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Functional analysis of lower limbs in individuals infected with the human immunodeficiency virus

Gabriel Pádua da Silva[1], Bruno Ferreira[1], Selma Siéssere[1], Isabela Hallak Regalo[1], Danilo Stefani Esposto[1], Camila Roza Gonçalves[2], Veridiana Wanshi Arnoni[1], Edson Donizetti Verri[1], Paulo Batista Vasconcelos[1], Maria Aparecida Carneiro Vasconcelos[3], Alcyone Artioli Machado[3], Simone Cecilio Hallak Regalo[1]

[1]Department of Morphology, Physiology and Basic Pathology, Dental School of Ribeirao Preto, University of Sao Paulo (FORP/USP), Ribeirao Preto, SP, Brazil, [2]Biomedical Engineering Lab, Federal University of Uberlândia, Uberlândia, Brazil, [3]Clinics Hospital of the Faculty of Medicine, University of São Paulo, Ribeirao Preto, SP, Brazil

Address for Correspondence:
Gabriel Pádua da Silva, Departamento de Morfologia, Fisiologia e Patologia Básica, Faculdade de Odontologia de Ribeirão Preto, Universidade de São Paulo, Avenida do Café s/n, Ribeirão Preto, São Paulo, Brazil.
Phone: +55 16 981665532.
E-mail: gabrielpadua@usp.br

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ABSTRACT

Objectives: The objective of this research was to analyze the functional changes of lower limbs by means of surface electromyography in patients with acquired immunodeficiency syndrome.

Methods: A total of 60 men and women (age mean of 36.77 ± 9.33 years) were divided into two groups: 30 individuals with human immunodeficiency virus group (HIVG) Subtype 1 and 30 healthy individuals control group. Muscle activity was evaluated using surface electromyography (sEMG). sEMG measurements were made while the subjects assumed the static positions: Rest in orthostatism (RS), squat "normalization factor," right and left single leg support (RSLS, LSLS) and during functional activities: Right and left single leg step rise (RSLSR, LSLSR), right and left single leg step down (RSLSD, LSLSD), rising and seating on a chair (RC, SC).

Results: To sEMG results revealed statistically significant values in the conditions of RSLS to left semitendinosus muscle, for LSLS to right and left semitendinosus, right rectus femoris and right gluteus medius muscles, for LSLSR to right rectus femoris and right tensor fasciae latae muscles, for RSLSD to right and left semitendinosus and right rectus femoris muscles, for RC to right rectus femoris and left gluteus medius muscles and for SC to right semitendinosus, right rectus femoris and right and left gluteus medius muscles.

Conclusion: It can be concluded that individuals with acquired immunodeficiency syndrome presented changes in lower limb muscle activity.

Keywords: Functional analysis, human immunodeficiency virus, lower limb, surface electromyography

Introduction

Acquired immunodeficiency syndrome (AIDS) is a chronic, incurable, viral disease complex transmitted by the blood, semen, breast milk, and vaginal fluids of infected patients. The infection is determined by the human immunodeficiency virus (HIV), a lentivirus of the Retroviridae family. There are two different types of HIVs: HIV Type 1 (HIV-1) and HIV Type 2 (HIV-2). HIV-1 is more prevalent, creating greater vulnerability and challenge to public health worldwide.[1,2] HIV-1 is transmitted through sexual intercourse, as influenced by sexual identity and behavior.

Musculoskeletal disorders in AIDS patients are common.[3,4] Main manifestations are myalgia, muscular atrophy, polymyositis, and pyomyositis. Polymyositis and pyomyositis, either together or as a single event, occur in 72% of cases and may manifest months or years after the onset of signs and symptoms. Muscle atrophy may be attributed to neurological, nutritional, and/or infectious changes and can occur in varying degrees of severity. Arthralgias occur in 35% of patients and usually indicate HIV seroconversion. In addition, HIV/AIDS cause rheumatic changes that may be associated with changes in muscle function. These changes are classified into three distinct categories: (1) Immunologically mediated, as those

observed in reactive arthritis, (2) psoriatic plaques, as those in undifferentiated spondyloarthropathy, and (3) changes due to irregular production of cytokines and depletion of CD4+ T lymphocytes, such as in infectious arthritis and osteomyelitis (both primary and opportunistic). In addition, pyomyositis, vasculitis, and diffuse infiltrative lymphocytosis syndrome may occur as a direct result of HIV-host interaction.[3,5]

Some studies point to the importance of investigating the physical factors, biological, and psychosocial relevant to the development of musculoskeletal disorders in patients with HIV and analyze the relationship between these factors and the occurrence of symptoms.[6] The objective of this research was to analyze the functional changes of lower limbs by means of surface electromyography in patients with acquired immunodeficiency syndrome.

Methods

The study was performed at the Electromyography Laboratory of Prof. Mathias Vitti in the Department of Morphology, Physiology, and Basic Pathology (FORP/USP). Data were collected from the human immunodeficiency virus group (HIVG) and the control group (CG) from February 2012 to March 2014. The study was approved by the Research Ethics Committee, process no. 01222712.0.0000.5419. Participants were completely informed about the experiment and signed the free and informed consent according with resolution 466/12 and the National Health Council.[7]

Sample selection

A total of 60 male and female individuals, aged 22–57 years (mean of 36.77 ± 9.33 years), were selected and divided into two groups: Group HIVG consisting of 30 individuals with HIV Subtype 1 (HIV-1) from the community of Ribeirão Preto and surrounding region and Group CG with 30 healthy individuals. The groups were matched individual-to-individual by age and anthropometric measures. As inclusion criteria for HIVG were the following: Clinical treatment with antiretroviral drugs and was without neurological impairment based on clinical and laboratory examinations. For the CG, the individuals of this research could not presents infectious diseases or degenerative and functional changes. As exclusion criteria for this research, the following parameters were used: Present functional and degenerative changes, not be undergoing clinical treatment, ulcerations, or skin hypersensitivity, and present cognitive problems. All individuals were subjected to the assessments of muscle activity in the lower limbs while performing their activities of daily living. Relevant information was given and questions were answered before the procedures started.

Surface Electromyography (sEMG)

Electromyography was performed using surface-active differential electrodes (two 10 mm-long, 2 mm-wide silver chloride bars, and 10 mm apart) with input impedance of 1010 ×/6 pf, bias current input of ± 2 nA, common-mode rejection ratio of 110 dB at 60 Hz, and gain equal to 20. For signal conditioning and data acquisition, a portable, high-performance, 12-channel data acquisition system (Myosystem-Br1 from DataHominis Tec. Ltda, Brazil) was used. The EMG signals were further amplified by 50 (total gain 1000), bandpass filtered (20 Hz–1 kHz), and sampled at a frequency of 2 kHz with 16-bit resolution. Data were visualized and processed using the Myosystem I version 3.5 program which enables the definition of processing windows and calculates various features, such as frequency spectrum, root mean square (RMS), and linear development.[7]

The differential active electrodes were positioned on the right and left semitendinosus, right and left rectus femoris, right and left gluteus medius, and right and left tensor fasciae latae muscles of both the limbs. Measurement and demarcation of the test areas were accomplished using a measuring tape and a pilot point pen, based on the surface electromyography for the non-invasive assessment of muscles protocol. Before the electrodes were attached, the subjects were placed in a chair, and 90° of hip and knee flexion was maintained. Asepsis was performed with alcohol, and when necessary, trichotomy was performed with a disposable razor. The electrodes were positioned using adhesive bandage tape. A stainless steel circular electrode (3 cm in diameter) was fixed to the skin on the dorsum of the wrist, and a reference electrode (ground electrode) was used. The electromyographic measurements were made while the subjects assumed the static positions: Rest in orthostatism, squat "normalization factor", right and left single leg support, and during functional activities: Right and left single leg step rise and step down, rising and seating on a chair [Figure 1]. All maneuvers were performed in a series of three movements lasting 5 s each, followed by 2 min of rest between each movement. The electromyographic activity was normalized by maximum voluntary contraction of each muscle without the use of resistors.

Data analysis

A descriptive analysis was performed (mean, standard deviation, maximum, and minimum values) for each of the variables. The obtained values were compared using independent *t*-tests ($P < 0.05$). Data were analyzed using the Statistical Package for the Social Science (SPSS), version 21.0 for windows (SPSS Inc., Chicago, IL, USA). Data on the electromyographic activities were normalized, tabulated, and encountered to have a normal distribution.

Results

The results of static condition and functional activities were analyzed independently and presented separately due to the static condition values derived from the RMS and the functional activities from the integral of the envelope.

Figure 1: Data collection procedures for static positions (a) and functional activities (b)

Analysis of the mean normalized electromyographic alterations to static conditions of rest revealed that the HIVG demonstrated greater average muscle activity to the right and left semitendinosus and left gluteus medius; and the CG demonstrated the highest average muscle activity to the right and left rectus femoris, right gluteus medius, right and left tensor fasciae latae. On the condition right single leg support, HIVG demonstrated greater average activity to the right semitendinosus, right and left gluteus medius, and right and left tensor fasciae latae; the CG demonstrated the highest average muscle activity on the left semitendinosus. and right and left rectus femoris. The statistical result was significant for the left semitendinosus muscle (*t*-test $P < 0.01$). It was observed that the HIVG demonstrated a higher mean muscle activity for all assessed muscles during left single leg support. The statistical results were significant for the right and left semitendinosus, right gluteus medius (*t*-test $P < 0.01$), and right rectus femoris (*t*-test $P < 0.05$) [Table 1].

For the HIVG, normalized electromyographic alterations in functional activities related to right step rise performed revealed a higher mean muscle activity to the left semitendinosus, right and left rectus femoris, and left gluteus medius. For the CG, the highest average muscle activity was observed on the right semitendinosus, right gluteus medius, and right and left tensor fasciae latae. For the HIVG in the condition of left step rise, a higher average activity was observed for the right and left rectus femoris, right and left gluteus medius, and right tensor fasciae latae. For the CG, the highest average muscle activity was observed on the right and left semitendinosus and the left tensor fasciae latae. The statistical results were significant for the right rectus femoris and right tensor fasciae latae (*t*-test $P < 0.01$). For the HIVG in the condition of right step down, higher average activity was observed for all assessed muscles except for the left tensor fasciae latae. Statistical results were significant for the right rectus femoris (*t*-test $P < 0.01$) and right and left semitendinosus (*t*-test $P < 0.05$). For the HIVG in the condition of left step down, higher mean muscle activity was observed on the left semitendinosus, left rectus femoris, and left gluteus medius. For the CG, the highest average muscle activity was observed on the right semitendinosus, right rectus femoris, right gluteus medius, and right and left tensor fasciae latae [Table 2].

Table 1: Normalized electromyography data (μV) during rest, right and left single leg support, for HIVG (participants with HIV) and CG, analyzed for the following muscle groups: RS, LS, RRF, LRF, and RGM, LGM, RTFL, and LTFL

Muscles	HIVG	CG	*P*
Rest			
Right semitendinosus	1.00±0.11	0.85±0.06	0.25^{ns}
Left semitendinosus	1.33±0.16	1.21±0.19	0.64^{ns}
Right rectus femoris	0.45±0.06	0.48±0.04	0.65^{ns}
Left rectus femoris	0.51±0.05	0.61±0.09	0.73^{ns}
Right gluteus medius	0.91±0.09	0.93±0.08	0.85^{ns}
Left gluteus medius	1.71±0.22	1.07±0.15	0.16^{ns}
Right tensor fasciae latae	0.69±0.12	0.73±0.06	0.80^{ns}
Left tensor fasciae latae	0.39±0.04	1.71±0.24	0.12^{ns}
Right single leg support			
Right semitendinosus	2.19±0.29	1.74±0.20	0.40^{ns}
Left semitendinosus	2.10±0.27	3.55±0.26	0.00**
Right rectus femoris	0.64±0.08	0.76±0.04	0.23^{ns}
Left rectus femoris	0.50±0.07	0.60±0.09	0.37^{ns}
Right gluteus medius	3.06±0.36	2.42±0.27	0.48^{ns}
Left gluteus medius	1.50±0.21	1.16±0.07	0.13^{ns}
Right tensor fasciae latae	1.42±0.20	1.17±0.07	0.25^{ns}
Left tensor fasciae latae	2.94±0.25	2.02±0.32	0.24^{ns}
Left single leg support			
Right semitendinosus	3.75±0.59	2.21±0.20	0.01**
Left semitendinosus	6.25±0.43	1.92±0.15	0.00**
Right rectus femoris	0.88±0.16	0.49±0.03	0.02*
Left rectus femoris	4.46±0.37	1.10±0.18	0.27^{ns}
Right gluteus medius	3.16±0.67	0.99±0.05	0.00**
Left gluteus medius	7.39±0.37	2.74±0.39	0.08^{ns}
Right tensor fasciae latae	4.49±0.60	2.45±0.54	0.29^{ns}
Left tensor fasciae latae	4.30±0.51	2.39±0.39	0.15^{ns}

^{ns}Not significant values, **: Significant ($P \leq 0.01$), *: Significant ($P \leq 0.05$). HIVG: Human immunodeficiency virus group, CG: Control group, RS: Right semitendinosus, LS: left semitendinosus, LRF: Left rectus femoris, RRF: Right rectus femoris, LGM: Left gluteus medius, RGM: Right gluteus medius, LTFL: Left tensor fasciae latae, RTFL: Right tensor fasciae latae

For HIVG, analysis of the condition rising from a chair demonstrated a higher mean muscle activity to the left rectus femoris, right and left gluteus medius, and right tensor fasciae latae. For CG, the highest average muscle activity was

observed to right and left semitendinosus, right rectus femoris, and left tensor fasciae latae. Statistical results were significant for the right rectus femoris and left gluteus medius (*t*-test $P < 0.01$). It was observed that HIVG subjects in the condition of seating on a chair demonstrated a higher average activity for all assessed muscles except for the right tensor fasciae latae.

Table 2: Normalized electromyography data (μV) during right and left step rise, and right and left step down, for HIVG (participants with HIV) and CG, analyzed for the following muscle groups: RS, LS, RRF, LRF, and right RGM, LGM, RTFL, and LTFL

Muscles	HIVG	CG	*P*
Right step rise			
Right semitendinosus	0.73±0.14	0.75±0.08	0.88^{ns}
Left semitendinosus	1.65±0.34	1.15±0.12	0.37^{ns}
Right rectus femoris	0.53±0.15	0.48±0.03	0.76^{ns}
Left rectus femoris	0.83±0.17	0.41±0.07	0.47^{ns}
Right gluteus medius	0.84±0.15	1.07±0.09	0.21^{ns}
Left gluteus medius	2.80±0.51	0.99±0.14	0.23^{ns}
Right tensor fasciae latae	1.46±0.42	5.39±0.81	0.34^{ns}
Left tensor fasciae latae	0.97±0.13	1.36±0.34	0.55^{ns}
Left step rise			
Right semitendinosus	0.96±0.13	0.99±0.15	0.89^{ns}
Left semitendinosus	1.41±0.30	1.43±0.21	0.97ns
Right rectus femoris	0.54±0.09	0.24±0.01	0.00**
Left rectus femoris	1.64±0.30	0.60±0.11	0.42^{ns}
Right gluteus medius	1.09±0.19	0.96±0.10	0.52^{ns}
Left gluteus medius	1.90±0.29	0.74±0.08	0.10^{ns}
Right tensor fasciae latae	1.76±0.32	0.56±0.06	0.00**
Left tensor fasciae latae	1.44±0.19	1.81±0.21	0.62^{ns}
Right step down			
Right semitendinosus	1.48±0.32	0.69±0.11	0.02*
Left semitendinosus	1.49±0.25	0.96±0.06	0.05*
Right rectus femoris	1.15±0.27	0.29±0.01	0.00**
Left rectus femoris	1.99±0.20	0.45±0.06	0.20^{ns}
Right gluteus medius	1.28±0.21	0.98±0.09	0.19^{ns}
Left gluteus medius	3.45±0.46	0.80±0.07	0.07^{ns}
Right tensor fasciae latae	0.97±0.22	0.64±0.08	0.17^{ns}
Left tensor fasciae latae	1.40±0.26	1.50±0.35	0.88^{ns}
Left step down			
Right semitendinosus	0.91±0.15	1.02±0.77	0.58^{ns}
Left semitendinosus	0.92±0.18	0.80±0.10	0.57^{ns}
Right rectus femoris	0.28±0.03	0.33±0.02	0.30^{ns}
Left rectus femoris	0.82±0.19	0.55±0.14	0.41^{ns}
Right gluteus medius	0.78±0.10	1.04±0.14	0.16^{ns}
Left gluteus medius	1.12±0.20	1.10±0.19	0.95^{ns}
Right tensor fasciae latae	0.71±0.18	0.73±0.10	0.94^{ns}
Left tensor fasciae latae	1.36±0.12	2.02±0.15	0.58^{ns}

^{ns}: Not significant values, **: Significant ($P \leq 0.01$), *: Significant ($P \leq 0.05$). HIVG: Human immunodeficiency virus group, CG: Control group, RS: Right semitendinosus, LS: left semitendinosus, LRF: Left rectus femoris, RRF: Right rectus femoris, LGM: Left gluteus medius, RGM: Right gluteus medius, LTFL: Left tensor fasciae latae, RTFL: Right tensor fasciae latae

Statistical results were significant for the right semitendinosus, right rectus femoris, right gluteus medius (*t*-test $P < 0.01$), and left gluteus medius (*t*-test $P < 0.05$) [Table 3].

Discussion

HIV/AIDS is regarded as a highly contagious disease, eliciting social concern primarily with respect to tracking its transmission and combatting and preventing its spread. In 1986, a high prevalence of transmission after blood transfusions was noted in hemophilic patients. Consequently, the search for alternatives for early diagnosis began through laboratory testing for HIV antibodies during procedures involving blood products.[8]

According to Hadigan *et al*.,[9] the main skeletal muscle clinical manifestation of individuals with HIV is lipodystrophy (loss of fat mass). The clinical picture is described as being composed of endocrine/metabolic changes that may be associated with a significant increase in cardiovascular risk[10] and demonstrated by progressive centripetal fat accumulation in the subcutaneous tissue of the extremities, giving individuals a false athletic appearance. The main changes to the subcutaneous tissue occur on the regions of the face, buttocks, and upper and lower limbs. According to Heise *et al*.[11] and Snopková *et al*.,[12] these morphological changes, primarily muscle changes, are related to high-dose antiretroviral therapy, Other neuroendrocrine side effects are insulin resistance and metabolic syndrome.

Table 3: Normalized electromyography data (μV) when rising from a chair and sitting on a chair for the HIVG (participants with HIV) and CG. Analyzed for the following muscle groups: RS, LS, RRF, LRF, and RGM, LGM, RTFL, and LTFL

Muscles	HIVG	CG	*P*
Rising from a chair			
Right semitendinosus	0.55±0.06	0.58±0.05	0.70^{ns}
Left semitendinosus	0.75±0.18	0.91±0.23	0.60^{ns}
Right rectus femoris	0.34±0.09	0.52±0.05	0.01**
Left rectus femoris	0.77±0.18	0.56±0.04	0.67^{ns}
Right gluteus medius	0.68±0.15	0.40±0.04	0.09^{ns}
Left gluteus medius	2.37±0.24	0.51±0.14	0.00**
Right tensor fasciae latae	1.00±0.26	0.48±0.05	0.06^{ns}
Left tensor fasciae latae	0.81±0.20	1.28±0.20	0.21^{ns}
Seating on a chair			
Right semitendinosus	2.35±0.24	0.50±0.05	0.00**
Left semitendinosus	1.65±0.34	0.45±0.02	0.11^{ns}
Right rectus femoris	0.62±0.06	0.39±0.02	0.00**
Left rectus femoris	1.78±0.14	0.50±0.06	0.27^{ns}
Right gluteus medius	0.80±0.17	0.32±0.02	0.00**
Left gluteus medius	1.75±0.30	0.74±0.18	0.04*
Right tensor fasciae latae	0.79±0.15	2.48±0.29	0.37^{ns}
Left tensor fasciae latae	1.45±0.34	1.22±0.38	0.73^{ns}

^{ns}: Not significant values, **: Significant ($P \leq 0.01$), *: Significant ($P \leq 0.05$). HIVG: Human immunodeficiency virus group, CG: Control group, RS: Right semitendinosus, LS: left semitendinosus, LRF: Left rectus femoris, RRF: Right rectus femoris, LGM: Left gluteus medius, RGM: Right gluteus medius, LTFL: Left tensor fasciae latae, RTFL: Right tensor fasciae latae

In this study, skeletal muscle activity was analyzed using surface electromyography. Analysis of muscle activity in the lower limbs of individuals infected with HIV revealed morphological and functional changes. Surface electromyographic analysis of static posture in relation to lower limb support revealed that the HIVG revealed a predominance of muscle activation to the right semitendinosus and left gluteus medius with left and right unipodal support. For the CG, the prevalence of muscle activation was observed on the left and right rectus femoris. According to the study of Kapreli *et al*.,[13] biomechanical control of the lower limbs is dependent on adequate support and neuromotor joint stability during functional activities. This suggests that HIV patients experience an imbalance in neuromotor control and joint stability. Hancock *et al*.[14] state that the semitendinosus and semimembranosus, along with the other muscles of the hamstrings, and the biceps femoris act directly in the movement of the hip (extender) and knee (flexor), with their movements dependent on the positioning of the knee. The gluteus medius, according to Hertel *et al*.,[15] controls the stability of pelvic movement during functional activities such as squatting.

Activities of daily living, according to Allet *et al*.,[16] play an important role in the function and independence of a human being, with the ability to perform these activities determining quality of life. For the HIVG, surface electromyographic analysis of functional activities of lower limbs revealed a predominance of muscle activation to the left rectus femoris and left gluteus medius during left and right climb "step," left and right lower "step," and chairlift and sit. For the CG, predominance of muscle activation was observed in the tensor fasciae latae. According to Simoneau *et al*.[17] and Dietz,[18] balance is a determinant factor in the function of the lower limbs and depends on the synergistic activation of the muscles of the upper and lower half of the body. This coordination is controlled by spinal circuits which, in turn, are under suprasegmental control. Therefore, it is suggested that individuals with HIV demonstrate motor coordination deficits in the lower limbs, based on the muscles involved.

Functional activity plays an important role in health promotion, in the context of sensory-motor integration, both neuromuscular and systemic.[19] According to Huang *et al*.,[20] maintenance of resistance, strength, and passive and active amplitude of movement are important components of motor function. Hirt[21] determines that, for HIV patients, motor physiotherapy is essential to the recovery and maintenance of movement, in addition to sensory-motor activities.

For individuals with clinical diagnosis of AIDS, a hyperactivity in most muscles evaluated compared to the control group was observed, possibly related to morphological and functional compromises caused by viral infection. Consequently, it is important to highlight the importance of this study in guiding new research on the subject, currently scarce in the literature. Furthermore, this study seeks to optimize the quality of life of individuals, as well as offers enlightenment to health professionals who study individuals with HIV-1.

Conclusion

It can be concluded that individuals with acquired immunodeficiency syndrome presented changes in lower limb muscle activity, related with a predominance of muscle activation during the static postures and functional activities.

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