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Perspective

A Proposal for Biomechanical Evaluation of Balance in HTLV- 1 Individuals

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Introduction

Studies on functional profile in individuals infected with HTLV-1 point to a serious balance deficit in this population. Scales and tests to assess balance are subjective, depend on examiners, and take a long time to be executed.

Objective

To investigate the functional characteristics in patients with HTLV-1 and to design a proposal for an evaluation of the biomechanical balance.

Methodology

This perspective study was based on a literature review using the keywords "HTLV", "balance", and "functional profile" in the SciELO, Medline, and Cochrane databases. Functional characteristics concerning the balance were extracted from the articles for analysis as an interest variable. In addition, biomechanical tools for assessment of the balance in population with neurologic problem were identified.

Results

It was found that lower limbs spasticity, the thoracic level of the spinal cord injury, pain, and joint locks generate postural and gait changes that affect the balance. The most appropriate tools for a quantitative assessment of biomechanical balance in these individuals are baropodometry, electromyography, and kinematics.

Conclusions

Difficulties to be in a standing position suggest that the ideal protocol for biomechanical evaluation of balance in patients with HTLV-1 involves quantitative simultaneous measurements of stabilometry, electromyography, and kinematics data.

Keywords: HTLV; Biomechanics;Balance; Assessment

Introduction

The human T-cell lymphotropic virus type 1 (HTLV-1) is a retrovirus regarded as a triggering agent of moderate to high-intensity chronic pain and neurological disorders that interfere with the daily activities, quality of life, and social interaction of those infected [1]. It is a sexually transmitted disease that predominantly affects women of low socioeconomic status [2,3]. It has been estimated that there are between 10 and 20 million individuals infected worldwide [4]. The city of Salvador, Bahia, Brazil, has the highest prevalence of seropositive individuals in the country.

This clinical condition is asymptomatic in most cases, which facilitates its horizontal and vertical transmission [2]. However, about 5 to 10% of infected people progress to moderate- and high-intensity pain, pelvic floor dysfunction, and spasticity of the lower limbs. This framework has been defined as tropical spastic associated myelopathy HTLV-1 (HAM/TSP) [5]. Ten years after the symptoms onset of HAM/TSP, most people experience difficulty walking, loss of control of sphincters, sexual dysfunction, pain (especially in lower back and lower limbs), and balance disorders [6,7].

Multidisciplinary teams composed of physicians, psychologists, physiotherapists, and fitness trainers have been developing research and assistance for this population [8]. The few studies that have investigated the functionality in this population demonstrate that balance is a problem that requires urgent actions to prevent and rehabilitate [8-11].

Values identified in the Berg balance scale in patients with HTLV-1 are below the cutoff points established for the elderly and people with Parkinson's and stroke sequelaea [12]. Risk of falls is higher (63.9%) in HAM/TSP individuals [10]. These findings point to the importance of balance rehabilitation protocols in such individuals [13]. The percentage of balance impairment among other neurologic symptoms is unknown. Some balance impairment cases maybe undetected by scales. Therefore, it is important to create a quantitative balance assessment protocol to improve diagnostic accuracy. The objective of this study was to investigate the functional characteristics in patients with HTLV-1 and to design a proposal for biomechanical evaluation of balance.

Methodology

This evaluation perspective study was based on a systematic review of the literature conducted by researchers independently in the main databases (SciELO, Medline, and Cochrane) without determining the period and language. The keywords used, interspersed by the Boolean operator "AND", were "balance", "HTLV", and "functional profile". Observational studies, case reports, clinical trials, and literature reviews were included. Studies that did not describe the postural balance assessment in detail were excluded.

Parameters for balance assessment of the specific characteristics of functionality as compared to balance in a healthy condition were extracted from the studies. Data were analyzed on the literature, and biomechanical tools for assessment of the balance in this population were identified. Finally, the authors based on the clinical experience suggested an evaluation protocol to be tested in a study of diagnostic accuracy.

Results and Discussion

Searching the databases resulted in 54 references. After screening on title and abstract, 17 references remained (Figure 1). Then, screening the full text article excluded 6 references, leaving 11 references for definitive analysis inclusion.

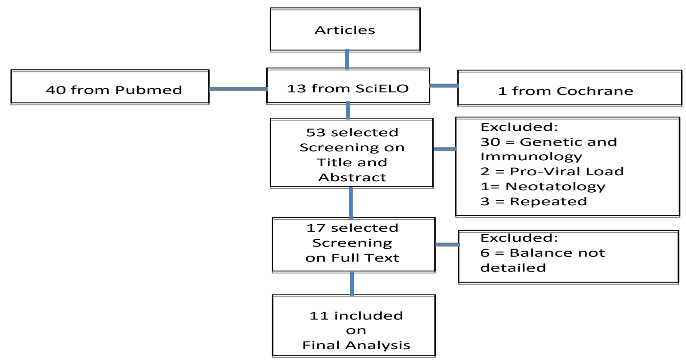

Figure 1. Flow chart of articles data collect.

Two were randomized clinical trials, two were a literature review, one was a case report, one was cohort and five were cross sectional studies (Table 1). The principal outcomes assessed were functionality, balance, gait, spasticity, falls, pain, posture and quality of life. Every study used scales and physical tests. Any quantitative balance analysis was found.

Functional characteristics and balance

Although functional disorders are more evident in the defined category for HAM/TSP, many people with HTLV-1 present inflammatory conditions in the lower limbs as arthritis and myositis [13]. These conditions can change the balance and gait due to the presence of pain — a common symptom — even in asymptomatic patients [16]. For this reason, infected people have to be under constant evaluation and care by multidisciplinary teams that can intervene early on to control pain in the lower limbs and ensure balance rehabilitation. Due to quick disease progression scenarios, early detection of balance function impairment can improve the prognosis [13]. The stance is significantly altered in people with HAM/TSP and may be related to loss of balance [9,12,17]. There is a lack of studies with balance assessment functional tests in HAM/TSP.

Table 1. References remained.

	Population/ Patients	Exposition	Comparison	Outcomes	Study Type
[9]	HAM/TSP	__	Multiple Sclerosis	Spasticity	Literature Review
			Amyotrophic Lateral Sclerosis	Functionality	
			Stroke	Force	
				Flexibility	
				Postural Control	
[6]	HAM/TSP=72	WHO Diagnosis	FIM≤108	Elderly Low Back Pain	Cross Sectional
			FIM>108	**Strength in Lower Limbs**	
[14]	HAM/TSP=73	WHO Diagnosis	__	Osame Scale=7.0	Cross Sectional
				ADL=very committed	
				SF-36 Physical Aspect and Functional Capacity	
[15]	HAM/TSP=1	PFN	__	Tinetti Scale	Case Report
				Balance Improve	
				Gait Improve	
				Gait Quantitative Parameters Improve	
[16]	HAM/TSP=115	Asymptomatic		Body Map = **Lumbar and Lower Limbs Pain**	Cross Sectional
		Possible		VAS = Moderate to Intense	
		Probable Defined	__	DN-4 = Neuropathic Pain	
[17]	HAM/TSP=38	WHO Diagnosis	Non Infected Individuals	SAPO Postural Analysis = Anteriorization of Head and Trunk; **Hip and Knee Flexion; and Ankle Angle Reduced**	Cross Sectional
				SF-36 = Functional Capacity and Physical Appearance Very Reduced	
[7]	HAM/TSP=206	WHO Diagnosis	__	Gait Disturbance= 76% Spasticity Elderly	Cohort
				Lower Limbs Limitations	
				Thoracic Neurological Level	
				Assistive Technology	

[10]	HAM/TSP=36	Ambulatory Patients	Physical Activities	**Falls**=63.9%	Cross Sectional
			Assistive Technology		
			Functional Ambulation Level		
			Number of Falls		
[13]	HAM/TSP	WHO Diagnosis	__	Hyperreflexia	Literature Review
				Neuropathic Pain	
				Backache	
				Falls	
				Arthritis	
				Myositis	
[12]	HAM/TSP=12	Virtual Therapy (Wii Nintendo)	Test Group (TG)	Berg Scale = Improve **Balance** on TG	RCT
			Control Group (CG)		
[8]	HAM/TSP=14	PFN	PFN	Ashworth Scale = Pain Reduce	RCT
		Physiotherapist Assisted = 7	Self-Administered = 7	FIM Improve	
				TUG Improve	

HAM/TSP – HTLV-1 associated myelopathy; WHO – World Health Organization; FIM – Functional Independency Measure; ADL – Activities of Daily Life; SF-36 – Short Form 36 items for Quality of Life Questionnaire; PNF – Proprioception Neuromuscular Facilitation; RCT – Randomized Clinical Trial.

About 30 to 50% of patients with HAM/TSP have adaptation needs to perform daily activities by means of using canes, crutches, walkers, and wheelchairs. The main functional losses are often walking impairment due to spasticity affecting the lower limbs [7,13,14]. Adequate control of posture and balance underlying the functional skills is achieved through the integration of sensory information and in avoiding falling down, an integration that requires rapid recalibration of visual information, both vestibular and somatosensory [18].

The foot and ankle are the most outstanding contributors to proprioceptive segmental adjustments in the standing posture due to their operation as fixed points on the surface contact on the ground [19]. In a theory known as the "theory of the inverted pendulum", the motor strategies involve small adjustments in muscular tension in the lower limbs, which allows maintaining the operational centre of gravity (COG) designed inside the support base through a series of anteroposterior (AP) and mediolateral (ML) oscillations. The further the COG is regarding the limits of body support, the better the postural balance control. Improper action of the muscles and joints of the legs added to the central nervous system sensory disturbances can lead to postural instability and increase the risk of falls. Falls were frequent in HAM/TSP ambulatory group (63.9%) in a cross sectional study [10] and in a cohort follow up [7].

The loss of gait function in patients infected by HTLV-1 is progressive and evolves more rapidly in people over 60, those who have more spasticity, and those with a level of thoracic spinal cord injury and joint limitations in the lower limbs [7]. Despite the knowledge of the abnormal number of falls in this population evaluated by longitudinal studies [10], action points have been identified on the balance for people with HTLV-1.

Functional tests

The functional kinetic aspects related to difficulties in walking and loss of functionality requires more precise assessments. Scales have been applied to evaluate and screen individuals with losses in postural control and functional performance [2,6,8,9,11,12,15,18,20]. However, more objective and precise measurements have been shown to increase confidence in scientific information that has been generated by rehabilitation teams.

The main tests adopted in studies evaluating the balance in people with neurofunctional disorders are the Berg scale [21] and the Timed Up and Go (TUG) [22]. Scales of spasticity, functionality index, and functional independence measure have also been adopted to assess the evolution of loss of functionality and functional responses to physical therapy interventions in people with HTLV, but they are not specific to assess balance [2,6,8,15] and Ferreira *et al.* [15] used specific instruments to assess balance – The Berg Scale and The Tinnet Test.

Among the principal limitations, the scales are subjective, evaluator dependent, and take a long time in the data collecting part. The TUG aims to be a quantitative measure that is less dependent on the examiner. Hence, it evaluates many other outcomes besides balance and often requires skills not possible in cases where the disease is already in a more advanced stage. Measurements performed more quickly and less dependent on the experience of the examiners can increase the accuracy of diagnosis of postural control [8,23].

Biomechanics balance rating

More objective techniques to measure the balance in other health conditions have been proposed by biomechanics laboratories. As assessment protocols practiced in these environments, baropodometry measures, electromyography, and kinematics have been used in association. These features can help improve the accuracy of functional kinetic diagnosis in affected populations.

Three complementary methods (movement evaluation in the centre of pressure, evaluation of muscle contractions, and evaluation of displacement of body segments) allow obtaining information on biomechanical balance [24]. To measure movements in the centre of pressure, we can use a force plate known as baropodometry [25]. To evaluate the pattern of muscle activation, we can get electrophysiological data on motor points skin surface [26]. And for information about the movements of body segments, we can include kinematics and goniometric measurements. These measures, correlated with a functional scale, can improve the accuracy of the balance assessment in patients with HTLV-1, with positive impacts for both research and clinical practice.

Baropodometry

Baropodometry is a measuring instrument consisting of a force platform with capacitive pressure sensors which serves to detect the pressure of various parts of the plantar surface and the operational centre of pressure (OCP) by measuring the pressure peaks and stabilometric fluctuations during a quasi-static posture. This feature allows measurement of plantar pressure and maximum average beyond the centre of mass of the positioning and speed of the oscillations in the support base at all times.

Stabilometry accomplished through force platforms is safe, reproducible, and objective to investigate changes in orthostatic stability [25], which is a constant interference factor by changing the torque caused by the ground reaction force and the conservation of angular momentum principle. This physiological condition leads to AP and ML oscillations of COG. The baropodometry platform comprises a base plate with dimensions of 465 x 520 x 25mm, 4,098 pickups pressure 7.62 x 7.62 mm. Individually recorded up to 120 N/cm^2 pressure, arranged in an area of 490mm x 490mm active surface, which allows baropodometric analysis of discharge pressure in kilogram-force/cm^2 (kgf/cm^2) and foot contact time with the ground (plantar surface in cm^2) in the static standing position. This equipment consists of a 16-bit converter sampling frequency of 200 Hz. References in stabilometrics for assessment by baropodometry are shown in Table 2.

Table 2. Measures in stabilometric references.

		Normative value	Standard deviation
Stabilometry			
	AP displacement	3.5 cm	0.5
	ML AP displacement	2.7 cm	0.5
	Speed oscillation	n/d	
Load distribution			
	Right foot	50%	3%
	Left foot	50%	3%
	Forefoot right	45%	3%
	Retro-foot right	55%	3%
	Left forefoot	45%	3%
	Retro left-foot	55%	3%

Electromyography

By measuring electromyographic signs of the postural muscles of the leg and lower back while maintaining the standing position, it can record the patterns of behaviour in a bilateral muscular balance maintenance task. Electromyographic signals are taken up by single-phase adhesive electrodes that record the electrical signals at the time of muscle activation. These signals are referred to an amplifier and a filter for cleaning the signals that are influenced by other chains in the environment, and then scanned to measure the currents generated by the muscles. The measurements obtained identify the moment of activation, signs of fatigue, and relaxing time. With the waves generated, it is possible to obtain the average amplitude of the contraction, contraction peak, the time of activation, and signs of fatigue of postural muscles [26]. Differences in surface electromyographical microvolt potentials between different anatomical regions are 7.7±3.7 for thoracic, 6.7±3.6 for lumbar, and 4.4±2.8 for sacrum body regions [27]. Segments necessary

Table 3. Descriptive statistic for paraspinal surface electromyography microvolt potentials collected at 25 through 500 Hz.

Segment	LEFT				RIGHT			
	Med	Min	Max	Mean±SD	Med	Min	Max	Mean±SD
T4	5.65	2.00	17.20	6.50±3.00	5.80	1.80	18.50	6.40±3.20
T6	7.75	2.20	21.20	8.40±3.50	7.56	1.60	22.40	8.20±3.50
T8	9.00	2.30	25.70	9.60±6.10	8.75	1.50	27.30	9.50±4.50
T10	9.25	3.20	22.80	10.00±4.20	9.00	2.60	23.70	10.00±4.30
T12	8.65	2.00	23.30	9.50±4.50	9.60	1.50	20.20	9.90±4.40
L1	8.20	2.00	26.40	8.70±4.10	8.40	1.70	21.60	8.80±4.00
L3	5.65	2.00	14.00	6.10±3.10	5.35	1.80	16.30	6.20±3.40
L5	4.75	1.50	16.30	5.20±3.20	4.25	1.70	17.00	5.30±3.50
S1	3.50	1.20	14.00	4.40±2.70	3.55	1.20	12.80	4.40±2.80

Source : [27]

for electromyography in HTLV-1 are shown in Table 3.

Electrogoniometry and kinematics

Changes in joint angles and trajectory of anatomical points modified by postural sway can be measured quantitatively by electrogoniometry and kinematics. The measurements obtained with these tools may allow the quantification of micro-movements of postural control, identifying the different motor control strategies in different segments through different sources of kinetic and kinematic information.

The CVMob® is a simple and free tool that allows kinemetrics analysis of movements through simple shooting with cameras, including the postural sway [28]. Our research group has developed the validation of this tool for gait analysis and its application in postural assessment

The electrogoniometer has been widely used to evaluate angular changes more accurately and consists of two rods articulated by a fulcrum which are fixed to the adjacent body segments to a physiological joint (which is set at the heart of the electrogoniometer) coupled to an EMG system. This equipment is sensitive to the angular variations per second in the studied joint. Kinematic references are shown in Table 4.

Table 4. Kinematic measures references.

		Reference
	Previous View	
Head		
	Horizontal head alignment	0.0 grade
Upper body		
	Horizontal alignment of acromions	0.0 grade
	Horizontal alignment of the anterior superior iliac spines	0.0 grade
	Angle between the two acromions and the two anterior superior iliac spines	0.0 grade
Lower members		
	Lower limb frontal angle	180.0 grades
	Left leg front angle	180.0 grades
	Difference in the length of the lower limbs (DE)	0.0 cm
	Horizontal alignment of the tibial tuberosity	0.0 grades
Knee		
	Q right angle	175.0 grades
	Q left angle	175.0 grades

Upper body		
	Horizontal asymmetry of the scapula in relation to T3	0.00%
	Lateral View	
Lower members		
	Leg angle/right hind	6.0 grades
	Leg angle/left hind	6.0 grades
Head		
	Horizontal head alignment (C7)	0.0 grades
	Vertical head alignment (acromion)	0.0 grades
Upper body	Vertical alignment of the trunk	0.0 grades
	Hip angle (torso and thigh)	0.0 grades
	Vertical body alignment	0.0 grades
	Horizontal alignment of the pelvis	45.0 grades
	Vertical alignment of the trunk	0.0 grades
	Hip angle (torso and thigh)	0.0 grades
Lower members		
	Knee angle	180.0 grades
	Ankle angle	90.0 grades

Conclusions

It was found that the presence of spasticity, the thoracic level of spinal cord injury, pain, and low back and lower limbs joint locks generate postural and gait changes that affect the balance and postural control. Scales and tests require long periods in the standing position and tasks beyond the means of many patients. We wish we could help to improve the tools for an accurate biomechanical evaluation of balance in these subjects with baropodometry, electromyography, electrogoniometry, and kinematics. The difficulties to be faced in the standing position suggest that the ideal protocol for biomechanical evaluation of balance in patients with HTLV-1 involves simultaneous quantitative measurements of stabilometry, electromyography, and 30-second kinematics for data collection.

Comments of experts

• Application of balance assessment methods will generate data for the profile design of postural control in these individuals.

• Biomechanical measurements can help improve the accuracy of diagnosis of functional kinetic equilibrium in individuals affected with HTLV-1.

• Accurate identification of changes in balance provides bases for designing balance training protocols for those individuals.

• Biomechanical measures compared within and between groups may be more sensitive and specific than the functional scales for detecting statistical differences in intervention studies.

• People with balance disorders may obtain data for monitoring the clinical progression and individual response to rehabilitation programmes.

• Rehabilitation of balance can reduce the risk of falling down and improve functional independence and quality of life for people with HTLV-1.

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