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IMPROVING MOTOR COORDINATION FOR MOTION ALEXANDER TECHNIQUE

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Abstract The Alexander Technique (AT) is defined as a movement reeducation method in which conscious control of posture and body mechanics is applied. Guided observation, verbal instruction, and manual support are used to modify habitual movement patterns. Posture and gait are recognised as key elements of the human locomotor system, and their role in musculoskeletal function and quality of life is established. AT is described as a holistic method in which body organisation, stability, and coordination are improved. The effect of AT on motor coordination is examined in adult male participants with mild spinal complaints. A four week intervention is completed with supervised sessions and home based practice. Motion analysis is performed before and after the intervention to assess gait and postural control. Significant improvements are identified in sagittal, vertical, and horizontal planes. Increased stride length, improved gait cycle dynamics, and greater joint amplitudes are observed. Improved dynamic stability and better coordination between body segments are also detected. These changes indicate improved neuromuscular control and more efficient muscular activity. It is concluded that AT supports the reorganisation of movement patterns through conscious control. Improved stability and more efficient gait patterns are achieved. The method is considered effective for improving motor coordination in preventive and rehabilitative contexts. Further research is required to examine long term effects.

Keywords: Alexander Technique, gait biomechanics, motor coordination, postural control, gait cycle analysis, movement symmetry, hip kinematics, dynamic stability, neuromuscular coordination, movement reeducation, sport informatics, motion analysis systems.

AMS Mathematics Subject Classification: 92C10, 68T99.

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1 Introduction

The improvement of motor coordination and movement quality is recognised as a key objective in health sciences and rehabilitation. Efficient movement patterns are associated with musculoskeletal health, balance control, and quality of life. Movement based methods are introduced to improve both the quantity and quality of movement. The Alexander Technique (AT) is defined as a method in which conscious control of posture and movement is applied to improve motor efficiency and reduce muscular tension [1].

Before the use of AT, motor coordination and posture are addressed through biomechanical analysis, physiotherapy, and gait assessment. These methods rely on anatomical measurements, functional scales, and kinematic evaluation [2]. Quantitative data on joint motion and muscle activity are provided [3]. General exercise is often applied in clinical practice to

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restore function [4]. However, these approaches focus on isolated impairments and external correction rather than habitual movement behaviour [5].

Conventional methods show limitations in complex motor coordination. Repetitive training and external correction are used, while internal awareness is limited [6]. As a result, postural habits are not effectively modified. Movement variability is not sufficiently addressed, especially in ageing populations [7]. Reduced adaptability and inefficient movement patterns are observed [8]. These limitations indicate the need for methods that combine neuromuscular coordination with cognitive control [9].

The Alexander Technique is introduced as an approach that integrates cognitive processes and motor control. Principles such as inhibition and conscious direction support the modification of movement patterns [10]. Improved postural coordination and reduced tension are achieved through guided instruction [11]. Studies show improved balance, gait stability, and smoother movement [12]. Better postural tone and dynamic stability are also observed [13]. These effects are reported in various populations, including older adults and individuals with movement disorders [14]. The method is also applied in specialised fields that require precise coordination [15]. Figure 1 presents a schematic representation of the Alexander Technique.

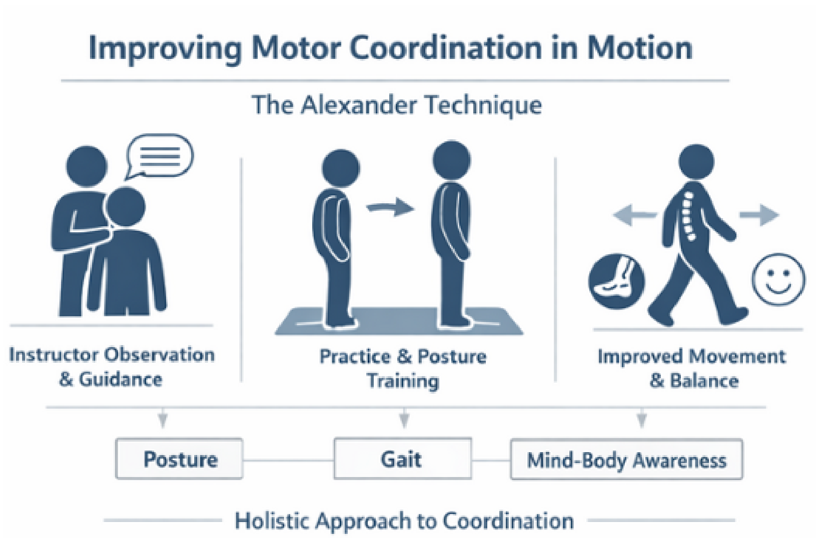

Figure 1: An illustration of the Alexander Technique.

Although the effectiveness of the AT is proven, several research gaps are identified. Many studies focus on balance, pain, or posture, while comprehensive analysis of motor coordination in dynamic conditions is limited [16]. Variations in study design and participant characteristics reduce the generalisability of results [17]. Long term retention of improvements and underlying neuromuscular mechanisms are not fully clarified [18]. In addition, limited use of quantitative motion analysis restricts objective evaluation of movement quality [19]. These limitations indicate the need for systematic investigation of coordinated motion and functional performance [20].

Consequently, this study is designed to address these gaps by examining the effect of AT on motor coordination during dynamic tasks. A structured training programme is applied, with guided sessions and daily practice. Posture, gait, and movement efficiency are evaluated as key elements of the locomotor system. The novelty of the study is defined by the combined assessment of coordination, stability, and functional outcomes within a unified approach. The study also supports the integration of movement reeducation with modern analytical methods in human motion research [21]. The findings are expected to provide further evidence for the effectiveness of AT in preventive and rehabilitative contexts [22].

2 Materials and Methods

The study population consists of adult male participants aged 30 to 40 years with sedentary occupations. Mild spinal complaints associated with early degenerative changes are reported. These conditions include initial deformities, mechanical wear, and early calcification, which do not require medical treatment. However, postural deviations and altered gait patterns are observed. The selection ensures the presence of functional impairment without severe pathology, which allows controlled evaluation of movement reeducation effects.

A longitudinal intervention design is applied to examine the effect of the AT on motor coordination, posture, and gait. AT is defined as a method in which conscious control of movement and posture is developed through guided instruction. Participants attend supervised sessions three times per week for four weeks, with a total of 12 sessions. Each session is conducted by a qualified instructor, and verbal guidance and manual support are provided. Attention is directed to head, neck, and spinal alignment, and reduction of muscular tension is achieved.

Participants are required to apply the learned principles in daily activities. Regular home based practice is performed, with focus on correct posture during basic movements. This approach supports the development of stable motor habits through repeated and conscious practice.

Movement assessment is conducted before and after the intervention. Gait is evaluated through a standardised 10 metre walking test, which provides information on step length, rhythm, symmetry, and coordination. Posture is assessed through a static standing test with a duration of two minutes, which evaluates balance and stability.

A total of 160 measurements are collected. A synthetic dataset of approximately 500 cases is generated to support statistical analysis and to preserve the characteristics of the original data.

Movement analysis is performed using the Goethe Gait Lab (GGL) motion testing system. Four synchronised cameras record movement from frontal, posterior, and lateral views. Data are captured at 50 frames per second with controlled shutter speed. These conditions ensure accurate motion evaluation. Figure 2 illustrates the methodology.

The recorded video data are processed using an anthropometric human body model with 16 key reference points that represent major anatomical landmarks. Additional markers are applied to capture hip rotation and torsional movement. Joint displacements, angular kinematics, and spatial coordination parameters are calculated. Calibration is performed before data collection to ensure accuracy and consistency. A minimum frame overlap of 40 percent is required, while approximately 60 percent is achieved to improve precision. A Depth Map Matrix method is applied to support three dimensional reconstruction and to improve spatial accuracy.

Statistical analysis is conducted using both parametric and non parametric methods. Independent sample T tests and paired T tests are used to evaluate differences within and between conditions. The Mann–Whitney test is applied when parametric assumptions are not met. Analysis of variance (ANOVA) is used to assess differences across multiple variables.

All analyses are performed using Statistical Package for the Social Sciences (SPSS) version 26. A high performance computational unit is used for data processing. An artificial intelligence based module is also applied to support pattern recognition and data evaluation.

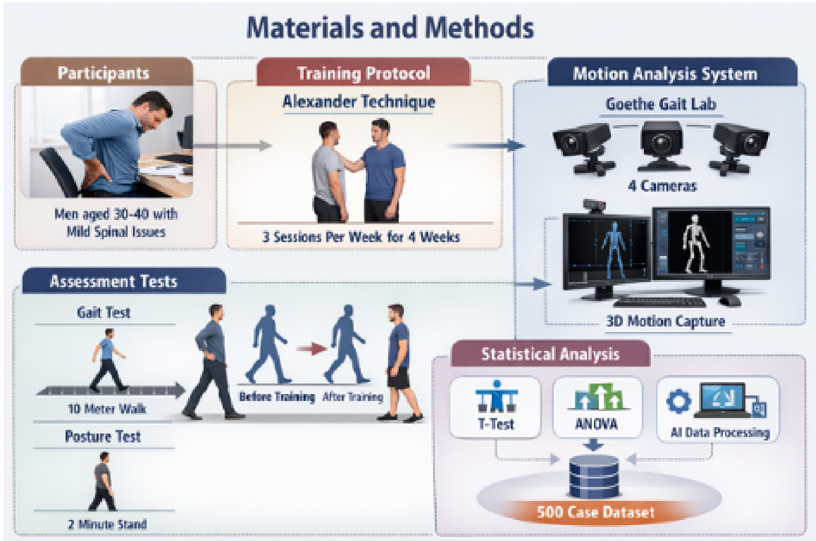

Figure 2: An illustration of the materials and methods section.

This approach ensures reliable assessment of motor coordination, posture, and gait performance. Figure 3 illustrates the validation and calibration of the body model.

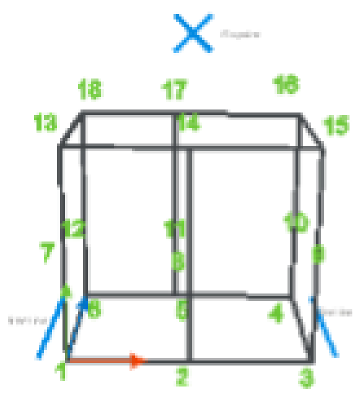

Figure 3: Validation, calibration and body model.

3 Results

The results reported were significant ($p < 0.05$). For gait and posture, our analyses were performed along the three axes: the x-axis represents the sagittal direction (direction of progress), the y-axis represents the vertical direction, and the z-axis represents the lateral displacement. The calibration body is set so the z-axis centre line is at +40 cm. During the gait analysis, we observed that the vertical movement's step length and quality changed. In addition, we observed that longer stride lengths also resulted in greater excursion in the vertical plane. These changes suggest improved muscle work and increased movement stability, as movements with higher amplitude can only be performed if the body's stability is enhanced.

A) Sagittal plane

By applying the Alexander Technique, we observed clear changes in the sagittal direction of movement, especially in the lengthening of the stride cycle, which increases the total stride length on both sides. As a result, both phases of the swing phase of the stride cycle are accelerated so that the peak of the swing phase is reached and the speed of the ground grasp is faster, making the movement more efficient from a muscular-energetic point of view. In the support phase, we found that maintaining balance in this direction of space no longer relies on static holding alone but on continuous movement. It suggests that the regulation of the nervous system is also improved, as dynamic control of movement overrides the static mechanisms that previously dominated. In this context, the Alexander Technique focuses on the strength of the stabilising muscles and increasing the mobility of the small joints, thus improving the joint range of motion. This approach is critical as more conscious and purposeful movements are often more effective than automated movement patterns. Figure 4 presents the results of means of joints in the sagittal plane before and after the programme.

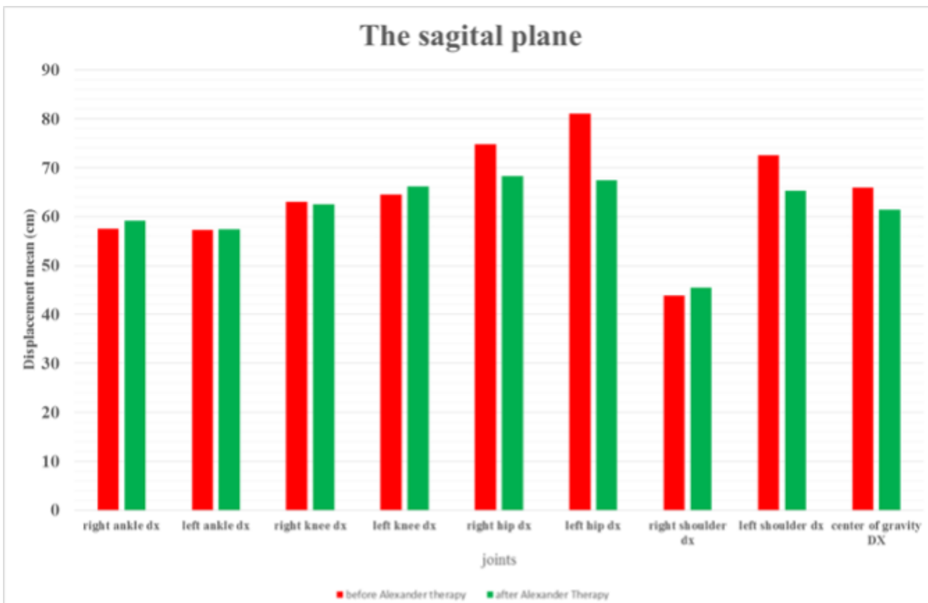

Figure 4: Means of joints in sagittal plane before and after the programme.

B) Vertical plane

When analysing the direction of vertical movement, special attention should be paid to the movement of the large joints, especially the shoulders, hips and knees. Significant differences were observed for the knee, indicating a higher deflection amplitude. However, these changes can only be obtained if the stable support of the opposite leg is also sufficiently strengthened. In comparison with the changes in the step cycle in the sagittal direction presented above, it should be noted that the acceleration of the cycles and the increase in the dynamics of the swing phase are observed in the context of an improvement in the efficiency of the nervous and muscular systems. It is the result of conscious movement.

Our results confirm that the knee and the hip joint have undergone significant changes. The hip amplitude and dynamics have increased, allowing the hip to play a more active role in the biomechanics of gait in several directions. The hip, as the suspensory belt of the lower limbs, has a special role in posture and movement coordination, facilitated by its large mass and central location. As the hip is a spherical joint, it can move in multiple directions, aiding the gait process while improving the body's dynamic balance. The Alexander Technique causes the vertical movement of the hips to occur with a higher amplitude but at a lower position, providing the body with a more stable coordination of movement. It is imperative as a lower centre of gravity helps to increase the dynamics and stability of the gait. The resulting stability is key to the optimal function of the hip and other major joints. These results confirm that the Alexander Technique is an effective way to improve posture and coordination of movement.

The range of motion of the hip in the sagittal plane was significantly reduced, while the increase in vertical stability increased step cycle dynamics. This biomechanical adaptation is analogous to the movement patterns observed in athletics, where the optimisation of ground contact and grip plays a key role in performance and injury prevention. The subjects aimed to place the body's centre of mass closer to the ground, which promotes optimal ground contact and a favourable modification of the biomechanical parameters of gait. The shoulder joint's movement has also changed similarly, which is important because the movement of the shoulder and hip is asynchronous during gait. With a stiffer spine, this movement may be synchronised, influenced by more active deep back muscles. Regular conscious movement exercises like the Alexander Technique are key to strengthening these muscles, improving spinal mobility and postural stability. Figure 5 presents the results for the means of joints in the vertical plane before and after the programme.

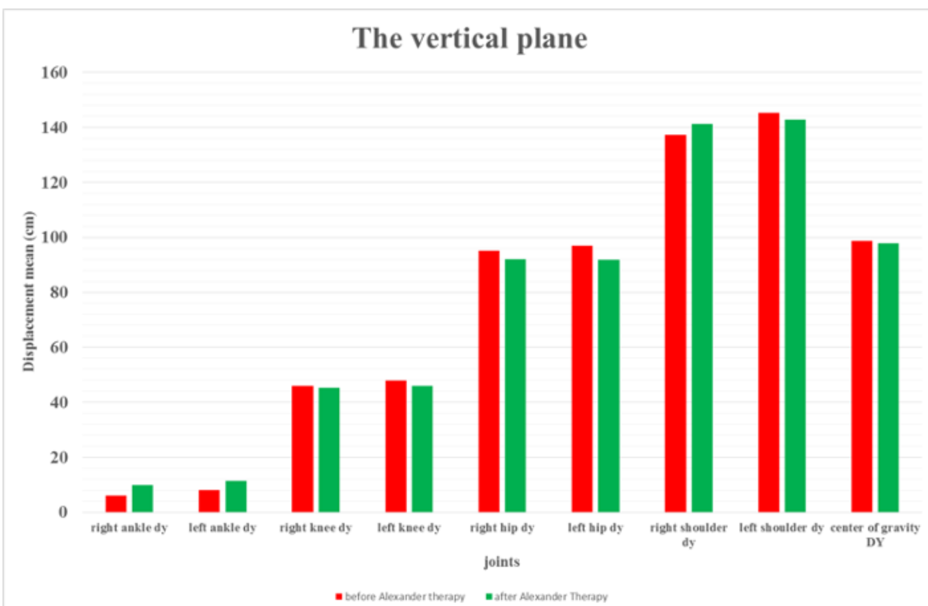

Figure 5: Means of joints in vertical plane before and after the programme.

C) Horizontal plane

During the tests, changes in the range of motion of the shoulder joint were observed in a similar direction to the hip joint. It is particularly significant as the shoulder and hip movement during gait is usually asynchronous. However, increased stiffness of the spinal column may induce a synchronisation of these movements, which may also be influenced by increased activation of the deep dorsal muscles. Regular, conscious movement exercises such as the Alexander

Technique are key in strengthening the spinal stabilising muscles. These exercises help to increase spinal mobility and improve static and dynamic postural stability.

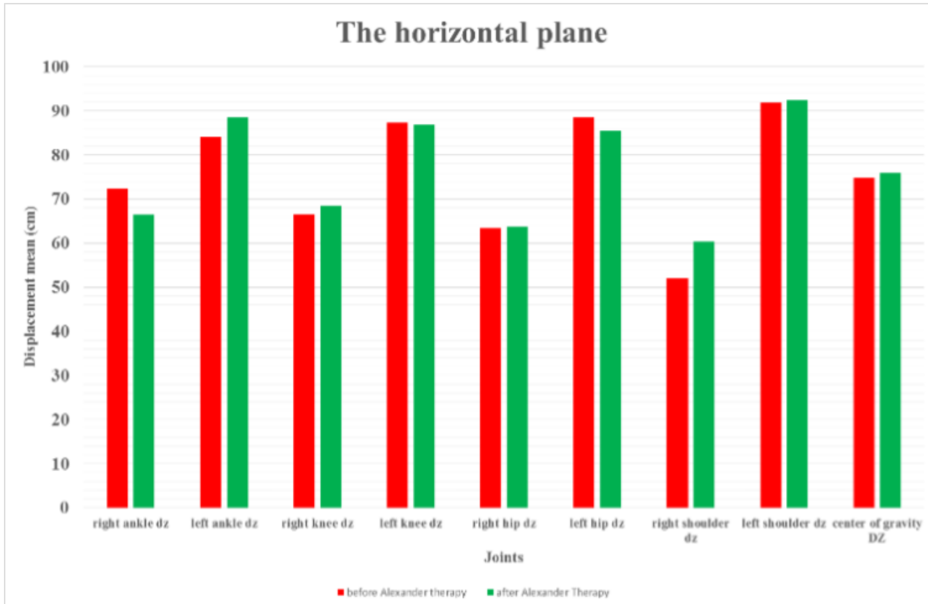

Figure 6: Means of joints in horizontal plane before and after the programme.

4 Discussion

4.1 Characteristics and biomechanical aspects of posture

The vertical, bipedal posture allows for increased freedom of movement of the upper limbs but also places increased stress on the spine, pelvis and lower limbs. The human body is in a state of continuous spatial positional change and, accordingly, posture can be divided into two main functional categories:

- *Static posture*: the whole body or its segments are stabilised in a specific position, for example, when standing, sitting or lying down.
- *Dynamic posture*: the body and/or its segments are in motion—typical examples: walking, running, jumping, dressing, working, sports movements, etc.

Maintaining balance depends mainly on the extent of the support surface and the height of the body's centre of gravity relative to the support surface. The relatively small support surface and high centre of gravity (at S2 height) may require increased muscular effort to maintain balance when standing on two legs. However, the optimal static body position can be stabilised with minimal muscular activity due to the biomechanically advantageous arrangement of anatomical structures.

4.1.1 Biomechanical analysis of the stance

During a static body position, balancing the forces acting on the body, including the gravitational force and the ground reaction force, ensures that equilibrium is maintained. When standing on two feet, the line of action of these two forces coincides, and their resultant can be defined by the line of gravity passing through the body's centre of gravity (centre of mass). In the frontal plane, the line of gravity passes through the body's centre line, dividing it into two symmetrical halves. In the sagittal plane, the line of gravity is located close to the joint pivot points. If the line of gravity passes precisely through the pivot point of the joint, the segments are in an equilibrium position, and no displacement torque is generated. Suppose the line of gravity deviates forward or backwards from the joint pivot point. In that case, a displacement moment is generated, which is mainly counteracted by tension in passive structures (joint capsules, ligaments) and, to a lesser extent, by minimal muscular activity.

When determining the direction of displacement, the movement of the proximal segment relative to the distal segment is considered. If the line of gravity passes anterior to the joint, the proximal segment would be displaced in an anterior direction (e.g., an anterior displacement of the tibia produces dorsiflexion of the ankle joint). For the knee joint, the anterior displacement of the line of gravity produces an extensor torque since an anterior displacement of the femur corresponds to an extension relative to the tibia.

4.1.2 The biomechanical basis of walking

We analysed changes in posture during both walking and static postures. The significance of these studies is that gait, as a complex movement form, can only be achieved if the skeleton, musculature, and nervous system coordination are well developed. The biomechanical basis for the execution of gait is the controlled change in posture. During the initiation of the movement, a minimal forward movement of the head induces a loss of balance, followed by the body, and the coordinated action of the nervous system and muscles stabilises the movement. Walking can, therefore, be understood as a series of controlled imbalances. From a biomechanical point of view, human gait can be considered a more unstable and energy-intensive process than other forms of locomotion in the animal kingdom (e.g., quadrupedal locomotion). Nevertheless, upright walking has provided evolutionary advantages but, at the same time, places significant structural stress on the body—especially the spine.

Human gait is a highly complex movement based on the central nervous system's complex regulatory and integrative workings. Gait is not just the alternating movement of limbs but is the result of a high level of coordination involving a wide range of neural structures. From as early as 20 to 22 weeks of foetal life, elementary forms of gait can be observed under specific conditions. As the stepping and carrying response, these so-called elementary gait reflexes can be triggered in premature newborns up to 2–3 months after birth. It is essential to point out that this elementary walk is not the same as the actual walk, as it does not contain any antigravitational elements nor show any equilibrium reactions. The pattern of steps is also very different from the later, mature gait.

After the third month, there is a so-called astasia, a period in which the infant cannot stand or walk. Then, from about 6–8 months, the ability to stand and walk is observed again—but then under antigravity conditions, i.e., with real muscle work, centre of gravity shift and balance control. Independent gait usually develops between 12 and 18 months of age, but the individual's rhythmic and dynamic plastic gait pattern is not fully developed until 6–7 years of age.

Effective walking requires the body's centre of gravity to be shifted mainly forward while the displacement in other directions remains minimal. Therefore, the intact nervous system controls movement so that lateral (maximum 5 cm) and vertical (also maximum 5 cm) displacement of the centre of gravity is minimised, and rotation of the body along the vertical axis is reduced. These displacements follow a sinusoidal pattern and contribute significantly to the economy of walking.

The lower limb continuously switches between closed and open kinetic chain operation while walking. In a closed chain, the foot is fixed to the ground, and the rest of the body moves relative to it. In this case, the pattern of muscle action and joint displacements are pretty different from the open-chain situation when the limb is free to move, for example, during the swing phase. Of particular relevance for biomechanical analysis is the movement of the subtalar joint (the joint between the talus and the calcaneus), which contributes to the global movement pattern of the lower limb through complex displacements such as inversion and eversion. In a closed kinetic chain, during eversion, the calcaneus turns outwards relative to the talus, while the talus adducts and performs plantar flexion. As a result, the talus moves inwards, i.e., in a rotatory direction, causing internal rotation, adduction and flexion of the whole lower limb. The medial longitudinal arch then descends, and the limb becomes relatively shorter. The process is reversed in inversion: the calcaneus turns inwards (supination), and the talus abducts and performs dorsiflexion. This movement causes the limb to rotate out, abduct and extend while the medial arch rises and the limb lengthens relatively.

Human gait requires sophisticated neural regulation, biomechanical coordination, and a long learning process. Effective gait ensures progress and maintains body stability while minimising unnecessary movements of the centre of gravity and energy loss. One of the most spectacular examples of this complex function is the artistic level of movement demonstrated by, for example, dancers or athletes, with subtle and conscious control of the elements of gait. It also coincides with the timing of muscle contraction. When walking, when the foot is in contact with the ground, the timing of muscle contraction is characterised by a proximal direction from the distal to the proximal (in spastic pathologies, this direction is reversed). The Alexander Technique helps these natural and naturalistic functions and sequences of movements by raising awareness of static posture and the tasks that occur during movement. These awarenesses, directing attention, provide the body with “forces” that help it to develop and execute a correct and more conscious posture and sequence of movements.

5 Conclusions

Posture and gait patterns are recognised as essential elements of the human locomotor system, and their influence on musculoskeletal function and quality of life is established. Increased attention is given to methods in which movement patterns are modified instead of symptoms. The AT is defined as a holistic method in which body organisation, stability, and coordination are improved through conscious control of posture and movement.

The results confirm that AT leads to measurable improvements in motor coordination and gait characteristics. Significant changes are observed in sagittal, vertical, and horizontal planes, which indicate improved movement efficiency and stability. Increased stride length, improved swing phase dynamics, and better coordination between body segments are identified. Improved control of the centre of gravity and more balanced weight distribution are also achieved. These changes result in more stable posture and more efficient muscular activity.

It is shown that awareness of movement patterns is developed, and inefficient habits are modified. Improved neuromuscular regulation is observed, which supports balance and coordinated motion. Motion analysis confirms that changes in the gait cycle improve movement quality and performance.

It is concluded that AT is an effective and non invasive method for improving motor coordination in preventive and rehabilitative contexts. Long term correction of movement patterns is supported through neuroplastic adaptation. Further studies are required to examine underlying mechanisms and long term effects.

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