ISSN 1413-3555
Rev Bras Fisioter, São Carlos, v. 16, n. 1, p. 54-60, Jan./Feb. 2012

Photogrammetry on the identification of postural asymmetries in cadets and pilots of the Brazilian air force academy

Fotogrametria na identificação de assimetrias posturais em cadetes e pilotos da academia da força aérea brasileira

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Abstract

Objective: To identify whether flight training activities cause postural changes in cadets and pilots of the Brazilian Air Force Academy (AFA). **Methods:** Eighty subjects were assessed through photographic images in anterior and right side views. Four groups of cadets (n=20 per group) divided according to the year since enlistment and a fifth group of fifteen pilots from the Air Demonstration Squadron (ADS) were included. Pictures were analyzed using the Postural Analysis Program (SAPO) and angles related to head vertical alignment (HVA), head horizontal alignment (HHA), acromion horizontal alignment (AHA) and anterior-superior iliac spine horizontal alignment (HAS) were plotted. **Results:** We did not find statistical significant differences in the angles: HVA, HHA and AHA. However, a significant difference was found for the HAS angle with pilots having lower values than cadets, suggesting greater postural stability for this variable in pilots. **Conclusion:** The horizontal alignment of the anterior-superior iliac spine was the only measure that showed significant difference in the comparison between pilots and cadets. The remaining alignments were not different, possibility because of the strict criteria used for admission of cadets at the AFA and the efficiency of the physical training that is performed periodically.

Keywords: photogrammetry; postural asymmetry; air activity; movement.

Resumo

Objetivo: Identificar se a atividade de treino de voo pode desencadear alterações posturais em cadetes e pilotos da Academia da Força Aérea Brasileira (AFA). **Métodos:** Os sujeitos foram avaliados por meio de registro fotográfico em vista anterior e lateral direita, tendo como casuística 80 cadetes da AFA, divididos em quatro grupos, 20 em cada, e 15 pilotos do Esquadrão de Demonstração Aérea (EDA), formando o quinto grupo. As fotos foram transferidas para o Software de Avaliação Postural (SAPO), sendo traçados ângulos relacionados ao alinhamento vertical da cabeça (AVC), alinhamento horizontal da cabeça (AHC), alinhamento horizontal dos acrômios (AHA) e alinhamento horizontal das espinhas ilíacas ântero-superiores (AHE). **Resultados:** Os resultados mostraram que, após comparação das médias das assimetrias posturais entre os grupos, não houve diferença estatisticamente significante em relação aos ângulos AVC, AHC e AHA. No entanto, na variável AHE, observou-se que o grupo de pilotos apresentou valores significativamente menores que os dos cadetes, sugerindo maior estabilidade postural em relação a essa variável. **Conclusão:** O AHE foi a única medida que apresentou diferença estatisticamente significate na comparação entre os pilotos e cadetes dos diferentes anos. Quanto aos demais alinhamentos, não houve diferença, podendo atribuir esse fato aos critérios exigentes de ingresso dos cadetes na AFA e a eficiência do treinamento físico realizado periodicamente.

Palavras-chave: fotogrametria; assimetria postural; atividade aérea; movimento.

Received: 05/31/2011 – **Revised:** 08/21/2011 – **Accepted:** 09/22/2011

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Introduction

Posture is the combination of positions of all body joints at a given moment[1]. Good posture is defined as the alignment of the body with physiological and biomechanical maximum efficiency that minimize the stress and gravitational overload of the support system[2].

Kendall, McCreary and Provance[1] define standard or ideal posture as the good alignment of body segments in the standing position. These authors suggest the use of a plumb line to check this alignment. When the anatomical landmarks align with the plumb line there is a balance of body weight and stability of body joints with minimal muscle activity. According to Smith, Weiss and Lehmkuhl[3], the vertical posture is not natural, because it requires a conscious effort and increased muscular activity. The authors suggest that a normal standing posture must have body relaxation and comfort rather than a predetermined ideal model of body alignment. In general, a normal posture may be defined as the ability of the body to maintain and move each body part in coordination, comfortably, with no loss of mobility and without overloading the anatomical structures and creating harmful tensions in the various situations of the daily routine[4,5].

Poor posture refers to a posture without normal alignment and structural changes and that is usually a response to pain or fatigue from mechanic overload[6-11]. The increase of the gravitational force on the human body during air activity, for prolonged time, can cause musculoskeletal imbalances and even premature joint degeneration[12,13]. These musculoskeletal imbalances due to muscular adaptations most often lead to misalignments of the spine and body segments, and consequently asymmetric posture[14]. When there is a postural change caused by external forces, the body is organized in chains of compensation, adapting to this disharmony[15,16].

The qualitative assessment of posture proposed by Kendall, McCreary and Provance[1] is widely used in clinical practice; however, because of its great subjectivity, it is not commonly indicated for use in research[17-19]. Radiologic exam is another resource used for postural assessment, but the risks of periodically exposure to radiation, its high cost and its poor reliability may hinder its use in researches[20]. However, despite the aforementioned, radiological examinations are still considered the gold standard in clinical practice[21-23].

A non-invasive method of measurement is the photogrammetry. Photogrammetry is a quantitative assessment tool that has advantages for use in clinical practice such as low cost, easiness of photo interpretation, high precision and reliability[24-28].

The Postural Assessment Software (SAPO) is a computerized program for quantitative postural analysis. SAPO is a program that respects methodological and clinical aspects[5]. Calibration of the image, for example, is a feature of the program that helps correct errors that have occurred during photographs acquisition. Developed in 2003 as part of a research project funded by the *Conselho Nacional de Pesquisa e Desenvolvimento* (CNPQ), Brasília, DF, Brazil and the *Fundação de Amparo a Pesquisa do Estado de São Paulo* (FAPESP), São Paulo, SP, Brazil, the program is available at no cost at: *www.sapo.incubadora.fapesp.br*[5,29].

The aim of this study was to analyze and study, using the SAPO program, whether flight activities can trigger postural changes in cadets and pilots of the Brazilian Air Force Academy (AFA),

Methods

This study, performed with cadets and pilots of the AFA of Pirassununga city, SP, Brazil, was approved by the Committee of Ethics and Research of the Faculty of Medicine of Ribeirão Preto, Universidade de São Paulo (USP), Ribeirão Preto, SP, Brazil (Protocol No. 6426/2008) and all subjects signed an informed consent.

The analysis consisted of five groups of male subjects divided according to years since enlistment. Group 1 consisted of twenty cadets from the 1st year of academy; group 2 consisted of twenty cadets from the 2nd year of academy; group 3 consisted of twenty cadets from the 3rd year of academy; group 4 consisted of twenty cadets from the 4th year of academy, and group 5 consisted of 15 pilots from the Air Demonstration Squadron (ADS), known as Smoke Squadron.

Cadets from the 1st year of academy were selected because they do not undergo flight training in the first year. Cadets from the 2nd, 3rd and 4th years were selected because they have some flight training. Every year, around 100 cadets join the AFA, however; in the subsequent years there is a decrease in this number to about 80 cadets per year. At the end of the second year, the ability of each cadet to fly has been defined and therefore many fail or give up their career. The 20 cadets that participated in each group of this study were drawn randomly. All pilots of the ADS in the year 2007 were included in this research. These 15 pilots were highly exposed to flying.

Exclusion criteria was a 1cm or larger difference between the lower limbs. Measurements of weight and height were collected for calculation of body mass index (BMI). BMI was used to verify whether there was homogeneity among participants of each group.

In this study, a Kodak digital camera of 4.1 megapixel, a simple tripod for supporting the camera, a plumb line, two balls of 10 cm in diameter made of Styrofoam, six balls of 1.5 cm in diameter made of Styrofoam, double-sided tape, tape measure and a non-slip rubber mat (50 x 50 cm) with a drawing of footprints serving as a support base and a black background for better image definition. A Pentium III computer was used to run the SAPO program.

All images were acquired in a room prepared with the dark background, and the plumb line fixed to the ceiling, serving as reference for calibration of the images obtained from measurements of the limbs alignments. In this line, two balls made of Styrofoam with 10 cm diameter spaced 1 m apart were used. The photographic camera position was standardized at a distance of 3 m from the rubber mat on a tripod at a height of 1.10 m.

Before the photographs were taken with subjects scantily clad, the following anatomical landmarks were located by palpation and marked with the balls made of Styrofoam: right and left tragus; right and left acromion; right and left anterior-superior iliac spines (ASIS). These landmarks were marked only once in each subject, always by the same examiner, using the tutorial offered by the SAPO program (Figure 1).

Subjects were positioned in front of the photographic camera to obtain pictures of an anterior view and were asked to remain in a neutral and relaxed posture, gazing at the horizon without moving the trunk or upper and lower limbs. They were also asked to breathe in and out and at the end of expiration, the first photo was taken. The same procedure was repeated with the subjects positioned in right lateral view (Figure 2).

The following measurements were extracted from the images; 1) in the frontal plane, the head horizontal alignment (HHA), to identify the head tilt; the acromion horizontal alignment (AHA), to identify the elevation of the shoulders; the horizontal alignment of the anterior-superior iliac spines (HAS), to identify the pelvic tilt; 2) in the sagittal plane, the head vertical alignment (HVA) was analyzed to verify if the head was in neutral, anterior or posterior position.

The digital photographs were analyzed once, by the examiner that identified the landmarks, with the software SAPO, using the mouse to mark the points on the landmarks . A report containing the information on the measures of distances and angles was generated for each picture. Therefore, two reports for each subjects were obtained, one for each view.

The mean angles analyzed in relation to HVA, HHA, AHA and HAS were compared between different groups of subjects. Such comparison aimed to identify differences and similarities between the studied groups. An analysis of variance (ANOVA) was performed and subsequently, when there was statistically significant difference, the Bonferroni post hoc test was used. The level of significance for all comparisons was set as 5% ($p \leq 0.05$).

Results

None of the selected subjects had a difference in length between lower limbs greater than 1 cm, and therefore, all were included in the study.

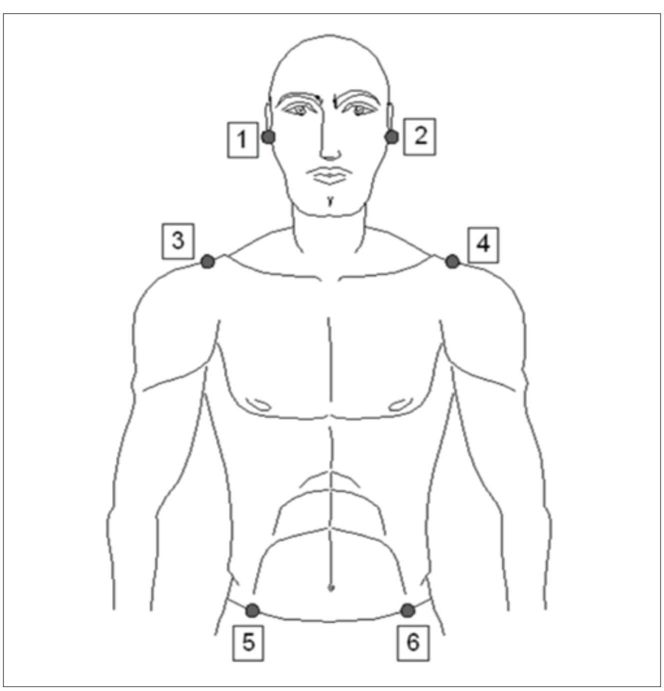

Figure 1. Selected anatomical points for the postural analysis, where: 1- right tragus; 2- left tragus, 3- right acromion; 4- left acromion; 5- right anterior-superior iliac spine; 6- left anterior-superior iliac spine. SAPO protocol (Font: Postural Analysis Software – SAPO in Portuguese *Software de Análise Postural*).

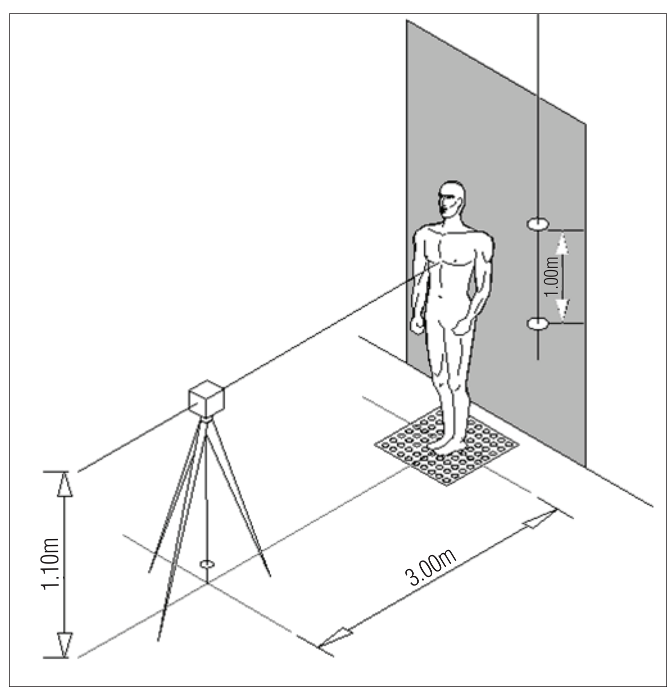

Figure 2. Individual positioned in front of the camera, where two balls of 10 cm of diameter made of Styrofoam were placed 1 m apart. The photographic camera was placed at a distance of 3 m from the individual at a height of 1.1 m.

Table 1. Mean and standard deviations of the five groups analyzed in relation to the variables: HHA, AHA, HAS, HVA and BMI. The alignments are presented in degrees.

Groups	N=95	HHA	AHA	HAS	HVA	BMI
		Mean/SD	Mean/SD	Mean/SD	Mean/SD	Mean/SD
Cadets 1st year	20	1.86±1.32	1.17±0.81	1.60±1.25	19.99±5.86	24.24±1.72
Cadets 2nd year	20	1.37±1.28	1.11±0.93	2.17±1.60	19.92±6.96	24.14±2.75
Cadets 3rd year	20	1.91±1.48	1.49±0.92	1.37±1.47	20.08±10.03	24.60±1.90
Cadets 4th year	20	1.58±1.62	1.16±1.00	2.02±1.39	22.33±6.94	23.92±1.54
Pilots	15	1.42±1.06	0.97±0.65	0.65±0.56	20.27±9.09	24.89±2.20
p-value		0.66	0.48	0.01	0.85	0.65

HHA=head horizontal alignment; AHA=acromion horizontal alignment; HAS=horizontal alignment of the anterior-superior iliac spine; HVA=head vertical alignment; BMI=body mass index.

The mean BMI of subjects from 1st, 2nd, 3rd and 4th years groups and pilots of the ADS were 24.24±1.72; 24.14±2.75; 24.60±1.90; 23.92±1.54 and 24.89±2.20 respectively. There was no difference in BMI between groups (p=0.65) (Table 1).

The mean HHA of the 1st, 2nd, 3rd and 4th years groups and the ADS were, 1.86±1.32°; 1.37±1.28°; 1.91±1,48°; 1.58±1.62° and 1.42±1.06°, respectively, There were no statistically significant difference of HHA between groups (p=0.66). In relation to the AHA, the mean values were 1.17±0.81°; 1.11±0.93°; 1.49±0.92°, 1.16±1.00° and 0.97±0.65° and there was no statistically significant differences between groups (p=0.48). The AHA means were 19.99±5.86°; 19.92±6.96°; 20.08±10.03°; 22.33±6.94° and 20.27±9.09°. There was no statistically significant differences between groups for HVA (p=0.85) (Table 1).

The mean HAS measures of the 1st, 2nd, 3rd and 4th years groups and pilots of the ADS were 1.60±1.25°; 2.17±1.60°, 1.37±1.47°; 2.02±1.39° and 0.65±0.56°, respectively. There was a statistically significant difference between groups (p=0.01) (Table 1).

Discussion

The strain of increased force of gravity on the pilots along with the poor ergonomics of the cockpit makes these professionals adopt certain postures during flights[30]. These adopted postures require the upper limb muscles to be active very frequently, which can lead to pain[13].

According to Xia et al.[31], the external forces on the upper limbs asymmetrically affect the paravertebral muscles. In the study of Vallejo et al.[13], during air activities in which helicopter pilots used the right arm to control the aircraft, it was observed, that the muscle electromyographic activity was higher in the lumbar region of the right side in 91% of the pilots studied. They also concluded that, during the flight, pilots do not maintain a symmetrical posture due to the increased muscle contraction of the side used for manual control.

Amaral[32] explained in his study that the head tilt to one side, identified in EDA pilots, may occur along with the elevation of the acromion on the same side, possibly due to increased tension of the muscles that elevate the shoulder. Knowing that these same muscles also have the function to head tilt to the same side, this action may have also occurred as a consequence of elevating the shoulder.

According to McLean[33], people who have a forward head posture when sitting, have an increased activation of the upper trapezius and elevator of the scapula, that are both also elevators of the shoulder and lateral flexors of the head.

In the present study, there were no significant differences in HHA, AHA and HVA, between the five studied groups. This result may have been due to the efficiency of the physical training that the cadets and pilots perform in order to achieve or even surpass the goals of the Assessment Test of Fitness Conditioning (ATFC). The ATFC, which is held biannually in AFA, is composed of the following exercises: push-ups until exhaustion; hip flexion and extension for 1 minute and race of 2400 meters. The goals of these tests are to assess muscular endurance of the upper limbs, abdominal muscle endurance and aerobic power, respectively[34].

According to Chandler, Duncan and Studenski[35], physical training causes more efficient motor action which consequently leads to better postures. Thus, the proper balance for motor performance in physical activity is a reflection of appropriate muscle synergies that produce effective motor responses able to minimize and even to restore the displacements of the center of gravity.

Campello, Nordin and Weiser[36] reported that exercises produce secondary effects, improving balance, the ability to acquire new skills and withstand static and repetitive loads. Granito et al.[37], through a 1 hour, three times per week, 12 weeks physical activity program consisting of general stretching exercises, postural correction, strengthening of trunk extensors and paravertebral muscles and a 20 minute walk, concluded that the proposed training was effective in reducing the degree of thoracic hyperkyphosis and back pain.

Neto Júnior, Pastre and Monteiro[38] conducted a study with the objective to analyze the activity of the trunk stabilizing muscles in subjects who practice different modalities of physical exercises. It was observed that runners had higher activity of the lumbar erector, while bodybuilders had greater muscle activity of the internal and external obliques and rectus abdominis muscles. However, there was no significant difference between the right and left sides in both activities, suggesting that both activities require symmetrical posture for the proper execution of the exercises.

In the exercise of elbow flexion and extension, also held symmetrically, it is believed that there is a greater bilateral recruitment of motor units in stabilizing muscles of the shoulder girdle and also of the paravertebral and erectors of the trunk muscles. Thus, muscle activity generated during this exercise can prevent musculoskeletal imbalances of the shoulder girdle and spine caused by air activity.

Rangel, Bastos and Jorge[39] showed that exercises performed in the open base posture (parallel feet) provided bilateral balanced muscle recruitment, promoting greater stability of the spine. On the same study, it was observed that regardless of the posture in which the exercise of elbow flexion was performed, there was greater recruitment of the paravertebral muscles than of the abdominals.

Another factor that may have contributed to non-significant differences in posture between groups of cadets and pilots is the selection criteria of candidates who attended the AFA's course. In addition to pass the entrance exam, the candidate must meet certain anthropometric requirements and undergo physical fitness tests. BMI of all subjects were not significantly different between groups demonstrating a pattern of antopometry of all subjects assessed. This anthropometric standardization and regular exercises performed by the subjects, probably support the findings of angles not being significantly different between groups.

According to Arruda[40], schoolchildren diagnosed as overweight or obese with high BMI due to physical inactivity, have higher prevalence of asymmetry such as scoliosis, lumbar hyperlordosis and thoracic hyperkyphosis. According to De Vitta, Neri and Padovani[41], a sedentary lifestyle is an important risk factor associated to musculoskeletal discomfort.

Although AHA was not significantly different between groups, a visual observation of the raw scores demonstrated that the absolute values were smaller in the pilot group. This finding may be due to the possible higher postural control and greater experience in this activity of pilots versus cadets.

In relation to the variable HVA, it was observed that all subjects had forward head posture, with no statistically significant difference between groups. Janik et al.[42] studied the changes in head position of college students and found that forward positioning of the head may be associated with long hours of studying activities.

In the AFA, flight cadets begin flight instruction in the 1st semester of the 2nd year, flying a Neiva Universal aircraft (T-25), airplane of basic primary instruction. In this aircraft, they fly a mean of 75 hours. In the 4th year, the cadets perform their instruction in the Embraer Tucano aircraft (T-27), turbo-prop of advanced instruction, in which they fly 125 hours, thus reaching a total of 200 flight hours in their education[43,44]. During the flight activity, four movements are described together with the forces applied to the stick. The up movement is executed by pulling the stick back, and the down movement when moving the stick forward. In the rolling movement, the stick is moved to the right and left sides[44]. The beginning cadets and those from the 3rd year do not perform the flight training activities. For the pilots of the ADS, the flight is their goal. Thus, it appears that the flight activity did not contribute to the results found in relation to the HVA measures.

As 1st year cadets have not gone through flight training, and have similar pelvic asymmetries to the cadets from the 2nd, 3rd and 4th year, it is likely that this asymmetry occurs due to the long hours of study, common among cadets. Based on this finding is it possible to determine that the asymmetries found in cadets are not related to air activity. In the pelvic girdle, the changes are usually secondary. They are associated with compensatory mechanisms in the processes of stabilization of the lumbar spine[38]. McLean[33] concluded in his study that muscle activation, resulting from external forces, has a profound effect on the posture of a given body segment. However, in this study, it was observed that the pilots had statistically significant lower HAS than cadets. This may indicate a greater pelvic postural stability of pilots probably due to the control and coordination of movements required during flight activities that provide postural control with segment alignment. To be a pilot of the ADS, subjects must be an instructor of the AFA with a minimum of 800 hours, must have a total of 1500 flight hours and be approved in the annual Squadron meeting[43].

According to Yoshitomi et al.[45], subjects trained in a particular activity show greater postural control when compared to untrained subjects. Performance on a specific task given to a subject is influenced by a reference system based on previous experiences[46,47].

Although the study found statistically significant differences in measures of HAS between the groups of pilots and cadets, it is suggested that the magnitude in degrees is not clinically relevant.

Conclusion

HAS was the only measure that showed a statistically significant difference in the comparison between the groups of pilots and cadets of different years. This is probably due to a greater control of the ADS posture of the experienced pilots during the flight.

Regarding the other alignments, there were no statistically significant differences between the groups, which may be attributed to the strict admission criteria of the AFA cadets and the efficiency of the physical training conducted periodically. Thus, it is concluded that the activity of flight is not a factor that predisposes AFA cadets and pilots to postural changes.

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