







Influence of Sport on Autonomic Dysreflexia of a Patient with Spinal Cord Injury

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Abstract: Spinal Cord Injury (SCI) causes loss of motor, sensory and autonomic functions below the injured level. The increase in the number of cases of SCI, the main cause being motor vehicle accidents, and the social impact that this condition causes makes the study on this condition very relevant. SCI brings physiological changes and physical adaptations to the individual, such as cardiovascular problems and increased blood pressure due to lacking of the sympathetic nervous system, known as autonomic dysreflexia (AD). Topographic observation of the retina can help to understand the change that occurs in the autonomic response of these individuals. The objective of the study was to analyze the vasculature changes in SCI with AD in athletes and non-athletes, through retinal photography of these individuals. Retinal photographs were taken of 40 subjects participating in the research, and these were divided into 4 groups: non-athletes with AD, athletes with AD, SCI without AD, individuals without SCI. We can conclude that there is a higher prevalence of vascular changes in patients with AD, especially in the athlete group.


1 INTRODUCTION


Spinal Cord Injury (SCI) is characterized by disruption of afferent and efferent nerve communication between the brain and the peripheral nervous system, which leads to loss or reduction of body function below the damaged level. SCI may be complete or incomplete. Complete injury occurs when there is no neurological function mediated by the spinal cord below the level of injury. Incomplete lesion occurs when there is at least some function such as an intact sensation or as light distal motor function (Eckert & Martin, 2017). More than half of the individuals with SCI have the complete lesion, which leads to total loss of sensitivity and movements. The condition is classified as paraplegia or tetraplegia, which are distinguished by the level of the spinal cord affected by the injury (Holmes, 2017).


The term tetraplegia refers to the decrease or total


loss of motor and sensory functions of the cervical segments, while the term paraplegia describes the loss of motor and sensory functions of the thoracic, lumbar and sacral segments.


The number of people with spinal cord injury has grown over time, both in incidence and prevalence. The main causes of injury are motor vehicle accidents, followed by falls from heights and firearms. The increase in the prevalence of comorbidities is a consequence of the longer survival of these patients due to the better preparation of pre-hospital care with polytraumatized patients. The world average of cases is 15 to 40/million inhabitants. This high prevalence added to the social impact that this condition brings to the lives of these people, mostly young male adults still in the age group of 15-40 years, (that is, the age of great productive strength), makes the study necessary and relevant (Casimiro et al., 2016).


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The autonomic nervous system is responsible for controlling body homeostasis. It is divided into sympathetic and parasympathetic, who act in an antagonistic and coordinated manners. In order for it to be activated, actions of neurotransmitters are necessary. Acetylcholine (ACh) is responsible for the post-ganglion synapses of the parasympathetic autonomic nervous system. When we refer to the sympathetic autonomic nervous system, the neurotransmitter responsible is norepinephrine, or adrenaline. The sympathetic nervous system leads to an increase in heart rate, respiratory rate, mydriasis and a decrease in gastrointestinal functions. The parasympathetic works in a contrary way, balancing the effects.

SCI that occurs at or above T6 neurologic level results in a syndrome called autonomic dysreflexia (AD). AD is thus defined as acute hypertension because sympathetic reflexes below the affected level are no longer modulated. This syndrome is often accompanied by baroreceptor-mediated bradycardia, which leads to a short-term control of blood pressure. It is precipitated by massive somatic stimulation, which leads to vasoconstriction. As factors of precipitation of the syndrome, we can cite the distension of the bladder by accumulation of urine or intestinal constipation. Systolic blood pressure can reach high values, being characterized as hypertensive crisis, thus being a medical emergency. Other related symptoms are: headaches, excessive sweating, hyperemia of the skin, blurred vision and anxiety (Edahan and Rabchevsky, 2018).

The human retina can characterize diseases of the eye and other systems such as the cardiovascular. The retina is a highly vascularized tissue, and its functioning can be drastically affected in the course of vascular changes. The retinal vasculature, because it allows the easy visualization of part of the human circulation through its microvasculature, is considered as a way to non-invasive vessel network access, without the need for procedures and with the use of technologies of simple complexity to access it. Thus, retinography can be an instrument for early identification of cardiovascular changes, one of the consequences of autonomic dysreflexia in spinal cord injuries. Quantitative measures of retinal vascular topography have already been proposed as a way of analyzing the effects of autonomic dysreflexia and its relationship with the diagnosis of this condition. AD can occur several times a day, depending on the amount of stimuli, which would justify the structural change of the peripheral vasculature and its remodeling (Edahan and Rabchevsky, 2018).

Retinal vasculature changes caused by uncontrolled arterial hypertension have already been described in the literature. These are: change in the branching pattern of the retinal vessels, change in caliber, tortuosity, and branching angle (Dai et al., 2020). In principle, the patterns of vascular changes that uncontrolled chronic arterial hypertension can cause would help define the pattern of autonomic dysreflexia.

The analysis of the vascular topography of the retina can help to understand the functioning of the autonomic nervous system in SCI individuals that have AD and understand the changes that arise from repetitive stimuli, such as the practice of Paralympic sports. In addition, it can facilitate the diagnosis of this condition.

The diagnosis of the presence of AD is important to manage the hypertensive crisis that these individuals present, since it differs from the management of hypertensive crises of other causes. It is based on the active search for precipitating factors of the episode to eliminate this stimulus such as, the emptying of the bladder. In addition, postural maneuvers such as sitting or lifting the patient with a straight back can help lower blood pressure from a better hydrostatic distribution of blood in the extremities (Edahan and Rabchevsky, 2018).

2 OBJECTIVES

This study aimed to analyze the differences in the patterns of retinal structures of spinal cord injured patients with autonomic dysreflexia with those without alterations of the autonomic system. It seeks to diagnose changes in the retinal arterial pattern of patients with AD, physical activity practitioners and non-athletes, through photographic analysis of the retina.

Changes in the parameters of the retinal vasculature are related to increased systemic blood pressure. Changes in the autonomic nervous system of these individuals lead to increased blood pressure. The detection and quantification of affected individuals can help to clarify the effect of AD on the cardiovascular system.

The work counts on the cooperation of the Spinal Cord Rehabilitation Outpatient Clinic- University Hospital, the Biomechanics and Rehabilitation of the Locomotor System Laboratory, Faculty of Medical Sciences, both at The University of Campinas - UNICAMP and the GIGANTES Paralympic Rugby Team, from the city of Campinas, State of São Paulo.

3 METHODS

40 individuals were recruited ($n = 40$), 30 individuals with spinal cord injury and 10 without spinal cord injury. Group A was composed of 11 SCI subjects with AD, all non-athletes. Group B was composed of 8 athletes (tetraplegics) who practice Paralympic Rugby. As control groups, 11 lower level paraplegic individuals were selected, by definition without autonomic dysreflexia, comprising Group C. A total of 10 individuals without SCI comprised Group D.

Participants with previously diagnosed cardiovascular disease, such as systemic arterial hypertension, were excluded from the study.

Photographs of the retina were taken from a portable retinographer of the company Phelcom (Figure 1), which made it possible to collect the data. The control groups were also photographed for comparison.



Figure 1: Photo of EYER, portable retinographer of the company Phelcom (Phelcom.com/product/ever).

The caliber of retinal arterial vasculature with uncontrolled hypertension was not significantly influenced by systemic blood pressure at the time of photography (Dai et al., 2020). This conclusion corroborates the structure developed by this work, since if the hypertensive peak momentarily altered the vasculature, retinal photographs could be a confounding element. Since the photograph is free of momentary alteration, it became an instrument for retrograde analysis of the pressure profile of the analyzed individual. The analysis of retinal photographs was carried out by two qualified ophthalmologists, who diagnosed changes in patterns compared to normality, based on changes previously described in the literature. When the diagnostic hypothesis diverged, a third ophthalmologist was requested for the correct classification of patients. The description of the changes found by them was carried out. The Ethics Committee approved the Project - CAAE number: 31510620.9.0000.5404. All

regulations regarding the ethical use of human volunteers were followed. Furthermore, all participants gave their written consent, thus allowing the use the results obtained for further analysis and the production of new data.

4 STATISTICAL ANALYSIS

The statistical analysis used the calculation of the odds ratio for comparison between the 4 Groups (A, B, C and D) to clarify the relationship between autonomic dysreflexia and the chance of vasculature changes. For instance, when comparing group A with group C, shown on Table 2: $(4*8) / (3*7)$ equals 1.52.

The epidemiological profile of groups A and B, groups referring to individuals with high spinal cord injuries and with the presence of autonomic dysreflexia, was also described from the interview with the participants (Table 1).

Table 1: Epidemiological profile of patients with autonomic dysreflexia (athletes and non-athletes).

Injury level	Age (years)	Sex	Trauma history	Injury time (years)
C5	38	Female	Automobile Accident	10
C4	34	Male	Automobile Accident	2
T4	23	Male	Automobile Accident	3
C5	19	Male	Diving Trauma	3
T3	49	Male	Automobile Accident	15
C5	49	Male	Automobile Accident	18
T4	54	Male	Automobile Accident	23
T4	20	Male	Automobile Accident	2
T4	38	Male	Firearm injury	12
C3	45	Male	Firearm injury	23
C5	50	Male	Fall from Height	18
C6	33	Male	Diving Trauma	11
T2	38	Male	Automobile Accident	17
C7	33	Male	Automobile Accident	15
C5	30	Male	Automobile Accident	10
C7	40	Male	Diving Trauma	13
C5	34	Male	Diving Trauma	16
C6	34	Male	Automobile Accident	15
C5	43	Male	Diving Trauma	20

The diagnosis (Table 2) of changes in the arteries of the retina: groups A, B, C and D were divided into: with retinal vasculature alterations and without retinal vasculature alterations.

Table 2: Presence or absence of retinal changes in the analyzed groups:

	With Alterations	Without Alterations	Total
Group A	4	7	11
Group B	4	4	8
Group C	3	8	11
Group D	2	8	10

- Group A: non-athletes with autonomic dysreflexia
- Group B: athletes with autonomic dysreflexia
- Group C: non-athletes without autonomic dysreflexia
- Group D: individuals without spinal cord injury.

5 RESULTS

According to the epidemiological profile of patients with autonomic dysreflexia found, we can conclude that there is a higher prevalence of spinal cord injuries in males, while automobile accident was the most prevalent mechanism of trauma. The mean age of the individuals was 35.2 years old. Mean years of injury was 12.3 years (Figure 2).

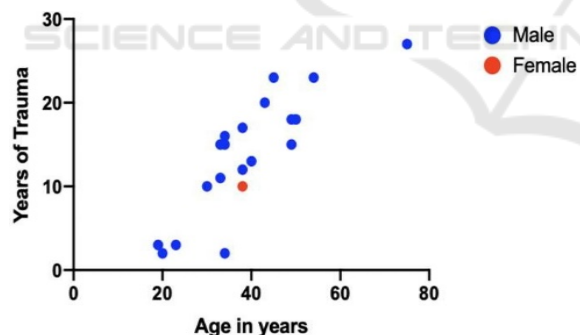


Figure 2: Distribution by sex, age and years of injury.

The retinal changes found and described in spinal cord injured patients with autonomic dysreflexia were: arteriolar narrowing, arteriolar tortuosity and pathological AV crossing. These alterations were also found in the control groups, but the number of individuals with alterations in the group with AD was higher. In addition, cases with two or more overlapping changes were present in the group with AD, but this was not observed in the control groups (Figures 3 to 7).



Figure 3: Arteriolar tortuosities and arteriolar narrowing.

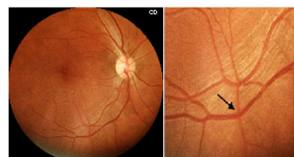


Figure 4: Pathological AV crossing.



Figure 5: Arteriolar narrowing.

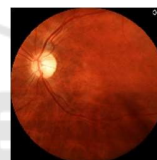


Figure 6: Retina without vascular changes (control group).

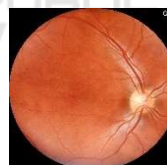


Figure 7: Retina without vascular changes (control group).

Considering the groups with AD non-athletes and athletes together (groups A and B), we concluded that there is a 2.33 times higher chance of developing retinal artery changes in these individuals, compared to individuals without AD (Groups C and D).

Considering only individuals with AD, when we analyzed only groups A and B, we noticed a chance of changes of 1.75 times more in Group B (athletes), compared to Group A (non-athletes).

Comparing only individuals with spinal cord injury that were non-athletes, we noticed a chance of 1.52 times more changes in Group A (with AD), compared to Group C (without AD).

Table 3: statistical analysis of the comparison between groups A, B, C and D.

	$(A + B) \times (C + D)$	$A \times B$	$A \times C$
Odds Ratio (OR)	2.33	1.75	1.52

6 DISCUSSION

From our analysis, it was possible to infer that there is a higher chance of occurrence of changes in retinal arterial vasculature in individuals with AD compared to those who do not present this comorbidity.

The chance of occurrence increases in individuals with AD who practice physical exercise, compared to individuals who do not practice sport.

When we analyze only the groups of non-athletes with SCI, we see that the chance of occurrence is still greater than 1, thus meaning an increase in occurrence, but it is still lower than that present in the athletes.

The results obtained lead to the discussion that it is possible to have a higher occurrence of retinal artery changes in these patients. Sport can influence the occurrence of these vascular changes, and this may be due to the higher frequency of stimuli that these individuals are exposed to, due to regular sports.

This study demonstrated the identifiable patterns in the retina of individuals with such condition, which may lead in the future to an early diagnosis from the analysis of the back of the eye from these individuals. Patterns of alterations such as arteriolar narrowing, arteriolar tortuosity and pathological AV crossing were described. These changes were previously described also in patients with Chronic Systemic Arterial Hypertension (Ponto et al., 2017). Since the changes in these arteries reflect systemic changes, it can be inferred that these patients are more prone to vascular diseases due to the presence of autonomic dysreflexia.

This study can serve as a warning about the increased risk of cardiovascular diseases that autonomic dysreflexia could bring, presenting as changes in the retinal vasculature. These can be considered as target organ lesions, and thus retinal photography can be a screening method for comorbidity, enabling the individual to detect early possible complications of cardiovascular disease that, as in chronic arterial hypertension, can manifest as ischemic or hemorrhagic stroke, coronary artery disease, peripheral vascular disease, and kidney disease (Oparil et al., 2018).

7 CONCLUSION

The current study was limited by the small number of participants, especially considering the group of athletes. More studies are needed, with larger numbers of individuals, to prove the association that this work aimed to demonstrate. In the future, early diagnosis of AD through ophthalmoscopy in these patients may be beneficial for early detection of the condition and better monitoring and progression of comorbidity.

Sport in this study was considered as a risk factor, but we did not aim to discourage its practice. It has already proven to be beneficial for this portion of the population, both in terms of quality of life and health. The practice of sport leads to a lower risk of developing shoulder injuries, especially on the acromioclavicular joint (Medina et al., 2015). In addition, it is undeniable that sport serves as a form of psychological support and social interaction for this population. Our main objective is to stimulate the regular follow-up of these patients, athletes or not, for early detection and control of future changes, since all individuals with AD are exposed to greater risks than individuals without AD.

Since the results are similar to those found in the analysis of retinal patterns of chronic hypertensive patients - pathological AV crossing, tortuosities, arteriolar narrowing, we can conclude that although autonomic dysreflexia crises are an acute condition, the condition can be considered as chronic. This is explained by the characteristic of AD of high degree of daily recurrence, justifying that acute pressure peaks behave as chronic throughout the life of these patients. Monitoring blood pressure during paralympic sports involving high lesioned spinal cord parathletes, tetraplegics in particular, is highly recommended.

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