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Ataxia: Physical Therapy and Rehabilitation Applications for Ataxic Patients

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Abstract

Ataxia is a movement disorder resulting from the incoordination of movements and inadequate postural control, presented in balance and walking disturbances. It has three subcategories, which are sensory, cerebellar and vestibular ataxia. Some researchers regard frontal ataxia as the 4th category. Mixed ataxia involves symptoms of at least two basic types of ataxia together. Different clinical symptoms, interference of different neurological structures and different diseases play role in the formation of each ataxia type. Since ataxia is resistant to medical treatments, physical treatment applications are of major importance. Physical therapy applications involve proprioceptive training, balance exercises, stabilization techniques regarding the extremity ataxia and vestibular exercises for accomplishing functional improvement and restoration of the ataxic patient. Compensatory applications employ supportive devices.

Introduction

Human beings develop normal motor movements by the continuing neuro-developmental maturation following birth. Process of motor development is completed when normal postural mechanisms are localized, followed by the ability to maintain balance in different positions and finally by the formation of muscular coordination.

Normal postural tonus enables standing erect against gravity, adaptation to changes on support surface and proximal stabilization. Balance can be defined as postural adaptation to changes in gravitational center with the contribution of normal postural tonus. Muscular coordination on the other hand, is the functioning of all muscles active during the voluntary motor movement in appropriate rhythm, velocity and amplitude. A person may perform daily life activities through normal motor movement formed by the above mentioned three components.

Nervous system diseases and/or injuries usually affect postural control mechanisms. Patients who have diseases like stroke, head traumas, spinocerebellar ataxias, multiple sclerosis, Parkinson disease and sensory neuropathies frequently suffer from balance and coordination problems. In some of these diseases, balance problems are more dominant, whereas coordination problems related to extremities are more forefront in others. However, when studied closely, co-existance of both problems in many patients can be observed.

In the literature, there are many different statements concerning the definition, extension and terminology of ataxia. This variety of statements forms a confusing situation. For instance, when referring to balance dysfunction as a symptom only of vestibular diseases (Brown et al. 2006), or defining ataxia as a symptom developing from cerebellar influence (Martin 2009).

The goal of this article is to review the definition of ataxia, study its subtypes, measurement and assessment methods, and physiotherapy applications regarding its management.

What is ataxia?

The word ‘ataxia’ is derived from Greek meaning ‘disorderly’ (Bastian 1997). In the literature, most common definition of ataxia is “the in-coordination of movements” (Bastian 1997, Mariotti et al. 2005). However, this definition is to a large degree inadequate in denoting ataxia. In ataxia, both insufficient postural control and incoordination of multi-joint movements is observed (DeSouza 1990). Postural instability results from the inadequacy in postural control and leads to clinical balance dysfunctions. Therefore it is not possible to analyze ataxia in isolation from balance dysfunctions. Although incoordination is usually accompanied by balance dysfunction and gait problems; in some cases, balance dysfunction is observed without the existence of in-coordination of movements (e.g. muscle weaknesses). For example, if normal walking is considered to be the perfectly timed sequence of muscle activity that occurs in response to both internal and external forces, then it is easy to consider walking as a task requiring coordination as well as balance (Crutchfield et al. 1989).

Thus, in-coordination and balance dysfunction in movements without muscle weakness is a more precise definition of ataxia.

Anatomical Structures Responsible for Balance Development and Coordination

A physiotherapist should have a basic understanding of the pathophysiology of the different types of ataxia in order to formulate effective treatment interventions.

Normal motor control is the outcome of normal postural tonus, muscle coordination, and balance working together in unison. Postural control within the normal functioning of the nervous system takes place due to different sensory-motor subsystems working in harmony with each other within a circular network. The vestibular, visual, somatosensory systems and cerebellum, for instance, interact in a flexible manner for postural orientation depending upon the goal of the movement and environmental conditions. Each subsystem may be dominant at different times. For example, as the type or quality of the surface on which we are standing changes, the qualities will be registered by the somatosensory system. When the information in the visual area changes, the visual system will register such changes. The subsystems presenting the most accurate information at the moment will dominate and ultimately determine the appropriate motor response (Crutchfield et al. 1989).

Somatosensory System (proprioceptive and superficial senses): The contribution of proprioceptive senses (position and kinesthesia) is particularly important in the formation of normal motor function (Sherrington 1907, Bear et al 2001). Input data related to lower extremities, position of cervical (Treleaven 2008) and lumbal area, length of muscles and positions of joints is transmitted through proprioceptors located in joints, ligaments, muscles and tendons.

Position and kinesthetic senses are transmitted via fibres with thick myelin which convey data quite rapidly. These senses are transmitted to central nervous system through two paths. The first one is the dorsal column- medial lemniscal system through which conscious sensations are conveyed to sensory areas 3,1,2 of cerebral cortex (Bear et al 2001) . Proprioception, together with data received from the visual system, provides information about speed, form and size of the movement that motor cortex has to generate. (Scneider et al. 1977)

Ventral and dorsal spinocerebellar tracts are the second path through which proprioceptive information transmitted from spinal cord to brain. The sensory input which is carried by these tracts comes to an end in the area called spinocerebellum within the cerebellum, and does not reach consciousness. In other words, the sensory input carried by these tracts is the subconscious proprioceptive sense. This sensory input enables the cerebellum to correct the faulty motor commands that the motor cortex may send by informing the cerebrum and cerebellum simultaneously about the size, speed, form and timing of the movement before the movement is performed (Guyton 1976, Ramnani et al. 2001).

Vestibular System

The central vestibular pathways coordinate and integrate information about head and body movement and use it to control the output of motor neurons that adjust head, eye, and body positions. Primary vestibular axons from cranial nerve VIII make direct connections to the vestibular nucleus of the same side of the brain stem and to the cerebellum. The vestibular nuclei also receive inputs from the cerebellum, visual and somatic sensory systems, thereby combining incoming vestibular information with data about the motor system and other sensory modalities.

The vestibular system, is composed of otolithic organs (utricle and saccule) and semicircular canals. Axons from otolith organs project to the lateral vestibular nucleus, which then projects via the vestibulospinal tract to excite spinal motor neurons controlling muscles in the legs that help to maintain posture even on unstable surface, which is called vestibulo-spinal reflex. Axons from semicircular canals project to the medial vestibular nucleus, which sends axons via medial longitudinal fasciculus to excite motor neurons of trunk and neck muscles that orient the head. These pathways help the head stay straight even as the body capers around below it.

One particularly important function of the vestibular system is to keep eyes fixed in a particular direction, which is actualized by vestibulo-ocular reflex. The vestibulo-ocular reflex works by sensing rotations of the head and immediately commands a compensatory movement of the eyes in the opposite direction. The movement helps keep line of sight tightly fixed on a visual target (Guyton 1976, Bear et al 2001).

Cerebellum

The cerebellum plays a major role in establishing balance and motor coordination. The cerebellum is divided into distinct functional zones based on afferent and efferent connectivity. These are medial, intermediate and lateral zones. All zones can influence locomotion, in different ways. Spino-cerebellum (medial and intermediate zone - vermis and paravermis) receives proprioceptive sensory inputs from the periphery through dorsal and ventral spinocerebellar tractus, and also contributes to locomotion and balance by receiving inputs from the vestibular nuclei, and from the pontine reticular nuclei. Vestibulo-cerebellum (medial zone- flocculus and nodulus) establishes balance through vestibulospinal and reticulospinal tracts by modulating the information in the reticular and the vestibular nuclei in particular. Cerebro-cerebellum (lateral zone-posterior lobe) is interconnected with the cerebral motor cortex, to enable fine, coordinated distal movement. The information from cerebral cortex is transmitted via cortico ponto cerebellar tract. Thus, from the proprioceptors in the periphery, cerebellum learns the position of the body in space. It receives information about balance from the vestibular system as well, and through cortico ponto cerebellar tract about the features of the intended motor movement. Based on this information, the cerebellum facilitates coordinated and balanced movement by making the appropriate adjustments. (Guyton 1976, Young&Young 1997, Herdman 1998).

Types of ataxia and their characteristics

Ataxia can result from damage to several different motor or sensory regions of the central nervous system, as well as peripheral nerve pathology (Bastian 1997). In general, problems in the proprioceptive system, visual system and vestibular system, the cerebellum and/or any problem in the interconnections of these systems, can lead to ataxia.

According to some researchers, ataxia has two categories: sensory and cerebellar ataxia (Bastian 1997, Mariotti et al. 2005), to others, e.g. Morgan, ataxia has three types: sensory, cerebellar and vestibular ataxia (Morgan 1980). Still other researchers consider frontal ataxia as a 4th type (Erasmus 2004). In some cases, the symptoms of two or three ataxia types can be observed, which is referred to as mixed ataxia (Edwards 1996).

Sensory ataxia

The term sensory ataxia is used to indicate ataxia due to loss of proprioception (sensitivity to joint and body part position), which generally depends on dysfunction of the dorsal columns of the spinal cord, since they carry proprioceptive information up to the brain. In some cases, the cause may be dysfunction of the various brain parts which receive that information, including the thalamus, and parietal lobes. Sensory ataxia shows itself with an_unsteady "stomping" gait with heavy heel strikes and postural instability that is characteristically worsened when the lack of proprioceptive input cannot be compensated by visual input, such as in poorly lit environments (en.wikipedia.org). The patient stands with his / her feet together and eyes shut, which will cause the patient's instability to worsen, producing wide oscillations and possibly a fall (en.wikipedia.org). This is an indicator that the Romberg's test is positive, which is the most significant finding that differentiates sensory ataxia from other types of ataxia (Bannister 1992). Losses of vibration sense in the extremities and deep tendon reflexes are important characteristics of sensory ataxia. Worsening of the finger-pointing test with the eyes closed is another feature of sensory ataxia (en.wikipedia.org).

Sensory ataxia can be observed in types of hereditary ataxia such as Friedreich's ataxia and spinocerebellar ataxia. Sensory ataxia may also be observed in diseases such as diabetic or alcoholic neuropathy, vitamin B12 inadequacy neuropathy, tabes dorsalis, tumoral conditions found in the posterior cord of the medulla spinalis, and in multiple sclerosis (Edwards 1996).

Vestibular ataxia

Vestibular ataxia develops as a result of peripheral or central diseases which directly affects the vestibular nuclei and/or the afferent and efferent connections of the vestibular nuclei. A patient with vestibular ataxia has disturbances of balance in standing and sitting. The patient tends to stagger when walking, has a broad base support and may lean backwards or towards the side of the lesion. Head and trunk motion and subsequently arm motion are often decreased (Borello-France et al. 1994). The patient is limited particularly when crossing the street and shopping at the market since his/her balance is disrupted when performing a head or eye movement. Vestibular ataxia may be accompanied by vertigo, nausea, vomiting, blurred vision and nystagmus due to the vestibular system's role in sensing and perceiving self-motion and stabilizing gaze via the vestibulo-ocular reflex (Horak&Shupert 1994). Extremity ataxia is by no means observed in vestibular ataxia. Deep tendon reflexes are considered normal.

Vestibular ataxia can develop due to central factors such as medullar stroke and multiple sclerosis, and peripheral vestibular diseases such as Menier's, hydrops, benign paroxysmal vertigo, or vestibular neuronitis.

Cerebellar ataxia

Cerebellar ataxia develops as a result of lesions to the cerebellum, and/or the afferent and efferent connections of the cerebellum.

Vestibulo-cerebellar dysfunction is related to the flocculonodular lobe (flocculus and nodulus) and involves problems regulating balance and controlling eye movements. This shows itself with postural instability, in which the person tends to separate the feet on standing to gain a wider base, and avoid oscillations (especially posterior-anterior ones); instability is therefore worsened when standing with the feet together (irrespective of whether the eyes are open or closed: this is a negative Romberg's test) (en.wikipedia.org, Liao et al. 2008, Morton&Bastian 2004).

Spino-cerebellar dysfunction corresponds to the vermis and paravermis and patients will present with a wide-based gait, characterized by uncertain start and stop, lateral deviations, and unequal steps and abnormal inter-joint coordination patterns. When this part of the cerebellum is damaged, gait ataxia or walking in-coordination occurs (en.wikipedia.org, Ilg et al. 2008, Timmann et al. 2008, Ilg et al. 2007, Morton&Bastian 2007).

Cerebro-cerebellar dysfunction indicates a lesion of the deep pontine nuclei connections with the cerebellum. The cerebrocereebellum contributes to planning and monitoring of movements and damage here results in disturbances in performing voluntary, planned movements (en.wikipedia.org, Schmahmann 2004).

Symptoms associated with cerebellar ataxia include:

Dysmetria: This refers to inaccuracy in achieving a final end position (hypermetria equals overshoot; hypometria equals undershoot). This clearly is demonstrated by the patient attempting the finger-nose test.

Tremor: Kinetic tremor, which is oscillation that occurs during the course of the movement

- Intention tremor, which is the increase in tremor towards the end of the movement

- Postural tremor, which occurs when holding a limb in a given position

- Titubation, which is tremor affecting the head and upper trunk typically after lesion of the vermis

- Postural truncal tremor, which affects the legs and lower trunk, is seen in anterior cerebellar lobe lesions

Dyssynergia: is distinct particularly during multi-joint movements. This may have several reasons: agonist-antagonist and synergistic muscles may not be able to contract in correct order during voluntary movement; or antagonist muscle may be failing to control eccentric contraction during the concentric contraction of agonist muscle. With the combination of these two factors, the extremity undergoes a sudden velocity resulting in inappropriate and uncontrolled motor movement.

Dysdiadockokinesia: This is the inability to perform rapidly alternating movements such as alternately tapping with palm up and palm down. The rhythm is poor and force of each tap is variable.

Hypotonia: This occurs in acute cerebellar lesions, but it is rarely seen in chronic lesions. Hypotonia is distinct particularly in proximal and antigravity muscles.

Weakness and fatigue: This describes a generalized non-specific weakness as a feature of cerebellar dysfunction. This occurs more often with extensive and deep lesions and is most apparent in the proximal musculature. Fatigue has also been noted as a common feature of cerebellar dysfunction.

Dysarthria: This occurs due to in-coordination between tongue and lip muscles. The patient speaks like he is drunk.

Nystagmus: abnormal eye movements that develop in horizontal and vertical directions mostly as nystagmus at the end point (Edwards 1996).

Deep tendon reflexes are maintained in cerebellar lesions, and gain a pendular characteristic.

Cerebellar ataxia can be observed in diseases such as spino-cerebellar ataxia among hereditary ataxias, Friedreich's ataxia, chronic alcoholism, paraneoplastic cerebellar degeneration, pontocerebellar angle tumors and multiple sclerosis.

Frontal ataxia

Frontal ataxia (also known as gait apraxia) is observed when tumors, abscesses, cerebro vascular accidents and normal pressure hydrocephalus effect the frontal area. It has the below listed features:

- Patient has difficulties standing erect

- Even with use of support, patient tends to lean towards hyperextension

- Patient's legs are in scissors-cross position during walking and there is incoordination between the legs and trunk

- Ataxia is accompanied by frontal dementia, urinary incontinence, frontal release signs and perseveration (jeffmann.net/NeuroGuidemaps/gait).

Mixed ataxia

Mixed ataxia refers to the type of ataxia when symptoms of two or more types of ataxia are observed together, such as occurance of sensory and cerebellar ataxia symptoms. In some diseases, mixed ataxia may be observed frequently. For instance, in Multiple Sclerosis, cerebellar, vestibular and sensory ataxia may be observed together; whereas in cases of spino-cerebellar ataxias, cerebellar and sensory ataxia may be seen. Features of basic types of ataxia are briefed in Table 1 below:

Table 1: Clinical Differences Between Basic Types of Ataxia

	Cerebellar Ataxia	Sensory Ataxia	Frontal Ataxia	Vestibular Ataxia
Head posture	Upright and sometimes fixed	Leans forward	Leans forward	Upright and definitely fixed
Trunk posture	Stooped-leans forward	Stooped-upright	Upright	Upright
Stance	Wide-based	Wide-based	Wide-based	Wide-based
Initiation of gait	Normal	Normal-wariness	Start hesitation	Normal
Postural reflexes	+/-	Intact	May be absent	+/-
Steps	Stagger-lurching	High-stepping	Small-shuffling	Normal
Stride length	Irregular	Regular	Short	Normal
Leg movement	Variable, ataxic	Variable - hesitant and slow	Stiff, rigid	Normal
Speed of movement	Normal-slow	Normal-slow	Very slow	Normal-slow
Arm swing	Normal, exaggerated	Normal	Exaggerated	Normal
Turning corners	Veers away	Minimal effect	Freezing-shuffling	Dysequilibrium
Heel-toe test	Unable	+/-	Unable	Unable
Romberg's test	+/-	Increased unsteadiness	+/-	-
Heel-shin test	Usually abnormal	+/-	Normal	Normal
Falls	Uncommon	Yes	Very common	Common

(jeffmann.net/NeuroGuidemaps/gait).

Physical therapy and rehabilitation of ataxia

The goal of the physiotherapist in the rehabilitation of ataxia resulting from defects in neurological structures and effecting the functions of the patient, is to improve the functional level of the patient through restorative techniques. When this is not possible, the therapist makes use of compensatory strategies to make the patient perform as independent as possible within the present functional level. The goals of restorative physical treatment can be briefly described as:

1. Improving balance and postural reactions against external stimuli and gravitational changes

2. Improving and increasing postural stabilization following the development of joint stabilization

3. Developing upper extremity functions

4. Through developing independent and functional gait, improving the life quality of the patient by increasing the patient's independence while performing daily life activities

Main principles of training

1. Throughout the whole training program, exercises should be practiced consciously at first, and in later stages should be followed by automatic exercise activities.

2. Exercises should progress from simple to complex.

3. Activities should be practiced first with the eyes open and later with the eyes closed.

4. After achieving proximal tonus and stabilization, the coordinated movement of the distal segments should be taken into consideration.

5. Compensation methods and supportive aids and equipment should be employed when necessary.

6. Treatment should be supported by an appropriate home exercise program and sports activities.

Measurement and assessment

In the treatment of ataxia, it is essential to determine treatment programs suitable for the patient and his/her needs in order to attain the desired goal of the physiotherapy and rehabilitation program. This can be achieved through the use of appropriate measurement and assessment methods, and the interpretation of the findings. Measurement and assessment is not only significant in terms of preparing a suitable treatment program but also in the follow-up of the changes in the patient's condition over a period of time and the observation of the effects of the treatment.

Standardization problems in measurement and assessment which are one of the most distressing aspects of neurological rehabilitation applications become more troubling in cases of ataxia. In the literature, there are more scales, observational methods and computerized systems developed to assess balance than to evaluate in-coordination.

Although the observational methods and scales mostly designed to assess balance are easy to use and can be readily utilized in the clinic, their ability to provide standardized measurements is limited, and the results can vary depending on the person who has done the observation. Though computerized systems are highly reliable, they are costly systems which require working within the laboratory environment. Balance assessment tools frequently used by physiotherapists are shown in Table 2.

Table 2: Methods of Balance Assessment

Assessment Tool	Purpose of Tool
External Perturbation Test - Push and Release test (Jacobs et al. 2006, Valkovic et al. 2008)	Static balance
External Perturbation Test - Pull test (Hunt&Sethi 2006, Munhoz et al. 2004, Horak et al. 2005)	Static balance in different sensory conditions
Clinical Sensory Integration Test (Smania et al. 2008, Chaudry et al. 2004)	Dynamic balance in different sensory conditions
Sensory Integration Test of Computarised Dynamic Posturography (Mirka&Black 1990, Jackson et al. 1995, Cham et al. 2006)	Static and dynamic balance
Static and Dynamic Posturography (Mohan et al. 2008, Federica et al. 2008, Buatois et al. 2006)	Static balance
Single Leg Stance Test (Soyuer et al. 2006, Mann et al. 1996)	Static balance
Functional Reach Test (Martin et al. 2006, Jacobs et al. 2006)	Functional static and dynamic balance
Berg Balance Scale (Yelnik&Bonan 2008, Ryerson et al. 2008, Enberg et al. 2008)	Functional static and dynamic balance
Five Times Sit to Stand Test (Buatois et al. 2008)	Functional dynamic balance and gait
Time Up and Go Test (Zampieri& Di Fabio 2008, Vereeck et al. 2008)	Gait and functional dynamic balance
Dynamic Gait Index (Herman et al. 2008, Chang et al. 2008)	Dynamic balance and gait
Tandem Walking (Ravdin et al. 2008)	Dynamic balance
Four Square Step Test (Blennerhassett&Javalath 2008)	Dynamic balance

Measurements such as gait duration, step length, step width can be used apart from these tests. Moreover, self-perception scales filled in by the patient such as Dizziness Handicap Inventory, Activity Specific Balance Confident Scale and scales for daily living activities such as FIM™ and Barthel Index can be employed to assist in assessment methods (Wrisley & Pavlou 2005).

There are a limited number of scales which have been developed to assess truncal ataxia and extremity ataxia together, and tested for validity and reliability. (Table 3)

Table 3: Scales of Ataxia

Assessment Tool	Purpose of Tool
International Cooperative Ataxia Rating Scale (D'Abreu et al. 2007)	Evaluating truncal and extremity ataxia, gait ataxia, nystagmus and talking
Scale for Assessment and Rating of Ataxia (Yabe et al. 2008)	Evaluating truncal and extremity ataxia, gait ataxia and talking
Ataxia Functional Composite Scale (Assadi et al. 2008)	Evaluating gait speed, upper extremity ataxia and visual acuity
Nine Hole Peg Test (Lynch et al. 2005)	Evaluating upper extremity ataxia
Computer Graphics Tablet (Erasmus et al. 2001)	Evaluating upper extremity ataxia
Brief Ataxia Rating Scale (Schmahmann 2009)	Evaluating truncal and extremity ataxia, gait ataxia, nystagmus and talking
Friedreich's ataxia impact scale (Cano 2009)	Speech, upper limb functioning, lower limb functioning, body movement, complex tasks, isolation, mood, self perceptions
Composite cerebellar functional severity score (du Montcel 2008)	Upper limb functions

Physical therapy approaches

A physical treatment program is prepared from the interpretation of the measurement and assessment results. The contents of the treatment program can vary depending on the type and characteristics of ataxia. For instance, while approaches which improve proprioception and incorporate visual aids are used more commonly in patients with sensory ataxia, stabilization training is more important to reduce truncal and extremity ataxia in patients with cerebellar ataxia. The patient with vestibular ataxia should be given habitation exercises in order to reduce vertigo, and also vestibulo-ocular, vestibulo-spinal reflexes should be stimulated to improve balance. In some cases, a problematic condition which requires the use of a number of approaches, such as mixed ataxia, may arise. In such cases, the experience of the physiotherapist and the patient's effort plays an important role in determining the program.

When preparing the treatment prescription, it should be kept in mind that the proprioceptive, vestibular and visual systems, and the cerebellum are in close relation, and that balance and coordination result from this relation. For example, proprioceptive exercises contribute to balance while improving proprioception. The opposite of this is also true. Approaches in the treatment of extremity ataxia may enable proprioceptive input to increase and the balance to develop by establishing stabilization. Therefore, it is not possible to classify the methods used in the rehabilitation of ataxia as approaches directed merely towards proprioception or balance, since all of these interact with each other.

The classification of treatment applications can be briefly described as follows:

Approaches for improving proprioception

The aim is to increase proprioceptive input by mechanically stimulating the joint surfaces, muscles and tendons, and decreasing postural instability by improving body awareness. There are many approaches that can be used for this purpose. These are: Proprioceptive Neuromuscular Fascilitation (PNF), rhythmic stabilization, slow reversal techniques (Adler et al. 2000, Gardiner 1976), resistive exercises (DeSouza 1990, Arai et al. 2001), use of

Johnstone pressure splints (Armutlu et al. 2001), gait exercises on different surfaces (hard, soft, inclined surfaces) with eyes open and closed, plyometric exercises (Risberg et al. 2001), balance board-ball and minitrampoline exercises (Diracoglu et al. 2005).

Recently, vibration has been a frequently used application. Vibration can directly be applied to the muscle and tendon, and also is applied by exposing the whole body to vibration (Schunfried et al. 2007, Hatzitaki et al. 2004, Semenova 1997).

Another method is the suit therapy. The suit is made up of a vest, shorts, knee pads and special shoes attached by using bungee type bands that are used to correctly align the body and provide resistance as movements are performed. Its major goals are to improve proprioception (sensation from joints, fibers, and muscles), and to increase weight-bearing for normalized sensory input regarding posture and movement (Semenova 1997).

In addition, methods which develop body awareness, such as the Feldenkrais and Alexandre Techniques (Jain et al. 2004), yoga, and body awareness exercises can be included in the program.

Activities for improving balance

Firstly, the proximal muscles and stabilization of the trunk should be improved (Edwards 1996). For this purpose, it is appropriate to use the mat activities of the PNF techniques. Following the neuro-developmental order, the patient should be trained to come to the bridge position from lying on the back, onto the forearms from lying face down, to crawl, and to come onto the knees, half knees and into a sitting position, and to establish static and dynamic stability in these positions. Initially, the patient should be maintained in the required position by approximation and verbal directions, and then static stabilization should be strengthened through external perturbation (pushing and pulling in different directions). Afterwards, the patient should be trained in these positions for weight transferring and functional extension so as to be prepared for dynamic stabilization. Subsequently, the patient should be trained in positions in which the support surface is narrowed or the center of gravity is changed in order to make the balance activities difficult. (e.g. establishing balance on two or three extremities in the crawling position or shifting the center of gravity upwards by the elevation of the arms in the sitting-on-the-knees position) (Addler et al. 2000).

In the standing position, following the transferring of weight onto the front, back and sides, narrowing the support surface and balance training in tandem position, balance training on one leg should be performed. This is a position with which ataxic patients have great difficulty.

Another option is to perform balance training on the posturography device in order to benefit from visual feedback obtained from observing the patient’s ability to sustain his/her postural oscillation in the center of gravity (Qutubuddin et al. 2007).

The best indicator of dynamic stabilization/balance is gait. Therefore, gait training should be given including the following applications : walking on two narrow lines, tandem gait, backward gait, slowed down gait (soldier’s gait), stopping and turning in response to sudden directions, flexion, extension and left-right rotations of the head.

Disciplines such as Tai Chi (Hackney&Earhart 2008) and Yoga consist of activities which develop balance.

Vestibular exercises

Since dizziness accompanies balance dysfunction in vestibular problems, repetitive head movements and Cawthorne and Cooksey exercises (Dix 1979) are of great importance. A vestibular exercise program consists of repetitive, progressively more difficult, eye, head and body movements designed to encourage movement and facilitate sensory substitution. Many components of this exercise program are used by physical and occupational therapists today (Ribeiro et al. 2005, Corna et al. 2003, Jauregui-Renaud et al. 2007, Brown et al. 2006).

Approaches to extremity ataxia

Exercises designed for the treatment of extremity ataxia are utilized to provide fixation by establishing balance between the eccentric and concentric contractions within the multi-joint movements of lower extremities and the upper extremities in particular. During the performance of these exercises, it is important to establish slow, controlled and reciprocal multi-joint movement and stabilization. Freenkel's coordination exercises were developed for this purpose (Edwards 1996, Danek 2004). Actively repeated contractions similar to PNF can be utilized on their own or by combining them with Freenkel's coordination exercises (Armutlu et al. 2001). While these two types of exercise are effective in cases with mild extremity ataxia, they can be insufficient in severe cases. In such cases, rhythmic stabilization and combination of isotonic techniques are more effective than PNF (Adler et al. 2000).

Coordination Dynamics Therapy (CDT) was developed by Dr. Giselher Schalow. This therapy, he says, "improves the self-organization of the neuronal networks of the CNS for functional repair by exercising extremely exact coordinated arm and leg movements on a special device (GIGER MD) and, in turn, the coordinated firing of the many billions of neurons of the human CNS" (Schalow 2006, Schalow 2004, Schalow 2002).

Use of supportive aids

In cases which restorative physical treatment applications are insufficient, use of supportive devices enables the patient to function more easily within his present functional level. In cases of severe ataxia, suspending weights from the extremities and the use of weighted walkers can be preferred (Gibson-Horn 2008).

Sports activities

Horse riding, swimming, playing billiards, golf and darts are suitable for this type of patient (Bertoti 1988, Hammer et al. 2005).

Conclusion

According to the physiotherapist, mobility and upper extremity functions are the most important functions of the patient. Ataxia is a neurological problem with major effect on both functions and it, when compared to other symptoms of neurological diseases (muscle weakness, spasticity), is sometimes more persistent and difficult to cope with. Therefore, physical therapy applications play an important part in the management of ataxia. Evaluation of the patient, determination of suitable treatment methods and problem solving approach, as well as performing the exercises regularly; are of major importance for the success of treatment programme.

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