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Sumathi Publications
Systemic Review

Relationship of Pelvic Alignment with Balance and Gait in Patients with Stroke: A Systematic Review

Mishra Ashwini V[1], Ganvir Suvarna S[1],

[1]MPT in Neurophysiotherapy, DVVPF'S college of Physiotherapy, Ahmednagar, Maharashtra, India
[2]HOD and Professor, Neurophysiotherapy, DVVPF'S college of Physiotherapy, Ahmednagar, Maharashtra, India

Abstract

Background: Pelvis is the key structure that connects the spine and the lower limbs. Altered Pelvic Alignment and asymmetrical weight bearing on affected lower limbs is a common problem leading to pelvic instability which may have an effect on balance and gait in patients with stroke. Hence, it was aimed to investigate the interdependence of these three components in patients with stroke. **Methods**: Four databases (PubMed, Google Scholar, Cochrane, Science Direct) were searched to identify eligible studies using the keywords Pelvic Alignment, Gait, Balance, Stroke. Only observational studies published in last 10 years (2010-2020) were included in this review. **Results**: Thirteen studies were included in the review conducted on sub-acute and chronic stage. All studies investigated the affection of pelvic mal-alignment, balance and gait in combination of two variables except 3 studies which investigated the combined effect of pelvic inclination on both balance and gait. The abnormal pelvic tilt results in lateral displacement of the pelvis on affected side, altered Base of Support, reduced balance control, asymmetry in weight bearing leading to altered gait. **Conclusion**: Pelvic tilt, anterior and lateral has a significant impact on static balance, gait variables, weight bearing symmetry.

Keywords: Pelvic Alignment, Gait, Balance, Stroke

Introduction

Stroke is the common neurological disorder that represents a major cause of disability. It is a significant health problem that needs continuous rehabilitation. It had been positioned 6th driving cause of disability within the year 1990 and is projected to rank fourth by the year 2020 [1].

Pelvis is the key structure that connects the spine with lower limbs, and plays a task in supporting the body, maintaining weight when sitting and transfer of weight from spine to the lower limbs [2]. Pelvic tilt is the parameter which is formed by an angle created by line passing from sacral endplate midpoint to the centre of femoral head and the vertical axis. When an individual is in sitting position, pelvis is a part of the lower trunk and becomes a functional component of the lower limb when a person is standing and walking [3].

Pelvic stability refers to the power of coordinated activity between the lower trunk and proximal hip muscles and therefore the pelvis serves as the proximal dynamic stability as to allow for effective lower limb mobility during functional balance and mobility task [4]. Tilting in one or the opposite way will cause the disruption within the kinetic chain. Change in Pelvic alignment occurs due to strategies of postural control influenced by mechanisms around the hip and ankle [5].

The abnormal pelvic movement are anterior, posterior and lateral pelvic tilt and this abnormal motion is related to trunk control, balance, gait and functional ability [6]. The altered recruitment of hip abductors and extensors on the affected leg influences the pelvic stability, thus resulting in

Correspondence: Ashwini Mishra, DVVPF'S College of Physiotherapy, Opposite Govt Milk Dairy, Vilad Ghat, Ahmednagar- 414111. E-mail: mishraashwini60@gmail.com

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more lateral and anterior pelvic tilt in the frontal and sagittal plane [7].

Altered pelvic alignment contribute for reduced weight acceptance on the affected lower limb and it is mainly due to poor trunk pelvis dissociation or decreased hip muscular control activity which lead to asymmetric weight distribution [8]. Inappropriate muscle activation and poor movement control around the pelvis lead to difficulty in mobility and daily functioning [9].

There are several factors affecting the functional independence in post stroke period during which Trunk performance and Balance play a significant role [10] and faces difficulties in carrying out daily activities due to reduced gait speed and muscle strength.

To evaluate the progress balance, gait velocity and fear of fall were assessed. Impaired balance and postural control cause tendency to fall [11].

For standard gait the important elements are pelvic rotation, tilt, stance phase flexion of the knee joints, movements of ankle and knee joints, and pelvic translation [12].

Alteration in gait pattern will result in loss of balance. Both gait deviations and balance dysfunction are related to similar impairments that's hemiparesis, altered sensory function, or lack of confidence in paretic limb.[13] Increased asymmetry in body weight distribution between the feet is noticed during normal quiet standing. [14] The tendency to keep the centre of gravity shifted toward the non-paretic limb which could be a common observation during Gait [15].

Recent studies reported that, along with kinematic factors of the paretic lower limb, standing balance function is additionally related to asymmetric gait patterns in stroke patient [16]. Asymmetric pelvic alignment between the pelvis and the lower limbs affects the stability and steadiness of the lower limbs and trunk, resulting in abnormal Gait [17].

Stroke patients find difficulty in ambulating oneself, as their ability to keep the spine straight and move the pelvis back and forth while rotating the trunk during any movement is affected as pelvis is crucial element in overall posture [18].

The major goal in rehabilitation is the functional independence and it is considered that almost 60% are significantly disabled following the stroke [19]. Pelvic tilting exercises affect the asymmetric pelvis in stroke patients, which reinforces the balance and gait ability [20]. Author Lennon et al., identified that pelvic re-education resulted in decreased Anterior Pelvic tilt with better knee extension during stance and more normal ankle pattern during swing phase emphasizing the importance of pelvic control and weight shift capacity towards the affected side [21].

Pelvic mal-alignment result into asymmetrical weight bearing which leads to altered Balance and Gait patterns and this study will provide transparent picture of interdependence of pelvis and lower limbs and their influence on Balance and Gait. So, this systematic review aimed at analysing the relationship of Pelvic alignment with balance and gait in patients with stroke.

Material And Methodology

Systematic search was undertaken in four commonly used search engines (PubMed, Google Scholar, Science Direct, Cochrane library) for the period from January 2010 to January 2021. The search strategy comprised of the following terms: Stroke, Gait, Postural Balance, Pelvic Alignment.

Selection criteria for observation studies:

Only observational studies published in English language evaluating pelvic alignment or balance or gait in patients with stroke were included. The Exclusion criteria was Randomized control Trial (RCT), Experimental studies as study design.

Data extraction:

The Data Analysis was done through various Electronic Data base searched by AM. The Title and Abstract of all the retrieved results were then screened for eligibility by AM & SG. The Screening process was aimed at narrowing down the volume of articles by rejecting the studies that are not relevant or appropriate according to previously stated criteria, Full text version of all relevant articles were evaluated by AM and SG.

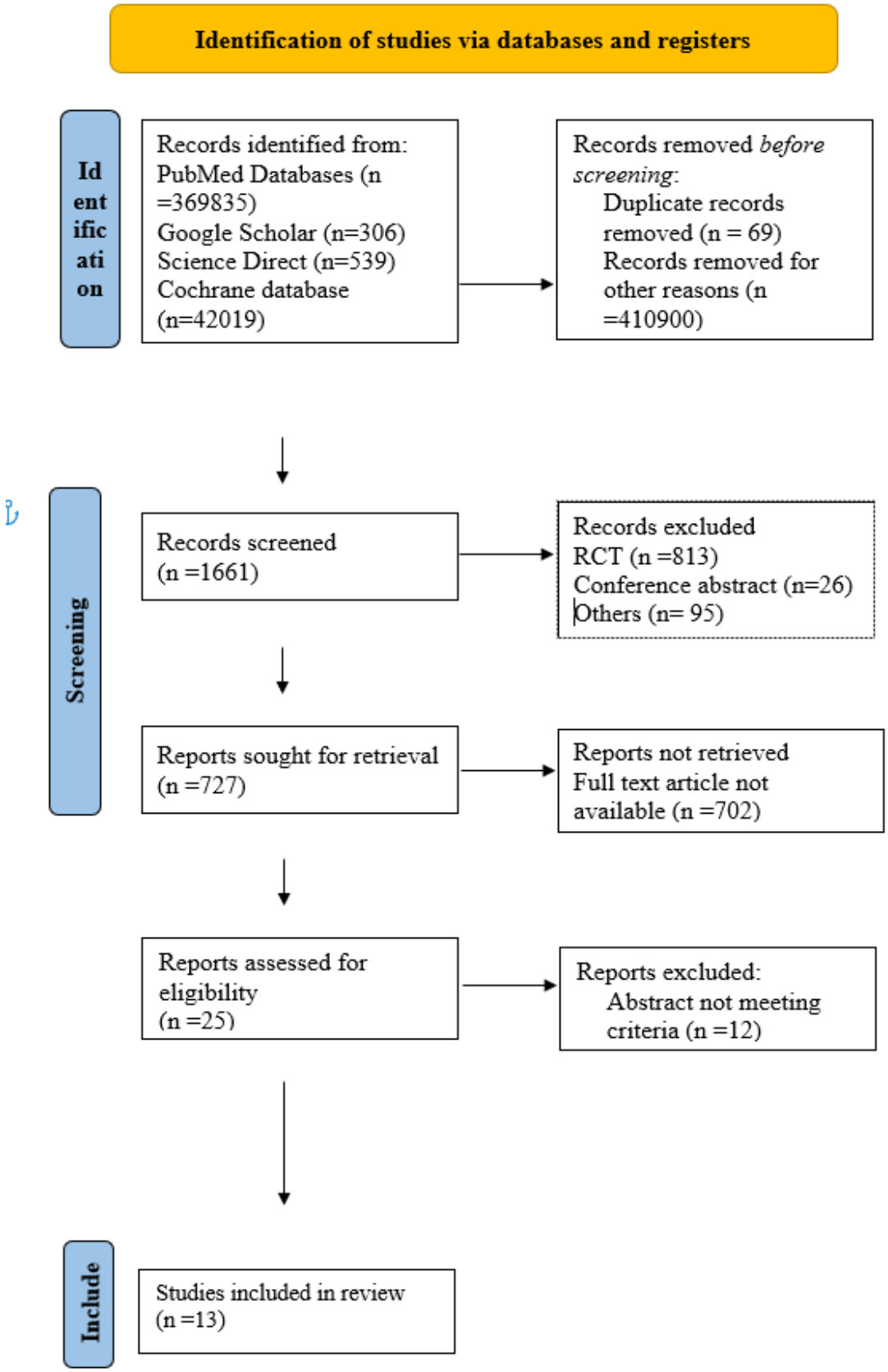
Data analysis:

The selected studies were analysed in terms of specific study design, no. of subjects included, procedure performed, outcome measures used in the study, conclusion, limitations and future scope.

Analysis of study design helped to confirm specific type of observational study. Details of participants suggested the stage of stroke whether subacute or chronic. Procedure of each study revealed how the information about pelvic alignment, gait & balance was collected. Outcome measures description indicated quality of tool along with its psychometric properties. Result of study produced a direction to understand the relationship between the variables that were investigated in each study. Limitations and future scope compiled from each study may trigger the concept of new study among the readers.

Risk of bias assessment:

Articles included in the review were in English language which may have biased some findings.



Duration of condition and extent of spasticity may affect the performance of gait and balance.

The Outcome Measures for Assessing Pelvic Alignment were: Palpation meter, Vicon motion capture system, Pelvic Inclinometer, Optical 3D measurement system Formetric II device, Global Postural System. The outcome measures for assessing Balance used were: Tinetti Balance scale, Berg Balance Scale, Force Platform, Tetrax Balance System, Bio- Rescue system, Community Balance and Mobility Scale. The measures for the Assessment of Gait were: GAITRite System, 10 metre Walk test, Figure of 8 test, Functional Gait Assessment Scale,

Table 1. Summary of Observational Studies

STUDY	DESIGN	SUBJECT AND PROCEDURE	OUTCOME MEASURE	RESULT AND CONCLUSION	LIMITATION	FUTURE SCOPE
Yu-Won Choe, et al 2021 [22].	Cross-sectional	• Twenty-two patients with chronic stroke • Pelvic inclination- sagittal plane- standing • Static balance - force platform with eyes open • Cadence and gait velocity- walking 3 metre	1. GAITRite system 2. Force platform 3. Palpation Meter	Pelvic Inclination is not important consideration for increasing the Gait function and static Balance.	Sample size was small	Additional longitudinal study
HarshaliGurli, et al 2019 [23].	Cross-sectional	• Eighteen patients with chronic Stroke • Anterior/ posterior and lateral Pelvic Tilt- standing. • Gait parameters- walking on platform by placing their foot in powdered chalk.	1. Pelvic inclinometer 2. Stride length 3. Step length 4. Step width 5. Cadence 6. Functional Gait Assessment	Significant relationship between Anterior Pelvic Tilt, Lateral Pelvic Tilt and gait parameters in patients with stroke.	1.Heterogeneous sample 2.Unavailability of standardised instrument, 3. shorter time span for conduction of research.	Relationship between muscle activity and gait parameters with a pelvic tilt
Surulirai Karthik Babu, et al 2019 [24].	Cross-sectional	• One hundred and twelve patients with chronic stroke • Lateral and anterior pelvic tilt angle- standing • Percentage of WBA- standing	1. Palpation meter 2. Two standardized weighing scale	Excessive lateral pelvic tilt toward the most affected side influences the weight bearing ability of the ipsilateral lower extremity.	1. The amount of pelvic rotation, a major postural deviation was not studied.	-
L. Sai Kiran et al 2019 [5].	Cross-sectional	• Hundred post stroke patients • Subjects assessed- weight distribution& pelvic variables • Other assessment- balance, trunk and lower extremity function.	1. Digital weighing machines 2. Palpation meter 3. Berg Balance scale 4. Trunk Impairment Scale 5. Lower Extremity Functional Index	Pelvic variables have an effect on lower limb weight bearing and Imbalance in weight bearing can also be a result of polarity in these variables.	1. Foot component not assessed properly- lack of proper assessment tools. 2. Postural parameter was not included 3. Small sample size	1. Posture, foot and hip components can be conducted to complete the lower limb variables. 2. Another study- aim at finding upper-limb and trunk involvement
Myoung-Kwon Kim et al 2018 [6].	Cross-sectional	• Fourteen patients with chronic stroke- Anterior pelvic tilt angle- upright position • Balance- moving distance and area of COP • Gait speed and parameters were assessed.	1. Palpation meter 2. Bio- Rescue system 3. 10 m walk test 4. GAITRite system	Anterior pelvic tilt is associated with balance dysfunction and gait function (gait speed and step length)	-	-

Margaretha M. van Dijk et al 2017 [25].	Case-Control	• Sixty-eight participants- (36-patients with sub-acute stroke, 32- healthy control subjects) • Lateral and diagonal maximum weight shifting-standing. • Further correlated- balance, gait and fear of falling	1. Force platform 2. Berg Balance Scale 3. Community Balance and Mobility Scale 4. Falls Efficacy Scale 5. 10 m walk test	Sub-acute PwS have decreased ability to shift their body weight diagonally in standing towards their affected side. And strongly related to balance and gait speed.	1. Limited sample size 2. Not assess sensory status or other clinical characteristics that affect balance performance	Further study to investigate if diagonal-forward MWS should be used as part of a standard balance assessment.
Andrzej Szopa, et al 2017 [26].	Case-Control	• Forty-Four participants- (22- patients with chronic stroke, 22-age matched healthy student) • Posturographic weight-bearing (WB) distribution-standing • 3DGA- walking on a treadmill.	1.Force platform 2. Gillette Gait Index (GGI)	Weight bearing asymmetry and decreased contribution of the paretic limb in quiet standing were associated with increased post stroke gait deviation from normal.	1. Findings from treadmill-based gait research differ from overground gait data 2. Small sample 3. No proper sample size calculation	1. Further studies with larger sample sizes 2. Consider the different degrees of severity and characteristics of stroke
Hyung-Sik Kim et al 2016 [27].	Case-Control	• Ten participants (5-healthy subjects and 5-post stroke survivors). • Joint kinematics and gait parameters- 10 m walkway.	1.Vicon motion capture system (ROM, pelvic tilt, rotation, obliquity, gait phases)	Main target to increase ROM of primary-joint movements and strong need to support pelvic motions in order to improve the outcome of gait rehabilitation.	1. Small sample size. 2. Variability- reduced-voluntary knee movement dysfunction was considered. 3. Two group- not age match. 4. Kinematic differences and their associations to gait were evaluated.	In future study, both kinematic and joint-power information should be investigated.
Surulirai Karthik Babu, et al 2016 [7].	Cross-sectional	• One hundred and sixteen patients with stroke • Pelvic Alignment- standing • Trunk performance- sitting. • Order of test- coin-toss method.	1. Palpation meter 2. Trunk impairment scale	Pelvic alignment is not normal after stroke, and influenced by poor trunk control and impairment of the lower extremities	1. Posterior rotation of the pelvis was not reported in the present study	-

SeonWoong Kong, et al 2015 [28].	Cross-sectional	• Fifty-eight patients with stroke • Pelvic displacement- Global Postural System. • Balance weight distribution index (WDI) and stability index (SI)-with eyes open and closed. • Gait- walking 14 m, straight and curved gait ability was assessed	1. Global Postural System 2. 10 m walk test 3. Fig of 8 test 4. Tetrax balance system	Increased pelvic displacement in stroke patients results in a decrease in balance ability and gait speed.	-	Studies on correlations between balance, gait, and other functional activities due to pelvic displacement, including the qualitative elements of gait.
Shivani Pathak, et al 2014 [9].	Cross-sectional	• Thirty-eight supra-tentorial stroke subjects- • Pelvic alignment- paretic& non-paretic side- sitting. • Trunk control was assessed	1. Palpation meter 2. Trunk impairment scale	Pelvic alignment influences the trunk control which in turn influence extremity motor recovery.	Pelvic alignment influences the trunk control which in turn influence extremity motor recovery. 1. Pelvic tilt and their correlation with balance and gait was not analyzed. 2. Small sample size	-
G. Jijimol, et al 2013 [29].	Cross-sectional	• Thirty patients with chronic stroke • Trunk performance and balance evaluated and compared- analyse corelation between them.	1. Trunk impairment scale 2. Tinetti balance scale	Trunk impairment and balance are positively correlated with each other.	1. Small sample size	-
Yahia Zakaria et al 2010 [30].	Cross-sectional	• Sixty patients with stroke • Divided- equal group- duration of illness. • Spine analysis and posture measurement • Assessment of trunk control test and Trunk ROM	1. Optical 3D measurement system Formetric II device 2. Modified Schober flexion technique	Stroke patients suffer from back and pelvis malalignment which are seen in long-standing patients with high degrees of spasticity	-	-

Community Balance and Mobility Scale, Gillette Gait Index (GGI), Vicon motion capture system.

Results

Please refer to Table 1.

Discussion

This systematic review mainly focus on Influence of Pelvic Alignment on Balance and Gait in Patients with stroke. There are studies which shows the effect of anterior pelvic alignment on gait and also the relation between trunk, balance and gait. [5,20] For balance assessment the two common outcome measure have been used in the study were Berg Balance scale and force platform [5,2,22,25].

For gait assessment the GAITRite system and 10 metre walk test was commonly used outcome measure [22,6,25,28].

For pelvic alignment, palpation meter was commonly used [22,24,5,6,7,9].

Pelvic alignment and gait:

One of the study found strong correlation between the Pelvic alignment and Gait and it was assessed by walking on platform by placing their foot in powdered chalk and they suggest that with an increase in Anterior Pelvic Tilt, the foot is placed little beyond the other foot but the lack of hip flexion control due to extensor spasticity prevents it from being taken much forward [23].

Studies shows correlation between Pelvic alignment and the Gait parameters and it was assessed by walking on 10 metre walkway. They found that with the increase in tilting of the pelvis, the gait velocity and all the gait parameters decreases [24, 27]. This suggest a strong negative correlation between them. It is because of reduced abductor activity that may allow the adductors to pull the leg in direction of adduction and may not allow the leg to go much beyond the midline thereby reducing the step width. The muscles of the lower trunk and hip working onto pelvis in anterior-posterior direction helps in activation of hip abductor and trunk side flexor during side-to-side weight shifts. This suggests that pelvic stability in forward-backward direction is well coordinated by trunk-pelvic and pelvis-hip dissociation.

Pelvic alignment and weight bearing asymmetry:

Few studies were done to find out the co-relation between pelvic alignment and its effect on weight distribution on lower limbs. The abnormal pelvic tilt noted in this study, which states that abnormal pelvic tilt occurs in stroke patients, and can be attributed to trunk control, gait function and balance, following stroke. And it suggest that the amount of spasticity can affect the supination of foot; more the spasticity, more the supination/high arches of foot which lead to abnormal weight-bearing [5]. And the better muscular recruitment of hip abductors and extensors of the paretic leg, could possibly keep the pelvis tilted posteriorly and iliac crests at the same level during standing balance.

Pelvic alignment and balance:

One of the study correlated pelvic alignment, trunk performance and lower limb recovery and reported that poor trunk control is related to balance dysfunction, gait abnormalities and daily functional difficulties. It suggested that lateral displacement of the pelvis on affected side were observed as a result of poor hip abductors and extensors control, and this lead to the poor pelvic stability and asymmetric weight shifting during gait [7]. There is impaired muscular control of the lower trunk, pelvis is tilted excessively forward bilaterally and laterally on the most affected side, so as to orient the pelvis towards least affected leg there is asymmetrical weight distribution between the feet. And there is Gluteus Medius muscle inactivation during perturbations in standing leading to impaired balance in stroke patient and thus it is compensated by more activity of the contralateral muscles.

Study reported that pelvic alignment influences the trunk control and suggest that external oblique muscle is responsible for fixing the position of pelvis. Hence it can be assumed that abnormal trunk control could lead to deviation in pelvic alignment from the neutral position. [9]

Pelvic alignment, balance and gait:

Anterior pelvic tilt and its correlation between balance and gait and they found negative correlation between pelvic anterior tilt and gait function including gait speed and step length and reported that individual balance ability is confounding factor which could influence gait parameters. And increased weight bearing on the non-paretic limb during quiet standing; leads to reduced balance control of the paretic limb and is related to increased asymmetry of the gait [6].

Correlation between balance and gait according to pelvic displacement in stroke patients and the study reported that control of pelvic displacement is necessary before functional training in stroke patients. They suggest that joints and muscles of the pelvis and legs operate in coordination. When disharmony occurs, abnormal gait and balance appears [28].

No significant correlation between Pelvic Inclination, Gait and Balance variables conclude that pelvic Inclination is not an important

consideration for increasing Gait function and static Balance [22]. They suggested that increasing the balance could lead to a better gait because they could walk within a narrow BOS, indicating ability to shift their COG in all Anterior-Posterior and Medial-Lateral directions.

None of the authors considered Pelvic rotation which is important component of pelvis. Most of the authors conducted study with small sample size which was major limitation in above given studies.

Further studies can be done to investigate the overall impact of Pelvic Alignment on Balance and Gait and other Functional activity and also the study exploring the Muscle activity, and Joint Power with Gait parameter with larger sample size can be done.

Conclusion

This systematic review gives information regarding the Impact of Pelvic Alignment on Balance and Gait. There is influence of Pelvic Alignment on trunk, and there is relationship between Balance and Gait. Pelvic alignment leads to asymmetrical weight bearing ability in patients with stroke.

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