

Posture assessment using ImageJ SN Omkar*, M Manoj Kumar*, Dheevatsa Mudigere*

ABSTRACT

Recurrent low back pain is common among pilots, aircrew and frequent fliers due to various vagaries of flight. The lower back pain manifests as a change in the posture. This change in posture can be used as an index to determine the health of the lower back. In this paper the authors propose a generic methodology to compare and quantify the changes in the posture without any dependence on the keen subjective observation of an expert. It is illustrated by taking two examples. ImageJ, a versatile public domain image processing tool, has been employed to carry out the postural analysis. The portrait and profile photographs of the subjects are considered to quantify the changes in the posture.

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Body posture is an index of the comfort levels of the body [1]. The posture is a determinant for optimal and pain free functioning of the body [2]. Disciplines such as ergonomics, anthropology and bio-mechanics deal with various aspects of human body posture in detail. A great deal of work has been carried out to establish a correlation between the body posture and clinical observations of many different disciplines of bodywork and movement practice [3].

Many posture related health hazards can be linked to the occupation of the patient. The ailments can be directly attributed to the nature of work and the working environment. This is also true in case of the aerospace domain. Fighter pilots have to perform a range of manoeuvres during flight; this causes excessive stresses on the body due to the varying G-forces. Such inhospitable working conditions may pose serious health hazards to the pilots. A lot of work has been carried out in the direction of identifying the effects of working under such hostile conditions. It has been deduced that fighter and helicopter pilots are susceptible to recurring lower back pain [4,5]. The major reasons for this are varying G forces experienced by the pilot during flight [5] and ejection from aircraft [6].

The effect of these factors on the health of the pilot

can be perceived by the change in the body posture.

In commercial aircraft, pilots, cabin crew and the frequent travelers are subjected to a great deal of fatigue owing to long hours of flight. This makes them vulnerable to lower back pain due to fatigue [7], developed over long periods of flight [8]. The treatments for such ailments could result in varying degrees of improvements and these improvements need to be accurately quantified to measure the efficacy of the treatments. A simple, yet effective method for quantifying the variation in posture proves to be very useful in this context to gauge the improvement in the posture and in turn to ascertain the efficacy of the treatment.

Recent developments in ergonomics have lead to many onboard changes to enhance the flying conditions. Ergonomic designs, positioning of seats and other accessories are reworked to improve the comfort level of the travelers. The cockpit is also tailored, based on various ergonomic studies to

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minimize the strain on the pilot's body. These ergonomic changes can be validated by the improvement in the body posture. A method to examine the response of the body to such changes through postural variations will prove handy. Apart from comparing and quantifying changes, this method should also be able to maintain a database, monitor improvements of a recovering patient and analyze the effects of ergonomic changes in the flight. This work can prove helpful in the aerospace environment.

Since the effect of all these factors can be observed through the variation in posture, the authors have made an attempt to come up with a methodology which can quantify the changes in posture without any dependence on the keen subjective observation of an expert. The authors are aiming to quantify and unambiguously define various parameters of the body posture for comparative studies.

Digital imaging applied in anthropometry for understanding human posture and to assist practitioners in therapy opens up a whole new dimension of diagnosis [9]. Digital photographs are one of the most simple and effective ways to record the body posture. Photographs provide a visually rich, recorded posture of the body. Digital imaging technology can be used with the photographs to precisely define the posture and its variations. Use of photographs would also help in carrying out comparative studies of posture variations over a period of time with the help of an image processing tool.

An image processing tool is required for inspecting the photographs and carry out the necessary manipulations. Images can be analyzed individually or can be studied in comparison with other images. But the challenge lies in quantifying the variation of

posture unambiguously by defining the parameters regarding the ideal body posture.

A large number of image processing tools are available, with varied capabilities. ImageJ is one such tool, which is available as a freeware [10], and is found to be appropriate for the above mentioned application. It is versatile software, which offers a wide array of functionalities that can also be customized to meet specific requirements. ImageJ is built on the open architecture platform using JAVA. Its entire source code is freely available and this makes customizations and modifications very simple.

This paper explores the usage of ImageJ for studying the characteristics of posture, specifically to be used for the pilots and aircrew who are suffering from lower-back related problems. The authors have made an attempt to develop a system to measure the variations in posture using ImageJ to assist doctors who come across cases such as low back pain during their practice. This could serve as a generic methodology to compare and quantify changes in the posture and assist professionals in various fields of aerospace to gain a better understanding of such flight related ailments.

Material and Methods

This system comprising of a desktop computer, a digital camera and a digital image processing tool finds a wide array of applications in postural assessment.

The position of the camera and the subject is fixed for both pre and post therapy images. If the positions are not fixed, the images are to be normalized to be brought under the same norms.

The subjects considered were two students practicing yoga in a yoga centre in Bangalore. The subjects were considered as examples to this generic postural assessment method. Some of the applications of postural assessment worth mentioning here are:-

(a) Measuring the effect of corrective operation. The effects of corrective surgery on the back or any other part to improve the posture are not directly measurable and the diagnosis is based mainly on the surgeon's discretion. An impartial measurement model can be formulated based on the requirement to identify the changes and measurements can be recorded.

(b) As a diagnostic tool for functional assessment. Pilots who come with backache are first examined for his attitude, gait and stance [8]. Further, a functional test is carried out based on the history of the case and the nature of flight of the pilot. A typical functional test for a pilot includes spot jog test, squat test, 4 feet jump test and jog test [8]. Photographs can be taken after each test and can be subjected to postural assessment to analyze the posture for better understanding of the problem.

(c) Continuous monitoring of recovering patients. In the aerospace environment, the improvement/deterioration in the condition of the lower back region of the pilots/ aircrew is a gradual process. A patient may develop back problems due to fatigue and long hours of flight [4, 7, 8]. The variation in the posture over a period of time can be monitored through this system.

(d) Effective anthropometric tool.

Anthropometry is the science of taking quantitative measurements of the human body. This can be used for various purposes, like gauging the effectiveness of ergonomic based changes on the aircraft and periodical postural check up for the aircrew/ frequent passengers. This system proves to be very efficient for such applications.

The authors considered two subjects as examples to illustrate the methodology. The subjects who practice yoga and apparently show change in the

posture after the yoga session. As yoga is a slow process, the change in the subject's posture must be recorded and quantified to remark on the efficacy of the yoga session. Also, the regions that necessitate greater attention can be identified.

In the following illustrations, the authors compare and quantify two images, one captured before the yoga session and the other after the session. The images were captured and normalized to bring the photographs under same conditions. The challenge was to compare these two images and accurately quantify the variation in the body posture.

For ease of analysis, the process is split up into two parts- Front view analysis and Profile analysis.

Front view analysis. In this methodology, the characteristic features of the body in the front view are used to analyze the image and determine the changes in the posture. There is a need to examine the relative orientation of the pectoral-girdle with respect to pelvic-girdle. The navel is taken as the origin, and-the measurements are taken from this point. Other noticeably salient points are the nipples and acromion process, the topmost point of the clavicle. The relative positions of these points on the body are as depicted in Fig 1.

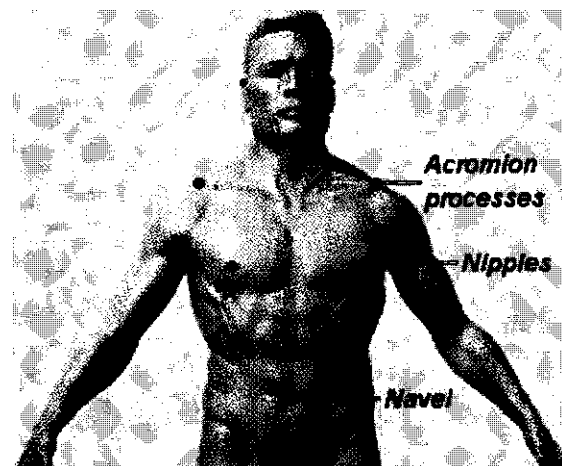


Fig 1. Salient points recognized on the front view of the body

The next logical step is to identify the characteristics of the posture based on the identified salient points. To achieve this, the three points, topmost points on the clavicle and the navel, are joined to obtain a triangle (Fig 2). The body is modeled down to a triangle for analysis. Information about the orientation, inclination and other properties of the body can be studied through this triangle.

Considering the upper line of the triangle, the line joining the topmost points of the clavicle is inclined to the horizontal by some angle, say e , which is the deviation. Ideally e should be zero and this is one of the characteristics of the ideal posture. Also, the bisector of the angle made by these points at the origin must coincide with the vertical. Since the body is inclined, the angle bisector makes an angle ϕ with the vertical. The angle ϕ gives the magnitude by which the body is skewed to the side. This angle ϕ is also a characteristic of the posture. The magnitude and the direction of the angle ϕ by mathematical deduction are given by the equation:

$$\phi = \frac{(m_1 - m_2)}{2}$$

where, m_1 and m_2 are the angles subtended by these points with the horizontal.

The angles e and ϕ can be obtained from different triangles depending on the point considered for analysis, one formed by the nipples and the other formed by the clavicle separately.

The above mentioned factors collectively facilitate the assessment of the body posture in the image. This model is used to analyze pre and post therapy images.

Profile analysis. Profile analysis necessitates a different methodology due to the absence of clearly visible features in the profile. The contour of the body is considered, and based on this a suitable model is developed for the profile analysis. In this method, outer-most points of the body i.e. points on the contour are selected and the properties of these points are taken as characteristics of the posture.

Extracting the contour of the body from the image is a complex technique that requires a series of operations to be performed. Fig 3 depicts the different stages of processing employed to extract the contour of the body. The contours from both the pre and post therapy images are extracted and superimposed. A point common to both the contours is selected as the origin. Points corresponding to a given height are taken on both pre and post images and the angle subtended by these points at the origin is measured. These angles for both the pre and post therapy images are compared. In profile



Fig 2: The upper body modeled down to a triangle for front view analysis.

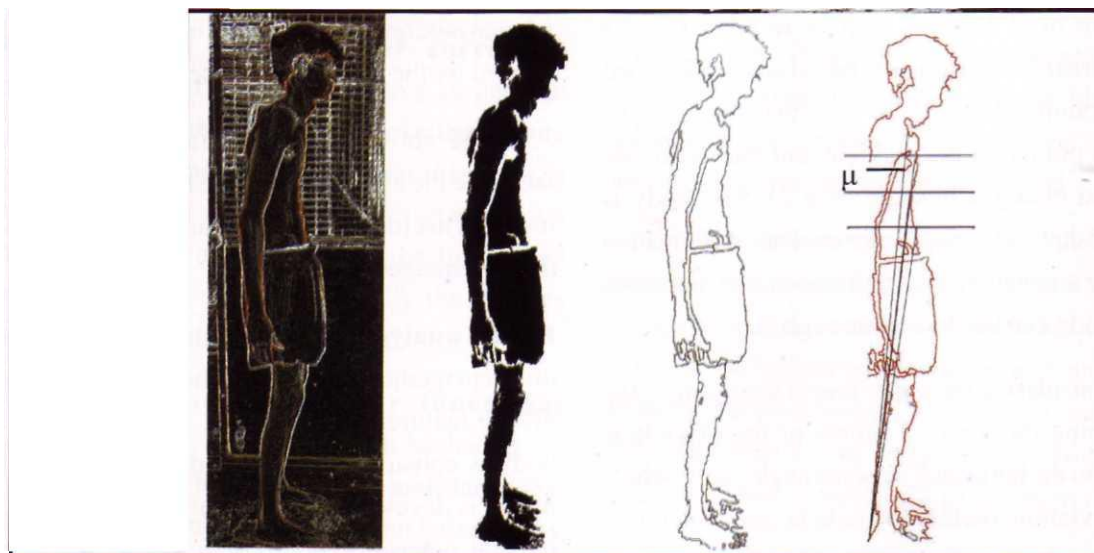


Fig 3: A figure systematically depicting the processes involved in contouring (In the order- Original image, Find edges, Threshold, Binary close, Fill, Outline, Fill color).

analysis, we are focusing at the changes in the body posture at a particular height. By repeating this process for a number of points, one can quantify the changes in the posture effectively.

Results

The results are discussed in two parts namely, Front view analysis and Profile analysis.

(a) Front-view analysis. The photographs were analyzed as discussed, by taking the navel as the origin. The salient points were connected and properties of these lines were measured. The calculated angles based on the measured values were obtained and tabulated (Table 1).

It is clearly evident that the value of the angles

e and 6 has changed from pre- to post- therapy. As described before, these angles are the deviation of the body from the reference lines. In the ideal posture, the angles e and 6 should be zero. Hence the decrease/ increase in these angles can be measured accurately even if they are very small and not noticeable just by observation. By observing the change in the posture, it can be inferred if the body is tending towards the ideal posture, thus showing signs of improvement or if it is deteriorating.

(b) Profile analysis. In profile analysis, the authors have extracted the contour of the body with various tools as demonstrated (Fig 3). The two images were superimposed by overlapping the heel of both the contours. Since the heel is common for both the

Table 1: Anthropometric measurements of the front view

Descriptio	Case		Case	
	Before therapy (degree)	After therapy (Normalized)	Before therapy (degree)	After therapy (Normalized)
Angle made by the body with the horizontal, e	3.933"	2.449"	2.317"	1.646"
Angle by which the body is slanting to the side taking the navel as the center. 0	5.822"	3.708"	2.01 1"	1.4705"

Note: The unit of measurement is the distance between the extreme points of the ears.

images, it was set as

Table 2: Parameters measured along the profile the health of the lower back

Description	Case		Case 2	
	Before therapy (degree)	After therapy (Normalized)	Before therapy (degree)	After therapy (Normalized)
5EL(M,,	8.423"	7.934"	11.124"	11.012"
6EL(^	6.778'	6.151"	10.638"	9.842"
7ELO,,	6.899"	6.322"	9.87"	9.022"
8EL(M4,	6.831"	6.069"	9.712"	8.74"
9EL(jt,,	7.557'	5.789"	8.009"	7.67"

Note: One EL is the distance between the extremities of the ear in the normalized picture.

the origin. The ear length was taken as the normative unit of measurement. Here the parameter considered is the angle subtended by the selected point on the contour at the origin, say jti. It can be observed that there is a decrease in the value of angle i (Table 2) implying the body has straightened. The variation in this parameter i can provide valuable information about the posture.

Visually it is evident from the photographs that there is a definitive change in the posture of the subject. After analyzing and quantifying the profile and portrait photographs, it confirms the changes in the posture and can be quantified. This can be used to analyze the effectiveness of the therapy. Also, by analyzing the changes carefully, the therapist can determine the response of each element to the prescribed therapy. Based on the observations, improvisations can be made as required.

Conclusion

The authors have developed a generic methodology to compare and quantify changes in the posture. In this methodology, they identified the significant points and tried to quantify the change in the posture. This method assists practitioners working in the field of aerospace medicine to treat patients with recurring cases of low back pain - a very common condition among

of time. This system also helps physiotherapists, surgeons and practitioners to educate themselves and refine their work.

of a subject can be monitored over a period

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