wk^{-1} (22). This recommendation is no different for IWVL and in order to decrease the functional limitations and improve ADL in IWVL. Muscle strength is imperative for posture and balance and reduced lower extremity muscle strength is associated with poor balance and greater risk for falls (32, 33). One of the earliest studies conducted by Wyatt and Ng reported that strength levels drop with the degree of VI and they found that congenitally blind children and children with low vision had weaker knee extensors than their sighted peers (34). Similarly, Horvat et al. reported lower muscular strength and power in adults with VI compared to sighted controls

(35). On the other hand, da Silva Alves et al. found that torque values obtained for the blind athletes were higher than those reported in the study conducted by Horvat et al. (29, 35). It has been found that isometric and isokinetic strength of the knee and ankle muscles were similar in blind and sighted women (33) and Loturco et al. reported similar performances in maximal isometric strength in Paralympic and Olympics Judo athletes (36). Based on these very limited findings, it can be recommended that regular participation in exercise promotes muscular strength in IWVL.

Key Considerations for Exercise Prescription

There are no definite exercise prescriptions and guidelines for IWVL because of various degrees of VI and adjustments may be necessary according to the needs of each IWVL. Some exercise considerations can be disability specific whereas others can be similar to those of the general population. A variety of instructional strategies can be used when teaching exercises for IWVL such as demonstration, verbal instruction, and tactile teaching (5). Two very common methods used with IWVL are physical guidance and tactile modelling coupled with verbal explanations (Figure 6). Exercise programmers, fitness instructors, coaches or guide can develop goals taking into the considerations mentioned in Table 2 (5, 22, 36-40).

Table 2. Considerations for exercise prescription for individuals with vision loss

• The exercise program should be modified according to individual's habitual PA, physical function, health status, exercise responses, and stated goals **(22,36)**.
• The most significant element when working with individuals with vision loss is safety while exercising.
• Medical clearance from physician who specializes in visual impairment should be obtained and a consultation with an ophthalmologist is advised.
• Glaucoma causes increased pressure in the eye and any activity such as headstands, handstands, or swimming deep under water may cause additional pressure in the head **(5, 40)**.
• Rapid elevation in blood pressure inside the eye may cause vessels to rapture, worsening retinopathy; therefore, contact sports must be avoided in order to avoid being hit in the head or hitting other individuals **(5)**. Lifting light weights as strength exercise and brisk walking as aerobic exercise are recommended because lifting heavy weights can cause the pressure in those vessels to increase and jogging or running can cause sensitive blood vessels to leak blood or fluid.
• Evening exercises (18:00-20:00) may lower the odds of vision field loss progression suggesting a decrease in glaucoma progression **(37)**.
• Regardless of muscle group or contraction, the endogenous period of the circadian rhythms in the blind individuals are free running (more than 24 h). Therefore, measurement of circadian rhythm with feasible techniques such as measurement of body temperature can detect this condition and exercise program can be evaluated accordingly **(39)**.
• Especially congenitally blind individuals rely on auditory (verbal cues/audible signals) and tactile stimuli (such as hand on hand technique). They have no visual stimulus to discover their surroundings which limits their ability to exercise and leads a decrease in their work capacity **(5, 38)**. Programs should be designed with taking these into consideration.

Aerobic exercise prescription

The aim of aerobic exercise is to improve functional mobility, and capacity and enhancing cardiovascular health in IWVL (36). Many authors highlighted that IWVL can benefit from aerobic exercises such as walking, rope jumping and aerobics despite their inability to monitor body movements visually (30, 41 ,42). Table 3 presents an example of an aerobic exercise program for IWVL. The most significant element while exercising in IWVL is using guide running techniques including assistive devices and/or sighted guides. Assistive equipment and accessories, such as guide wire, cane, running line (Figure 2), tether (Figure 3), or rope guide and individuals as sighted guides (Figure 3) are very significant (5).

As presented in Table 3 adults with VI can perform ≤20 minutes of continuous activities at a low to moderate intensity at the beginning and as the fitness level improves, work duration can be increased up to ≤60 minutes. Kobberling (23) recommended that both sighted and blind adolescents need a minimum of 30 minutes of daily activity at minimum

oxygen consumption at 8 METs to attain and maintain their age-predicted normal aerobic capacity. This can be used to plan appropriate aerobic exercise for visually impaired children and adolescents with VI because they can attain aerobic fitness levels similar to those of sighted children.

Table 3. Exercise prescription for individuals with vision loss

	Aerobic fitness
Frequency	≥ 2-3 d.wk^{-1} or 5-6 d.wk^{-1} depending on the fitness level
Intensity	Low to moderate (RPE=3 out of 10 or 50-65% of HR_{max}) and moderate to vigorous (RPE= 5-10 out of 10 or 65-85% of HR_{max})
Duration	≥20 min.d^{-1} to ≥60 min.d^{-1}
Type	Aerobic exercises involving large muscle groups
Modes	• Cycling [regular, tandem (Figure 4) or stationary upper and lower body hand cycling ergometer depending on visual acuity] • Walking, jogging or running activities on treadmill (Figure 5) or step ergometer. • On ground using guide running techniques, guide wire, tether, running to a sound source, running line, rope-guided or with a sighted guide depending on visual acuity • Stationary rowing • Battle rope • Swimming
Special element	Using the auditory and tactile stimuli is significant for learning, progression and safety. Let the IWVL touch you (hand on hand approach as in Figure 6)
	Muscular strength
Frequency	2-4 d.wk^{-1}
Intensity	• 1-15 RM • Number of repetitions depend on requirements for developing various type of strength
Duration	1-3 sets X 1-15 reps X 5-15 exercises depending on fitness level
Type	Strength exercises involving major muscle groups in the chest, shoulders, back, hips, legs, arms and abdomen.
Modes	• Calisthenics • Resistance bands • Medicine balls (see Figure 7) • Dumbbells and bars (see Figure 8) • Wearable resistances (weights) • Resistance machines
Special element	• Aerobic warm-up • Strict posture and correct technique • Equipment familiarization with 'hand on hand' as tactile stimulus is utmost important • Consistent repetition duration

RPE: rating of perceived exertion; HR_{max}: maximal heart rate; IWVL: individuals with vision loss.

Figure 2. A blind girl running with running line (Image is credited to 'Loughborough University' and permission is obtained)

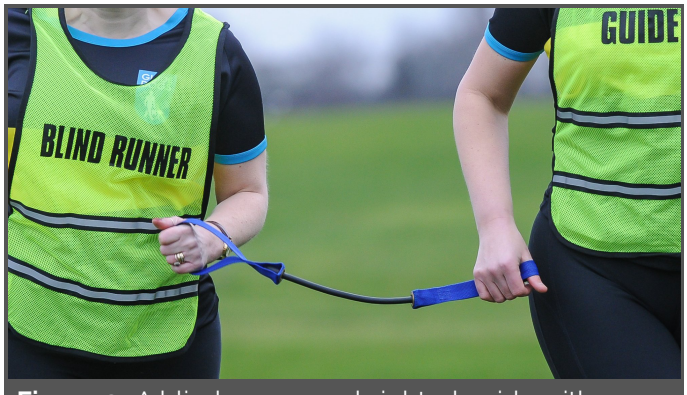

Figure 3. A blind runner and sighted guide with a tether

Figure 4. The sighted rider (pilot) with a blind cyclist

Figure 5. Blind person walking on a motorized treadmill. As seen in the figure, a treadmill with handrail supports should be preferred and rope can be tied up to either end of handrails behind the blind person for safety.

Resistance exercise prescription

According to the ACSM, strength exercise training may improve or maintain bone mass, muscle mass, glucose tolerance, musculotendinous integrity, the ability to carry out the ADL, fat free mass and resting metabolic rate of daily living (36). The most significant element is to make sure that IWVL performing the exercises with the strict posture and correct technique. Equipment familiarization and supported exercises are also of utmost importance. Strength exercise training for IWVL resembles those of healthy individuals.

Figure 6. Instructor is demonstrating a swimming technique with hand on hand approach

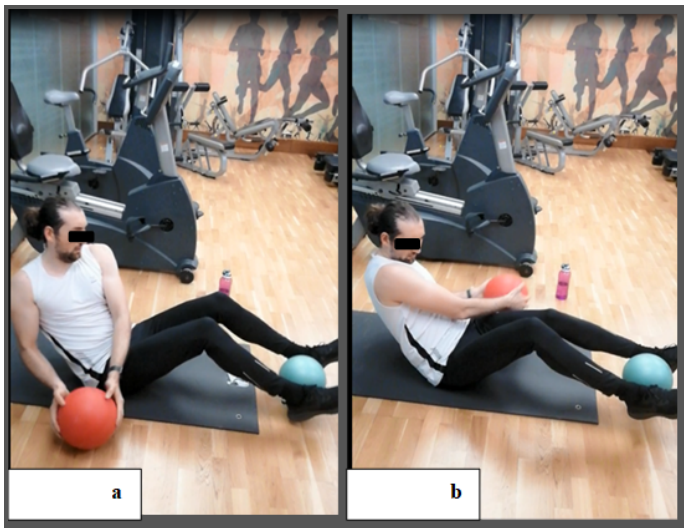

Figure 7. Medicine ball side twists. Blind person is exercising with medicine ball to increase muscular strength and endurance.

The strength exercise training for IWVL should warrant improved physical functioning and increased core and dynamic strength, improved postural balance and reduced risk of falls. Strength is one of the components of physical functioning and strength training improves functionality in IWVL. Additionally, strength exercise training will strengthen key muscles needed for ADL and prevent injuries from muscle imbalances because it is reported that IWVL adopts compensatory postural changes in order to adjust the centre of gravity (42). It is important to adapt and structure the program according to strength level and loss of visual sense in IWVL (Table 3). For this, resistance machines with support base such as smith machine can be safer for IWVL compared to free weights. Furthermore, training load to determine 1 repetition maximum (1RM) values from multiple repetitions can be applied to adopt the strength exercise program (43). Primary focus of the initial program should be on improving the strength and endurance of each major muscle groups; the progression of the strength exercise program should be arranged week to week with the focus on anatomical adaptation to balance and strengthen the musculoskeletal system. Anatomical adaptation is the most basic and fundamental method and light resistance with high repetitions circuit weight training are recommended (44). Following the anatomical adaptation phase in strength exercise training, the exercise program should be individualized addressing the needs and desires of the IWVL.

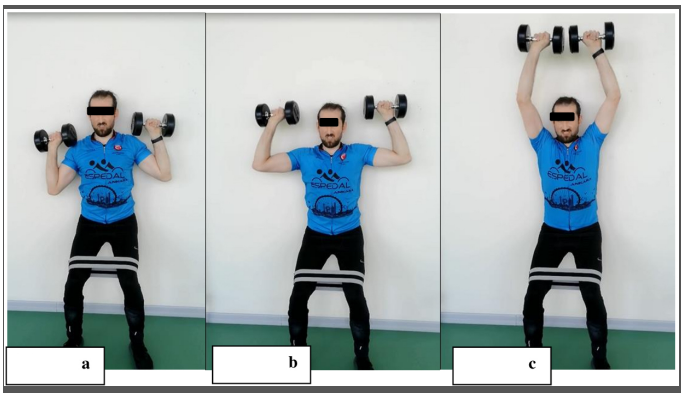

Figure 8. Dumbbells for the development of shoulder strength. This is also a good example including tactile demarcations as the blind person leaning against a wall. Additionally, blind person is performing dumble shoulder press exercise

CONCLUSION

Improving aerobic and strength conditioning of IWVL can help advancing independent living and quality of life and can allow them to perform ADL without getting exhausted quickly. Adapting exercise to this particular population requires specific exercise guidelines and consideration of VI characteristics. The variability of VI degree demonstrates the importance of an individual approach determining the appropriate exercise program. Life time blindness (congenital vs acquired), degree of VI, VI causes, gender and age are key factors when designing exercise plan for this special population. Maintaining a healthy body weight, increasing strength and improving functional mobility means a better quality of life for IWVL. Creating an adaptive exercise by trainers, reviewing and improving the program to achieve requested goals will be of great benefit to this particular population.

Conflict of Interest / Çıkar Çatışması

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Author Contributions / Yazar Katkıları

Concept FE; Design FE; Supervision SA, LK, GD; Materials FE; Data Collection and/or Processing FE; Analysis and Interpretation All authors; Literature Review FE; Writing Manuscript FE; Critical Reviews All authors.

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