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Scleroderma: Assessment of posture, balance and pulmonary function in a cross-sectional controlled study

Tatiana Rafaela Lemos Lima [a], Fernando Silva Guimarães [a,b], Rafael Santos Neves [a], Sara Lucia Silveira Menezes [a,b], Agnaldo José Lopes [a,c,*]

[a] Rehabilitation Sciences Master's Program, Augusto Motta University Center, Praça das Nações, 34, Bonsucesso, 21041-010, Rio de Janeiro, Brazil
[b] Physical Therapy Department, Federal University of Rio de Janeiro, Rua Rodolpho Paulo Rocco, 255, Cidade Universitária, Ilha do Fundão, 21941-913, Rio de Janeiro, Brazil
[c] Postgraduate Programme in Medical Sciences, State University of Rio de Janeiro, Av. Prof. Manoel de Abreu, 444, Vila Isabel, 20550-170, Rio de Janeiro, Brazil

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ABSTRACT

Background: Systemic sclerosis leads to significant physical limitations in patients, such as diffuse weakness, skin sclerosis, loss of joint function and lung damage. This study aimed to assess posture and balance in systemic sclerosis patients and secondarily to verify correlations between such measurements and lung function.
Methods: Thirty-one patients and a similar number of control subjects matched for age, gender, weight, height and body mass index underwent postural assessment using photogrammetry, balance measurement using the Berg Balance Scale and stabilometry, and pulmonary function tests.
Findings: When compared to healthy volunteers, the patients had postural deviations in hip angle ($P = 0.009$ in anterior view and $P = 0.028$ for the right side), horizontal alignment of the pelvis ($P = 0.002$ for the right side and $P = 0.004$ for the left side), vertical alignment of the trunk ($P = 0.012$ for the right side) and ankle angle ($P = 0.019$ for the right side). Postural balance was similar between the two groups as assessed by the Berg Balance Scale and stabilometry. We observed significant correlations between balance measures and posture variables involving the knee and ankle, and between postural control and lung function (ratio between forced vital capacity and diffusing capacity for carbon monoxide).
Interpretation: Our results suggest that posture and balance should be assessed in systemic sclerosis patients in clinical practice, as significant postural changes and compensations are needed to maintain balance. Furthermore, it is important to monitor lung function because vascular injury impacts on postural control in these patients.

1. Introduction

Scleroderma, also called systemic sclerosis (SS), is a rheumatic disease characterised by excessive collagen deposition and vascular changes in different organs and body systems (Hunzelmann, 2013). There are important biological mechanisms involved in the aetiology and progression of SS that are not yet well established, although there is speculation about the influence on disease onset of the autoimmune system and genetic and environmental factors (Hunzelmann, 2013). Epidemiological studies reveal an incidence of 0.3 to 2.8 cases per 100,000/year in European countries and a prevalence of 10 cases per 100,000 inhabitants (Sticherling, 2012). SS develops across all age groups but is most common between 30 and 50 years of age and most often affects females, in more than 80% of cases, with no predilection for race (Strollo and Goldin, 2010).

SS usually presents with an insidious course and late diagnosis, and many patients already have several characteristic clinical manifestations of the disease when it is diagnosed. This condition can present itself very aggressively, with important repercussions on the skin, musculoskeletal system, gastrointestinal tract, kidneys and cardiopulmonary system that together contribute negatively to the quality of life of these patients. More than 80% of cases involve the osteomyoarticular system, with myositis, myopathy, calcification of joints and arthritis (Lima et al., 2015; Ranque et al., 2010). The systemic consequences of cutaneous and osteomyoarticular involvement may thus cause significant physical limitations in these patients, including diffuse weakness, muscular atrophy, skin sclerosis, loss of joint function and increased production of the enzyme creatine phosphokinase, which can lead to impairment of the functionality of various body segments and systemic muscular disorders (Schade et al., 2011).

Posture may be defined as the spatial arrangement of the body's segments in space that determines the joint angles between them (Duarte and Freitas, 2010). Posture depends on the optimal coordination among the various segments of the body. It is expected that when an individual has proper postural alignment, the components of this

* Corresponding author.
E-mail addresses: tatiana_trll@hotmail.com (T.R.L. Lima), fguimaraes_pg@yahoo.com.br (F.S. Guimarães), rsneves.prof@gmail.com (R.S. Neves), saraposgraduacao@yahoo.com.br (S.L.S. Menezes), phel.lop@uol.com.br (A.J. Lopes).

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system, such as muscles, ligaments, joints and fascia, will be in appropriate balance (Penha et al., 2005; Lima et al., 2015). The presence of an osteomyoarticular disorder or dysfunction may burden the body structure, which in turn can lead to changes in posture (Almeida et al., 2013; Lopes et al., 2014). In SS, the constant changes due to the chronicity of the disease and treatment side effects lead to important modifications of the osteomyoarticular system. Furthermore, it is possible that the posture is also influenced by movement limitations caused by the stiffness of the skin resulting from excessive deposition of collagen in connective tissue (Giacomini et al., 2005).

Postural balance refers to the ability to keep or return the centre of body mass (CoM) over its base of support (BoS) in a gravitational field (Horak, 1987). For this adjustment to be effective, there must also be a proper contribution of the centre of gravity (CoG) and centre of pressure (CoP) on the surface areas in contact with the ground (Lopes et al., 2014; Penafortes et al., 2013). The CoM is the more general term representing the space coordinate that creates the same net gravitational moment of force about any point along the segment axis as did the original distributed body mass. In contrast, the CoG corresponds to the space coordinate where the resultant gravitational force is applied in the body mass (Duarte and Freitas, 2010), or alternatively the coordinate of the CoM in the axis defined by the direction of gravity (Winter, 2009). Posture and postural balance are thus closely linked as follows. The body's posture may need adjustment whenever internal (e.g. movement of a body's segment) or external perturbations drive the CoM towards the limits of the BoS. In this scenario, the central nervous system gathers the sensory information regarding the actual body's posture and generates the necessary motor response to optimally adjust the position of each body segment. By changing the position of each body segment the spatial distribution of the total body mass also changes, ultimately resulting in the maintenance of the CoM horizontal coordinates inside the BoS and avoiding a fall. Considering the various dysfunctions observed in SS, it is believed that bodily balance may be compromised in these patients (Giacomini et al., 2005; Johnson and Van Emmerik, 2012).

Investigations of postural control and balance in SS are of fundamental importance because they can support more targeted interventions based on evidence in the follow up of these patients (Kwakkenbos et al., 2013; Mattsson et al., 2015). We hypothesised that sensorimotor stimulation may be impaired in these patients due to myoarticular changes and postural misalignments and therefore that balance control may also be compromised. This study aimed to assess posture and balance in SS patients and secondarily to verify correlations between such measurements and lung function.

2. Methods

2.1. Subjects

A cross-sectional study conducted between April and August 2013 assessed 31 SS patients enrolled up at the Clementino Fraga Filho University Hospital of the Federal University of Rio de Janeiro, in the city of Rio de Janeiro, Brazil. The inclusion criteria were patients with a diagnosis of SS according to the American College of Rheumatology/European League Against Rheumatism (van den Hoogen et al., 2013) and aged 18 years or over. Patients with history of smoking, neurological diseases, any disability that might interfere with locomotion, orthopaedic disorders or a history of orthopaedic surgery were excluded. All patients continued their regular treatment throughout the survey period.

A control group of 31 healthy volunteers from both genders aged 18 years or over was recruited from the Augusto Motta University Centre (UNISUAM). These individuals did not exhibit any history of smoking or evidence of cardiopulmonary, neurological or musculoskeletal disorders.

This study was approved by the Research Ethics Committee of the UNISUAM, and all participants signed terms of free and informed consent.

2.2. Measurements

Spirometry, diffusing capacity for carbon monoxide (DLco) and measurement of respiratory muscle strength were performed using the HD CPL model computerised system (nSpire Health, Inc., Longmont, CO, USA). All tests followed the standards and interpretation of the American Thoracic Society (ATS). The Pereira and Neder equations were used to interpret pulmonary function parameters (Pereira et al., 2007; Neder et al., 1999a,b). The reference values were extracted from these equations. Thus, the values in % predicted were calculated for both SS patients and healthy controls.

Postural assessment was performed by static photogrammetry at the Human Movement Analysis Laboratory (UNISUAM). For photographs, the participants were asked to remain static, and at their side, a plumb line with two Styrofoam balls was placed 120 cm away for calibration of the photographs in the software. The camera was placed 163 cm above the floor and 3 m from the patients. Styrofoam balls were used to mark the anatomical points, which were determined according to previous studies (Almeida et al., 2013; Lopes et al., 2014; Penafortes et al., 2013). Photographs were taken in the anterior, posterior and right and left lateral views and then transferred to a compatible PC and analysed using the Postural Assessment Software (PAS, FAPESP Incubator, SP, Brazil) (Ferreira et al., 2010). Fig. 1 indicates the bony landmarks and angles used in the PAS protocol.

The Berg Balance Scale (BBS), validated for the Brazilian population, was used to assess the functional balance (Miyamoto et al., 2004). The scores are given according to the subjects' performance in standing and to execute some motor tasks related to 14 daily life items, challenging the static and dynamic balance (Miyamoto et al., 2004).

Participants performed stabilometry on an AccuSway force plate (Plus, AMTI, Watertown, MA, USA), and the data were analysed using the EBG Suite software, version 1.0. The platform was controlled by an internally connected computer in which body sways were measured using pressure-sensitive strain gauges. This measurement produced an image formed by the oscillations of the subject on the platform, providing information about the position of the COP. All participants were assessed in two tasks: feet apart, eyes open (FAEO) and feet together, eyes closed (FTEC) (feet parallel and <1 cm apart). Participants were instructed to maintain a static position and keep as still as possible with their eyes focused on a target for 30 s. The CoP displacement was measured using the following variables: length; rectangle area; elliptical area; average velocity (V avg); medial–lateral range (X range); anterior–posterior range (Y range); medial–lateral standard deviation (X SD); and anterior–posterior standard deviation (Y SD). All stabilometric parameters were defined by equations and calculated using the CoP data. Briefly, (a) length is the path length for the duration of the trial, (b) rectangle area is the bounding rectangular area that encompasses 100% of the CoP data, calculated as the linear product of the maximal displacements in the anterior–posterior (i.e. $Y_{max} - Y_{min}$) and medial–lateral ($X_{max} - X_{min}$) horizontal directions, (c) elliptical area is the region that covers the centre of a sample with 95% probability (Baracat and de Sá Ferreira, 2013; Cunha et al., 2013; Rocchi et al., 2005) and (d) V avg is the path length per unit time.

2.3. Statistical analyses

Descriptive results are reported as means (SD) or frequency (percentage). The data distribution was assessed by using the Shapiro–Wilk test. The unpaired Student's t test was used to compare healthy volunteers and SS patients' data. Correlations were measured by Pearson's correlation coefficient. Data analysis was performed using