Chapter

Adapted Physical Activity and Ataxia

Katerina Asonitou and Dimitra Koutsouki

Abstract

Ataxia affects the neurological system by impairing balance and motor coordination, which results in significant sensorimotor impairment in both children and adults. Physical activity (PA) has been linked to changes in the structure and functionality of the brain as well as effects on brain plasticity, according to numerous experimental and clinical studies. PA can help with concerns with standing and walking, fine and gross motor function regulation, and muscular tone. This chapter discusses the effects of various training programs on people with ataxia. Exercises that target balance, coordination, and muscular strength include: a) physical activity; b) treadmill training; c) locomotor training on a treadmill; d) trunk stabilization training; e) overground walking for balance; f) intensive exercises; and g) body-controlled videogames (exergames) played at home. Exercise and physical activity must be done frequently to maintain health, wellbeing, and quality of life. The duration and severity of the disease have an impact on how well adapted physical activity works.

Keywords: adapted physical activity, training exercises, ataxia, intervention, rehabilitation

1. Introduction

> *"Lack of activity destroys the good condition of every human being, while movement and methodical physical exercise save it and preserve it." – Plato (ancient Greek philosopher, 427–347 BCE).*

Inherited degenerative ataxia (DA) represents a clinically varied range of inheritance patterns, including autosomal dominant, autosomal recessive, X-linked, and mitochondrial. Hereditary ataxias with distinct mapped brain structures include fragile X tremor ataxia syndrome (FXTAS), ataxia telangiectasia (AT), ataxia with oculomotor apraxia types 1 and 2 (AOA1, AOA2), cerebellar ataxia/neuropathy/vestibular are flexia syndrome (CANVAS), and spinocerebellar ataxia (SCA). However, many inherited DA cases are idiopathic. A person's freedom and quality of life are negatively impacted by this group of disorders, which are characterized by a progressive deterioration in balance and coordination [1].

Cerebellar degeneration may result from inherited genetic mutations. Control over coordination is located in the cerebellum. The consequent lack of coordination in the

lower and upper limbs, trunk, and neck affects all activities such as walking, standing, being on all fours, kneeling, squatting, sitting, controlling gestures, controlling speech, initiating an action, and stopping an action. Movements involving the fingers, hands, eyes, and voice are also affected. Because of this, the central nervous system's various regions and the communication pathways that carry information to them are dysfunctional, resulting in the typical ataxia symptoms [2].

There is currently no cure, and both medical and surgical interventions have only minor effects [2]. However, rehabilitative training regimens are advantageous for this population. By reducing the risk of the most prevalent age-related diseases, such as cardiovascular disease, stroke, diabetes, obesity, metabolic disorder, inflammation, muscle atrophy, bone and cartilage loss or degeneration, a decline in aerobic capacity, and the progression of several neurodegenerative diseases, physical activity has been shown in the literature to improve overall health. There is proof that living an active lifestyle and having good health go hand in hand [3–5] (**Figure 1**).

Exercise benefits all of the physiological systems in the human body, including the digestive, immune, circulatory, respiratory, and musculoskeletal systems [7]. Additionally, the benefits of exercise for brain health may slow the cognitive loss associated with aging. Regular exercise enhances cognition, memory, attention, processing speed, and executive function in healthy individuals and reduces the risk of dementia and other age-related cognitive illnesses [8, 9]. The authors recommend that future studies examine the amount of exercise that will best promote protection.

Exercise promotes pre- and postsynaptic function, synaptic plasticity, neurogenesis (neuroplasticity), and neuronal number [10]. Astrocytic degeneration, astrocyte size, and astrocyte levels may also increase [11] (**Figure 2**).

Maugeri and her colleagues conducted research on the effects of exercise on brain function in 2021, concentrating on the activity of astrocytes in a healthy central nervous system. They observed astrocytes and exercise have a positive relationship, and astrocyte changes may play a significant role in the improvement of executive and cognitive brain processes that is associated with exercise. The findings of this review showed the importance of exercise as a reliable and commonly used method

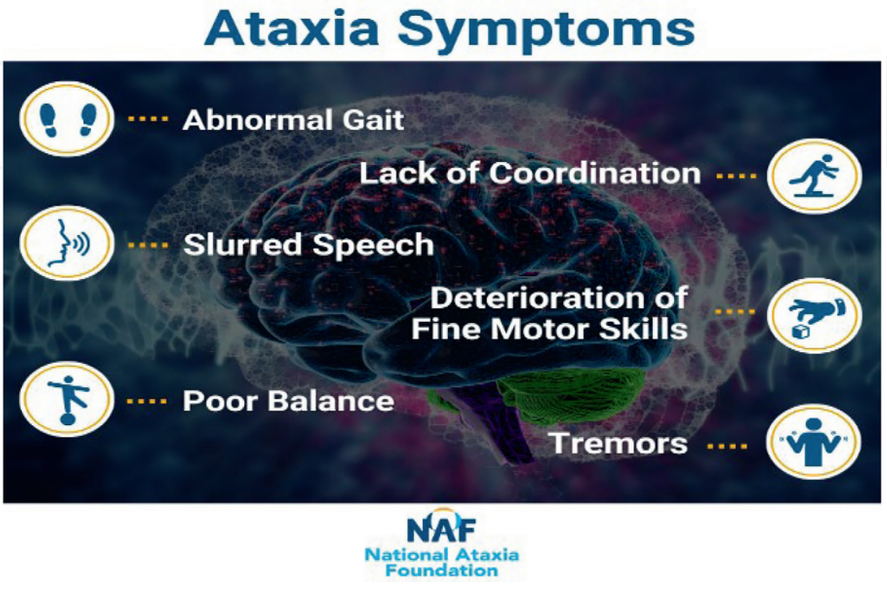

Figure 1.
Common ataxia symptoms [6].

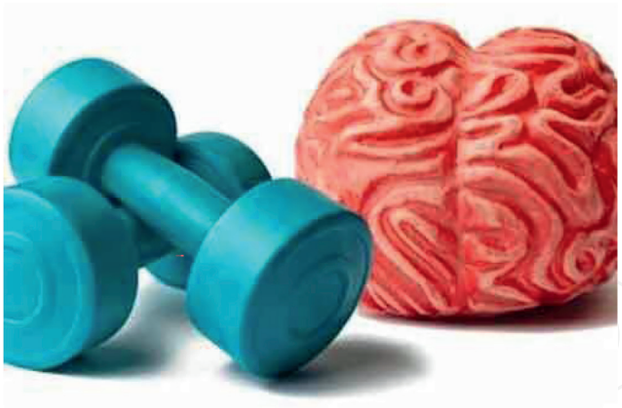

Figure 2.
Mental benefits of weight training [12].

for improving cognitive brain functioning through mechanisms that also include astrocytes. Even if it cannot be used alone, exercise is a potential treatment for neuropathologies [13].

There has been some research on the hippocampus, a vital brain area for memory and learning [14]. After participating in aerobic exercise for many months to a year, the prefrontal and temporal cortex [15], as well as the hippocampus [16], have all been shown to have increased activity and volume. In order to successfully support "brain rejuvenation" in important executive and cognitive domains, exercise is recommended.

2. Adapted physical activity

Structured group exercises are a part of adaptive physical activity (APA), which aims to improve patients' lifestyle, well-being, and quality of life [17]. Common phases are included in each training session: Warming up is followed by moderate-intensity aerobic activities, which are crucial for the harmonious stimulation of the entire body, strength exercises (such as a series of repetitions of 10 exercises for each muscle group), and exercises to increase venous return and energy restoration during cooling down. The APA program should include stretching activities for the stomach and upper/lower limb muscles, as well as limb mobility exercises for the head and shoulders.

Additionally, it uses basic, adaptable, light, and colorful equipment (such as elastics, sticks, hula hoops, bottles, balls, walls, rugs, and lesser weights for the barbell exercises) to enhance motor function, coordination, and motivation [18]. Additionally, the favorable effects of music on mood, motivation, and socializing during practice cannot be overstated. Particularly, SCA patients who consistently work out in the gym had improved psycho-physical health, which suggests reduced rates of anxiety and depression [19].

Due to its positive effects on neuromuscular rehabilitation of degenerative conditions such cerebellar ataxia, Parkinson's disease, and multiple sclerosis, dancing, and tai chi (a balance-based exercise) have gained popularity recently [1]. A case study by Song and his colleagues from 2019 had a patient with severe SCA who was 39 years old. They took part in an 8-week partnered tango dancing therapy program that was modified for intervention. His overall ataxia symptoms did not change,

but his standing balance, gait, functional mobility, and quality of life did improve. Additionally, many of the improvements vanished one month after therapy [20].

The effects of 12 weeks of Tai Chi training on dynamic balance and disease severity were studied in 24 patients with cerebellar ataxia [21]. Twelve participants were randomly assigned to receive conventional treatment and twelve to participate in a tai chi intervention. Dynamic balance was assessed using the Berg Balance Scale (BBS), Scale for Assessment and Evaluation of Ataxia (SARA), SARAbal balance subcomponent, Sensory Organization Test, and Limits of Stability Test. Disease severity and health-related quality of life were assessed using the SARA and EuroQol visual analog scales, respectively. At baseline (week 0), after the intervention (week 12), and at the end of the 24-week follow-up period (week 36).

Three 60-minute sessions each week of the eight-part Tai Chi exercise program were part of the 12-week intervention. Participants were expected to perform tai chi at home alone for the ensuing 24 weeks. Although they participated in all programs, the control group received no help. The results showed that the experimental group's dynamic balance improved after 12 weeks of tai chi instruction. The increases, however, were not kept up during the 24-week follow-up evaluation period. Tai chi training did not lessen the severity of the problem, but after 12 weeks in this cohort, it did improve dynamic balance right away [21]. Tai chi and yoga have many similarities. People with cerebral palsy and ataxia can benefit from yoga by practicing it to relax their muscles and avoid atrophy.

The Duret et al. study [22] examined the outcomes of a 6-month modified physical activity-based program (APA-program) designed for patients who reside in their communities (mean age 59 14 years) and had experienced 47 strokes, 13 episodes of multiple sclerosis, and 19 other neurological illnesses. This APA program included both individual and group workouts, and it was led by an APA instructor twice a week in local fitness centers. The six-minute walk test (6MWT), the single-leg stance test (SLST), and the Short Form-36 (SF-36) were all strength tests carried out on exercise equipment. Standing time on one leg increased by 86%, standing time on one leg grew by 22%, upper body strength increased by 49%, lower body strength increased by 37%, and SF-36 Mental and Physical scores increased by 23%.

The quality of life and all physical capacities both increased.

At the end of the six-month program, more than half of participants (83%) decided to buy a one-year gym membership, enabling the development of community APA-programs for persons with chronic neurological disorders in collaboration with rehabilitation institutions. 68 percent of participants finished the course. The conclusion of this research paper's most important section contains the author's conclusions and recommendations: A program based on physical activity delivered in a gym effectively improves the physical health and quality of life for people with neurological conditions like multiple sclerosis and stroke; b) collaboration between rehabilitation clinics and nearby fitness centers, instruction in adapted physical activity from qualified instructors, and group activities are crucial elements for successful participation [22].

2.1 Physical exercises based on coordination, balance, and muscular strength

He and co-workers [1] conducted a systematic review through five electronic databases (Cochrane Library, Physiotherapy Evidence Database (PEDro), EMbase, PubMed and MEDLINE) including articles from 1999 to 2020 concerning the effectiveness of balance and coordination training in patients with inherited degenerative

ataxia. A total of 515 publications were initially retrieved but only 33 of them met the eligibility criteria. They were categorized by their interventions and study design. Three rehabilitation methods were examined: a) conventional physical/occupational therapy, b) virtual reality/videogame-based training, and c) adapted physical activity.

The results showed that static/dynamic balance and coordination training as a intervened tool in the field of the conventional physical/occupational therapy can improve more effectively the balance and coordinative function of patients with genetic DA. Current literature has shown that this rehabilitation method improve gait, motor function and other ataxia symptoms without causing major adverse effects. Leg cycling and core stability training have also been reported as effective tools in improving dynamic balance in progressive degenerative cerebellar ataxia. The use of proprioceptive stabilizer, vibration assisted therapy, and neuromodulation facilitates motor learning enhancing the effect of conventional physical therapy on DA [1].

Strength training and dynamic postural balance can improve motor coordination of limbs and trunks giving to patients a better lifestyle either walking or in a wheelchair. The effectiveness of a more functional gait as well sitting and standing without help was observed in a 24-week intervention study [23] as well a case study [24]. In the 24-week intervention study participated 38 spinocerebellar ataxia type patients who received 6 hours of neurorehabilitation therapy, emphasizing on balance, coordination, and muscle strengthening on weekdays. In the case study 3 male patients 20–30-year received 45 min—1 h per session, daily for 12 weeks, 3 days in supervision of therapists and remaining days at home. The constant benefits through strength training were the regression of ataxia symptoms, such as limb tremors and imbalances. After training, patients gained more mobility controlled and functional independence [23, 24].

Salci and colleagues investigated the effects of different exercise protocols for 42 ataxia patients with multiple sclerosis. Participants were divided into three different groups: a balance training (BT) group, a lumbar stabilization (LS) group and a task-oriented training (TT) group. Within 18 training sessions all these groups received balance training. The LS group also received specific lumbar stabilization exercises. The TT group received task-oriented training. The results showed significant improvements; however, balance training alone is not enough for the rehabilitation of these patients. A combination of lumbar stabilization exercises or task-oriented training enhance the benefits of balance rehabilitation [25].

2.2 Treadmill training and overground walking for balance and gait

According to a case report by Cernak and associates published in 2008, a 13-year-old girl with severe cerebellar ataxia who was not mobile improved in walking ability with a treadmill training program. Her long-term goal was to be able to independently move around her house with a walker. The intervention strategy involves both floor-based walking and treadmill exercise training using a body weight support system (BWS). It was done at a clinic five days a week for four weeks. Five days a week, for 20 minutes per session, exercise training with the BWS was continued for four months at home. The results showed an improvement in stride length and velocity. Exercise training utilizing BWS on a treadmill combined with ground-based gait training may be a useful approach to improve walking abilities in those with severe cerebellar ataxia. The amount and duration of training, however, can be increased to achieve functionally meaningful gains [26].

A comparable longitudinal case study with a specialist personal trainer was carried out in a gym [27]. An exercise program was completed by a 43-year-old man with motor ataxia, and his performance was evaluated both before and after the test. For six months, there were two 30-minute training sessions per week that targeted body stabilization, strength, and cardiovascular fitness. One month later, the post-test was completed. The following seven things were rated using the Scale for the Assessment and Rating of Ataxia (SARA): 1. Gait 2. Position 3. seated. 4. Finger Snatching. 5. The nasal finger test. 6. Quick hand motions that alternate. 7. Heel-chin slide. Additionally, balance exercises for standing and sitting were included of the rehabilitation regimen.

The clinical scale for the Assessment and Rating of Ataxia (SARA) is most typically used to assess a variety of distinct cerebellar ataxia abnormalities, including Friedreich's ataxia, ataxic stroke, and spinocerebellar ataxia. Reliability and validity were initially published in 2006, were certified [28], and were extensively used to assess the severity and development of disease in clinical practice and longitudinal investigations [1–3].

Exercises of varying degrees of difficulty were performed during the training sessions, including back rowing (3x: 8,10,12 repetitions), chest and shoulder presses (3x: 8,10,12 repetitions), assisted walking on the treadmill (15 m), spinning on the bike (15 m), astatic body stabilization (2x: 1 m), glute stabilization (2x: 15 repetitions), leg presses (3x: 8,10,12 repetitions), leg extensions (3x: 8,10,12 repetitions), elliptical training (3x: 10,15,20 repetitions), trunk lift on inclined platform and with medicine ball (2x: 15 repetitions), front swing with kettlebell (3x: 8,10,12 repetitions), butterfly (3x: 8,10,12 repetitions), reverse butterfly (3x: 8,10,12 repetitions), squat with and without load (3x: 8,10,12 repetitions to 12, 15, 20 repetitions depending on load), rope jumping (5x: 30s), hill climbing on elliptical trainer (2x: 30s), Jumping jacks (5 times for 30 counts), deadlifts with parallel bars (3 times for 10, 15, and 20 repetitions), TRX rows (3 times for 10, 15, and 20 repetitions), Russian twists with medicine balls (2 times for 30 counts), hack squats (3 times for 10, 15, and 20 counts), push-ups with hands (3 times for 10, 15, and 20 counts), wall ball and lunges with disks on the head (3 times for 20, 25, and 30 reps). A variety of exercises were used, depending on the goal of each session [27]. The treadmill itself might be a useful instrument. This program may enhance the health, happiness, and quality of life for people with ataxia. The findings showed improvements in blood pressure and body composition, as well as gains in all SARA scale items except than "sitting" and "finger chase," where the value remained same [27].

Similar studies [26, 29] demonstrated that patients with cerebellar syndrome benefit from three times per week of treadmill exercise for improving gait parameter. Less gait assistance was needed after the training program, and the walking distance had increased. The usage of these activities, according to the authors, is advised for people who are no longer able to walk. Additionally, it has been shown that patients' quality of life can be improved by greater mobility in later stages of cerebellar degeneration [30, 31]. This study [27] also established the proper level of intervention. Because rehabilitation cannot stop the progression of cerebellar degeneration, this is a significant contribution to the research. In summary, this study offers support for the use of physical exercise regimens in ataxia patients.

Previous studies concluded that patients with SCA can benefit long-term from motor activity and physical exercise if they engage in steady and continuous motor activity. However, the clinical effect is quickly lost once this activity is terminated [32]. Future longitudinal training studies should therefore monitor this problem and maximize functioning throughout.

2.3 Locomotor training using a treadmill/intensive exercises

A systematic review study conducted by Milne and colleagues examined 7 categories of intervention for individuals with genetic degenerative ataxia: a) coordination and balance training, b) multifaceted inpatient rehabilitation, c) a cycling regime, d) balance training (exercises with technology assisted biofeedback), e) treadmill training, f) occupational therapy, and g) respiratory muscle training. Seventeen (17) studies met the criteria for long-term outcomes, optimal duration, and intensity of rehabilitation and included in this review [33].

The results highlighted the different types of intervention regarding intensity and duration. Preliminary findings suggested that multifaceted programs incorporating more than one type of intervention, such as coordination and balance training, may have greater effect than isolated rehabilitation programs, such as only balance training or occupational therapy. Significant within-group outcomes suggested that improvements in balance can occur at 3 weeks, and improvements in ataxia require a minimum of 4 weeks.

Intensity as the duration of intervention programs appears to have similar effectiveness. Subgroup analyses indicate improved effectiveness with greater rehabilitation intensity; 60 minutes or greater for 2 days or more per week appears more effective than less intensive training program. The results were less clear for functional gains regarding the duration and benefits beyond 3 days [33].

A crucial new piece of knowledge came from the Miyai et al. study, which examined the short- and long-term effects of intensive rehabilitation on gait and activities of daily living (ADLs) in people with progressive cerebellar ataxia. There was a total of 42 patients in the immediate group and the control group. The immediate group received physical and occupational therapy for two hours on weekdays and one hour on weekends for a period of four weeks, with a focus on balance, coordination, and ADLs. The control group received the same therapy but with a 4-week delay. The results showed that patients with degenerative ataxia benefit from and tolerate a 2-hour daily program well. Short-term outcomes between the two groups were examined. The highest level of rehabilitation intensity gave the largest advantages, which sustained in more than half of the participants, even though the functional status of participants tended to revert to baseline within 24 weeks [34]. Patients in both groups had long-term follow-up data collected up to 24 weeks after the intervention. Each outcome measure for the long-term result was evaluated prior to (pre) and immediately following (post) the intervention for 4 weeks as well as at 4 weeks, 12 weeks, and 24 weeks passed in both groups after the intervention.

Long-term follow-up showed that, as we predicted, the improvements ultimately diminished. Ilg and colleagues {24} found that patients with cerebellar ataxia but not those with afferent ataxia benefited from a less frequent intervention of one hour of physical therapy administered three times weekly for four weeks. With a self-directed home workout regimen, the impact persisted for 8 weeks. Their view is consistent with our findings that improvements in gait speed and SARA persisted for 12 and 24 weeks, respectively. We demonstrated that the SARA score decreased to baseline at 24 weeks in addition to their findings. There are at least two reasons that could account for this drop. Cerebellar lesions may affect the first consolidation of the encoded motor skill. Second, the advancing degenerative process itself might impair motor function. After an intense intervention, systemic self-exercise and intermittent home therapy may be required to maintain functional status [34].

Although frequent rehabilitation programs focusing on balance, walking, and ADLs may lessen impairment and its associated handicap despite significant cerebellar damage, such motor learning depends on both the cerebellum and basal ganglia systems. Ataxia did demonstrate improvement in the trunk, but it also significantly improved in the limbs. This suggests that the effect cannot be fully explained by the encouragement of physical fitness. Patients with cerebellar injury have poorer motor learning, according to earlier investigations. Most of the research, however, employed a stimulus-response methodology, suggesting that action-based working memory, rather than a learning mechanism, may have an impact on performance. In fact, when the replies were given a direct cue, patients with cerebellar degeneration displayed improved sequence learning.

Although fewer falls could be a desirable outcome in daily living, the intervention did not lower risk for falls. Environmental factors and practice at home may be more significant than therapy in a hospital. Finally, the study's examination of patient subgroups showed that patients with mild ataxia benefited the most from rigorous rehabilitation. It is necessary to investigate an optimal intervention for those with moderate to severe ataxia. Further research will be required to determine whether a multimodal strategy involving neuromodulation, rehabilitation, brain stimulation, and neuropharmacological therapy, such as thyrotropin-releasing hormone, may improve functional result. In conclusion, it is proposed that patients with degenerative cerebellar illnesses can at least partially overcome reduced motor learning by intensive and concentrated rehabilitation. Additional research will be required to establish the ideal dosage, durations, and spacing between therapies to maintain substantial functional improvements [34].

The longitudinal case study by Honorio et al. might lend support to earlier case studies that advocated for frequent and intense training [27]. Additionally, Milne et al.'s systematic review study validates and supports that exercise therapies such as coordination and balance training, balance exercises, respiratory muscle training, and treadmill training can improve the participants' quality of life [33].

2.4 Trunk stabilization training-postural exercises- trunk muscle performance

Postural instability is a basic clinical feature of SCA related to static, and dynamic imbalance, difficulties in gait and mobility, fallings with a risk of bone fractures and other complications. These outcomes often lead to refusal of physical activity and consequent social isolation. SCA-related rigidity is a main cause of postural instability and is associated with postural destabilizing and other abnormal reactions. Treatment strategies should consider podalic and visual receptor stimulation. Structural exercises are implemented to improve muscular strength and balance using fitball as a wall squat, single wall squat, balance reversal lunge, balance push-up, ball pass, and balance oblique crunch [18].

Moreover, in some cases postural instability may lead to chronic lumbar backache. Stretching of lumbar muscles by using specific methods, such as Pilates, Mezieres, and Feeldenkrais is an important rehabilitation exercise (**Figure 3**).

On the other hand, physical activities of daily living (e.g., getting up from a chair, holding and throwing objects, and the standing position) in conjunction with "re-learning" of destabilizing responses (e.g., by using moving platforms) are essential components of interventional approach [18].

The motor activity program in the fields of adapted physical activity, kinesitherapy, and physiotherapy includes the preparatory and operational phase. The first aims

Figure 3.
Trunk stabilization exercises: a) elbows extended; b) conventional back-bridge; c) elevated right leg; d) feet resting on the BOSUTM balance trainer; e) left foot on BOSUTM balance trainer and elevated right leg [35].

to learn the patient's own body perception, spatial-time awareness, coordination, respiration, and simple motor movements. The second, progressively learns complex tasks, by repetition of the activities, with result to enhance patients' sensorial experience, executive strategies, and anticipatory capabilities [36].

Due to limited diagnostic methods and scientific evidence in the last years researchers have focused on different rehabilitative techniques. The motor recovery and adaptation after the cerebellar degeneration involves synaptic plasticity. So the intervention programs of motor dysfunction have mostly focused on exercises of balance, stretching, coordination, proprioception, and walking [18].

Also, trunk weighting has been recommended for postural and movement control with reduction of coordination disorders and improvement of balance and gait [26–29]. A treatment that includes the addition of small weights on the torso is a promising intervention that may improve balance and mobility.

The scientific feasibility of BBTW (balance-based torso-weighting) for improving standing stability proved in patients with multiple sclerosis as well ataxia [37]. In this single-session quasi-experimental pilot study participated 10 individuals with cerebellar ataxia and 10 matched controls. For standing stability was used the modified Clinical Test of Sensory Interaction on Balance mCTSIB; [38]. All participants stood for up to 30secods (or for shorter time if the person moved their feet out of position or needed assistance to prevent falling) on firm and foam surfaces with eyes open then eyes closed for standing stability. For dynamic balance participants performed the Timed Up and Go test TUG; [39] where they stood up from a chair, walked 3 m, turned around, walked back, and sat down in the chair again. Light weights (0.57–1.25 kg) were strategically applied to a vestlike garment. The participants performed all testing tasks without weights before undergoing the BBTW procedure. After receiving BBTW weights, participants repeated the standing stability and TUG tasks [37].

Weighting training may be particularly useful in increasing stability of people with ataxia. However, functional movement speed did not improve. Additional variables such as testing accuracy (e.g., step length, step width, and percent of gait

cycle in single- and double-limb support during gait) should be examined in the future research. Also, individuals with ataxia may use slower movement as a strategy to perform tasks, with the speed–accuracy trade-off formalized by Fitts' law [40]. Future studies should further examine gait stability measures along with movement speed [37].

2.5 Home-based training with body-controlled exergames

The body continuously adapts its motor and cognitive behavior when the senses are stimulated. The developing technology of virtual reality is being used to rehabilitative settings. Different activities in real time, such as playing, walking, and manipulating objects permit stimulation of senses and interactively operate. Indeed, this method can non-invasively improve motion, balance, coordination, and cognition.

Ten kids with mild SCA who could walk on their own participated in a study with three popular video game platforms. The 2-week study methodology focused on certain whole-body motions that can increase stability and reduce falls. Results from the post-treatment phase revealed improvement in SARA items pertaining to posture, balance, walking, and coordination. Although it is uncertain whether this method can be used with severe patients, the authors found that playing video games improves eye-motor coordination, anticipatory skills, and rapid motions to be conducted in a virtual world [41].

A similar exploratory study looked at SCA patients who were treated with a variety of videogames for 12 weeks while in a wheelchair. The findings indicated progress at SARA, but the authors recommended additional research to corroborate these preliminary findings [42]. at terms of the genre, coordination sports like table tennis, squash, badminton, and games of boules are advised at the beginning. To significantly enhance posture and coordination, perform these games on an elastic carpet [43].

To minimize falls and enhance mobility, resistance, posture, balance, and muscle strength in people with severe ataxia, video games or virtual reality therapy should be used in conjunction with a particular training regimen. Console games like Ski Slalom and Tightrope Walk offer exercises for both static and dynamic balance as well as whole-body movements (**Figure 4**).

3. Individualized education program and physical activity coaching intervention

Since fitness is a main goal of physical activity, Physical Education (PE) teachers or coaches should take in to account that individuals with disabilities generally display the same physiological responses to exercise found in non-disabled people. "Although specific disabilities may affect the intensity, duration, and frequency of exercise, individuals with disabilities can benefit from training improving their performances. Wheelchairs can be adjusted or modified (by those qualified to do so) to improve physical activity performance. Those practicing physical activities or athletes in wheelchairs play basketball, tennis, and many other sports" [45].

The Individual Education Program (IEP) is the basic tool of PE teachers who firstly evaluate the cognitive-motor profile of those practicing physical activities. Subsequently the instructor designs the IEP which focuses on short- and long-term goals and objectives for training of the patient. Individuals with disabilities (children and adolescents) are entitled to receive special services based on their

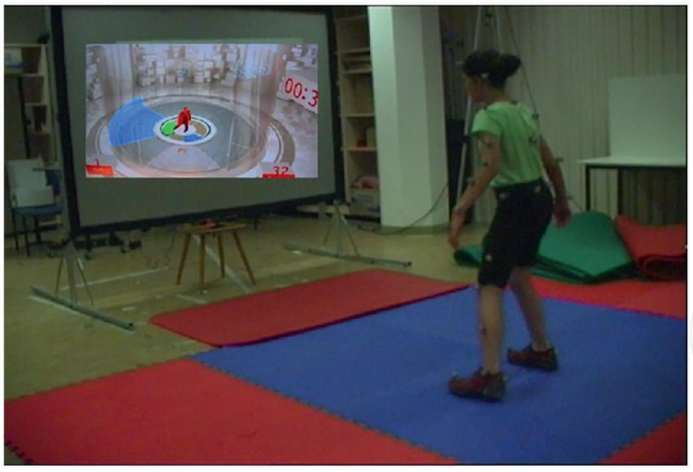

Figure 4.
Exergame-based training (e.g., Kinect games: a. 20.000 leaks trains whole-body coordination and engagement with a dynamic environment; b. table tennis trains goal-directed upper limb movements, dynamic balance, and movement timing; c. light racing trains goal-directed lower limb motions, quick movements, and dynamic balance) [44].

individual needs, which are determined by their assessment and evaluation. In a corresponding context Physical Activity Coaching Intervention is an Individualized Intervention Program (IIP) that take in to account the fitness profile and the individual characteristics of the patients to implement, for instance, a strength training program.

The PE instructor or coach should put the individual, not the disability, at the center of their planning when deciding how to instruct or train a student with a handicap. For instance, the instructor encourages the patient to continue attempting to build physical activity and health-related fitness with the goal of inclusion, challenges his intellect, and helps the patient stay on task longer. When working on basketball shooting techniques, for instance, the PE teacher or coach may also utilize modifications as a fundamental technique to make sure the patient feels competent and actively participates in the task. Given that he has trouble moving, you may try to make the basketball hoop smaller, use a lighter ball, or construct a basket that is worth more points.

Planned adaptations for physical activities include a modified setting, adjustments to the rules, the goal and content of the activities, and the rate of learning. For example, because field sports like baseball and soccer require adaptations, the surroundings will need to be changed when walkers and wheelchairs are used. Wheelchairs and walkers can also benefit from adaptive equipment, such as smaller or lower targets, areas on the playing field marked with cones, scoops for catching, and different balls (size, weight, color, and texture). "A person with cerebral palsy can stand up straight with the help of walkers or standing frames. The tool is helpful in maintaining range of motion, boosting endurance, and strengthening trunk muscles for cerebral palsy patients [45].

The term "least restrictive environment" refers to the practice of including people with disabilities as much as is practical in circumstances where their counterparts without impairments are present. "Empowerment is generally defined as a process through which individuals gain control over their lives, a sense of power equitable with others, and a feeling of responsibility for self, other, and environment" [46] (**Figure 5**).

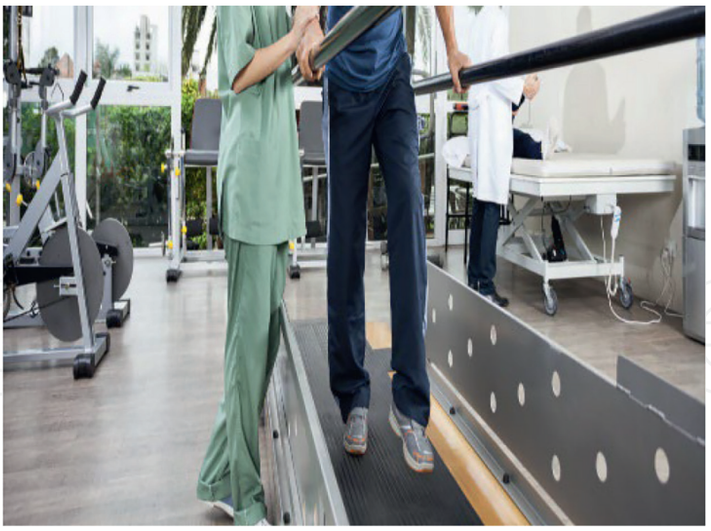

Figure 5.
Balance & Gait Disorders [47].

These two ideas are crucial for modification or adaptation in a learning environment when a PE instructor or coach wants to provide patients with ataxia with the least restrictive environment possible.

Maintaining one's health, wellbeing, and quality of life requires regular physical activity. The World Health Organization WHO, [48] suggests engaging in low to moderate intensity physical or recreational activities at least three times per week for a total of roughly 30 minutes per day. This can involve resistance training, aerobic exercise, or a combination of the two [48]. Regular aerobic training, manual wheelchair propulsion, arm cranking, swimming, and circuit training have all been shown to increase the cardiorespiratory fitness, upper extremity muscle strength, and endurance of wheelchair users. The patient's cardiometabolic profile is improved by aerobic exercise because it increases maximal oxygen consumption, improves cardiorespiratory status, and lowers blood glucose, body fat, and BMI levels. Patients also tend to engage in daily activities like wheelchair use, personal grooming, and cleaning their surroundings frequently [49].

For those who have neurodegenerative disorders, physical activity (PA) might be a potent neuroprotective intervention; unfortunately, rehabilitation programs frequently overlook methods to boost PA engagement. It has been demonstrated that the *Engage intervention* increases exercise self-efficacy and PA uptake in adults with ataxia, Parkinson's disease, and Huntington's disease. An ongoing single-cohort study called *Engage-Ataxia* is being conducted at Columbia University.

Over the course of 12 weeks, a physical therapist offered a 5-session coaching program (PA) via telemedicine. Based on the self-determination theory, the intervention featured a disease-specific workbook to direct the sessions and take into account balance and gait issues, deficiencies in motor learning, and weariness. Individualized workout advice, goal-setting, and strategies for overcoming movement challenges were all covered in the sessions. Only 19 of the 25 participants (mean age 55.8 years; SD: 13.7) completed the intervention (8 men; 11 women). To keep an eye on PA and heart rate, they used a Fitbit. The authors concluded that *Engage-Ataxia* offered a workable framework to increase PA in ataxia patients. This intervention was supported by preliminary results, which showed improvements in behavior change and disease-specific motor and cognitive function tests [50].

The practical benefit of evaluating ataxia patients for a variety of challenges and intensity, regardless of a specific medical diagnosis, is that a PE teacher can get a personalized appraisal of the patient's strengths and weaknesses. Future studies in program evaluation and design may be required to concentrate on patient profiles across a variety of domains (motor, cognitive, social, and emotional), examining each individual's strengths and limitations. Therefore, regardless of the diagnosis a patient receives, PE teachers and coaches will be able to modify their support in accordance and implement an effective IEP and IIP.

4. Final remarks and recommendation

Although supportive care is necessary to manage the symptoms, there is currently no treatment to halt the disease's progression. Issues with balance, poor voluntary movement coordination, double vision, slurred speech, and difficulties swallowing are among of the condition's most prevalent symptoms. Individuals may also experience stiffness and a loss of sensation resembling Parkinson's or multiple sclerosis.

A variety of rehabilitation programs may be helpful for ataxia patients. Physiotherapy can preserve muscle tone, improve strength and mobility overall, and stop joints from dislocating. Patients who need assistance utilizing adaptive equipment like a wheelchair, cane, or walker can benefit from occupational therapy. Speech and language therapy can help with swallowing and speech improvement. Other forms of therapy and treatment can include medical or pharmaceutical, healthy eating, getting enough sleep, conducting education, biofeedback, yoga, and surgery, among others. Adaptive physical activity, occupational therapy, and physical therapy are three professions that have a lot in common. They often practice the same abilities and clearly understand the importance of the underlying neuromuscular systems that regulate how motions are performed.

The APA intervention is described as a rehabilitation program as opposed to "therapy." Most rehabilitation methods are derived from basic physical activities like aerobic, muscle- and bone-strengthening, balancing, and flexibility exercises. Basic elements of physical activity are included even while utilizing exercise equipment, such as a treadmill, which is an aerobic/cardiovascular workout. People with severe ataxia may benefit from overground walking, trunk stabilization exercises, functional manipulative skills, sports, and leisure activities to help them improve their balance, gait, function, motor coordination, trunk, and movement performance.

The outcomes of an intervention training program are significantly influenced by its length. Adults with severe ataxia may benefit from a 6-month planned physical activity and focused training program since it will improve their general health by boosting their fitness levels, balance, and strength. Ataxia patients may become more involved in community outdoor activities, which will help them integrate with people who do not have disabilities, increase their physical fitness so they can manage daily tasks more easily, and adopt a happier, healthier lifestyle.

Susruta, Hippocrates, and Galen's contributions to the notion that *"exercise is medicine"*, along with the concept's historical context, show that the foundations for the exercise prescription for health and disease prevention has roots that go back more than two millennia in antiquity. Exercise and medical experts should be aware that Susruta, an Indus Valley physician who lived more than 2.5 millennia ago, was the first person to prescribe moderate daily exercise for this reason. They should also be aware that the first "recorded" physician to recommend writing exercise for a patient with a

disease (consumption) was Hippocrates of Greece. He is widely regarded as the "father of medicine". Last but not least, Galen's influence led to the promotion of exercise for health benefits and to lessen the consequences of disease. Up until the beginning of the 16th century, he used exercise to cure patients suffering from a range of maladies [51]. However, current studies with a strong evidence-based data also indicate the advantages of physical activity for both physical and mental health [52, 53].

According to the results of other studies, adapted physical exercise and ataxia are associated with positive health outcomes that support an active lifestyle. The use of personalized physical activity-specific therapies to a larger sample of children, adolescents, and adults is also required, while taking sociocultural, gender, and age factors into consideration. Research is still needed to determine the number and length of treatments required to provide a higher chance of improvement and a higher chance that changes will last. Long-term research examining the best physical activity therapies for children and adolescents with different genetic ataxias are lacking.

Future research will be needed to maintain the advantages, determine the frequency that is most effective, as well as the dosage and delivery method. Ataxia patients can benefit from any sort or amount of intervention, according to this review of the domain of interventions. Due to the complexity of the disease and the unique characteristics, it is required to provide particular diagnoses, symptoms, or "severity" while conducting research in this population. This is significant because, while an intervention might be helpful for a population with ataxia that shares the same features (for example, speech issues), it might not be helpful without modifications for other individuals who have other characteristics (for example, issues other than speech issues).

The findings of this evaluation of the available literature support the necessity for further research into the efficacy of APA treatments for children and adolescents with generative ataxia. In order to better understand the effectiveness and safety of treatments for degenerative ataxia, longitudinal studies are also necessary in this field of research. And finally, the multidisciplinary team is always undeniably important in diagnosing and treating patients with ataxia. Ataxia patients typically receive reviews many times a year, ideally from a specialized team that comprises a neurologist, an advanced palliative care nurse, and, as necessary, additional medical professionals like psychiatrists, physiatrists, social workers, and others.

Adaptive physical activity intervention, occupational therapy, physiotherapy, speech and language therapy (for both feeding and communication), and other interventions can all be very helpful at different periods in the patient's life.

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Author details

Katerina Asonitou* and Dimitra Koutsouki
Laboratory of Adapted Physical Activity/Developmental and Physical Disabilities, School of Physical Education and Sport Science, National and Kapodistrian University of Athens, Athens, Greece

*Address all correspondence to: kasonitou@phed.uoa.gr

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