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Postural Rehabilitation with Machine Vision

Angélica Hernández-Rayas, Rafael Guzman-Cabrera, Marco Cervantes-Becerra

***Abstract*—In recent years, people's postural health has deteriorated due to the constant and excessive use of technologies such as cell phones and computers, as well as a sedentary lifestyle. These factors have greatly affected the posture and general well-being of the population, including both students and workers. The continuous development of technologies has provided valuable tools to the medical area for the treatment and diagnosis of diseases, making these processes less invasive for patients. The aim of this work is to strengthen treatments for the early and preventive correction of postural problems through the use of artificial vision and other technological tools. A system has been developed that helps patients perform postural correction exercises correctly, providing real-time feedback if they are performed incorrectly. Preliminary results indicate that the use of this system significantly improves the accuracy of diagnosis and the effectiveness of postural rehabilitation treatments.**

***Index Terms*—Technologies, postural correction, Rehabilitation.**

I. Introduction

The field of artificial intelligence (AI) has gained notable importance in recent years, with applications being developed for various purposes, from chats that answer almost any question to voice assistants [1, 2]. One branch of AI is computer vision, which allows computers to obtain meaningful information from images, videos, and other visual inputs, and take actions or decisions based on that information. The famous IBM company mentions: "If artificial intelligence allows machines to think, computer vision allows them to see, observe and understand" [3, 4].

Computer vision has a wide range of uses in the medical field, from diagnosis to treatment of different conditions, such as posture correction. In recent years, postural problems have become clinically important due to the sedentary lifestyle of modern society. According to WHO data, 70% of people in industrialized countries suffer from back problems at some point in their lives [5, 6]. This is partly due to the "second industrial revolution" and the arrival of devices such as the typewriter, telegraph and telephone, which brought with them an office life with little movement, a lot of sitting and the constant use of computers and cell phones.

Low back pain (LBP) is a significant health condition that affects approximately 577 million people worldwide. Its impact extends beyond the individuals directly suffering from it, influencing entire communities and society at large. The widespread prevalence of LBP leads to substantial healthcare costs, lost productivity, and diminished quality of life, underscoring the urgent need for effective prevention and treatment strategies [7].

In 2020, the world faced an unprecedented challenge: the COVID-19 pandemic, caused by the SARS-CoV-2 virus, which forced many people to work from home, increasing computer use [8]. These problems can start as low back pain and progress to more serious conditions, such as lordosis, which in severe cases may require surgery.

These problems can be prevented with physical activity, which can include small exercises that do not require much effort, time or space. Even in cases of obvious poor posture, corrective exercises can be performed to improve lower back health. This project seeks to be a real-time assistant for the exercises proposed by health professionals and specialists in rehabilitation and physiotherapy.

II. Method and Materials

The results are presented in a process diagram containing the main stages, as shown in Figure 1(A)Software Development, (B)Initial Software Testing, (C)Exercise Procedure and (D) Initial Test Results.

A. Software Development

The programming development was carried out using Python and the OpenCV and MediaPipe libraries for the acquisition of images of the patients and their recognition and pre-training that recognizes 33 reference points on the body [5], which serves as a basis for designing the markers necessary for the correct performance of the exercises.

B. Inicial Software Testing

To evaluate the effectiveness of the software, an initial test was carried out with university students aged between 18 and 27 years. During this phase, a specific exercise involving arm movements and the use of a wooden bar was selected which the instructor called the "Chest Release" exercise. Participants were instructed to perform the exercise in front of a camera, while the software analyzed their execution in real time.

C. Excesice Produce

The exercise consisted of a series of movements designed to assess posture, as shown in Figure 2. The selected movements allow you to observe and analyze the body alignment, balance and symmetry of the different parts of the body, ensuring a comprehensive evaluation of posture. This methodology is crucial for identifying potential misalignments or imbalances that may affect overall health and well-being.

Figure 2(A) shows the video guide for the exercise that was presented to each patient. They were asked to perform an exercise consisting of three movements using both arms and a wooden bar. Ideally, an elastic rubber band was used, as can be

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A. Hernández-Rayas, M. Cervantes Becerra are with the Division of Sciences and Engineering, University of Guanajuato Campus León, Mexico (ahernandez, ma.cervantesbecerra, guzmanc@ugto.mx).

R. Guzman-Cabrera is with the Engineering Division, University of Guanajuato Irapuato-Salamanca Campus, Mexico.

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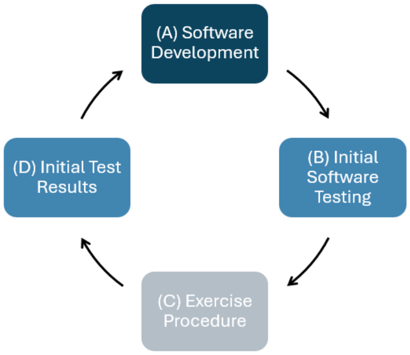

Fig. 1. Process diagram

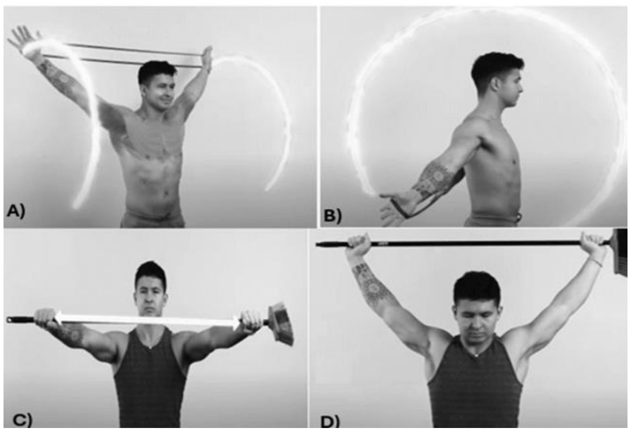

Fig. 2. Stages of the rehabilitation exercise

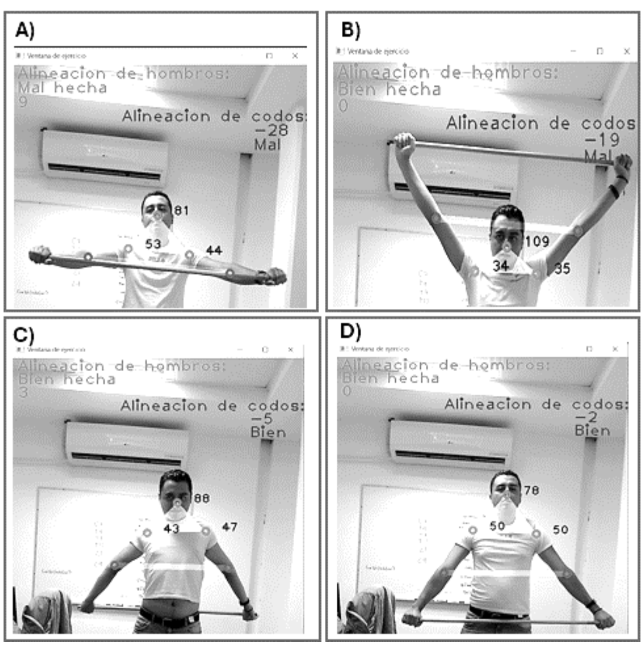

Fig. 3. Stages of the Patient Exercise Process.A) Stage 1: Initial Position , B) Stage 2: Transition to Position 2 , C) Stage 3: Holding Posture 3 and D) Stage 4: Return to Initial Position

seen in images (A) and (B), but a wooden stick could also be used, as shown in (C) and (D). The exercise procedure was carried out as follows:

- Starting position: The patient stood in front of the camera and held the wooden bar with their arms outstretched.
- Movement: In Figure 2 (A and B), the patient had to perform a complete return movement with the barbell, bringing it above the head until reaching the lower back.
- Posture: In Figure 2 (D), during this movement, it was crucial to keep your shoulders aligned and not bend your elbows.

The software was designed to detect any deviations from the correct performance of the exercise. If the shoulders did not stay aligned or the elbows flexed, the software would immediately issue a message indicating that the exercise was not being performed correctly.

D. Initial Test Results

The first results show a correct operation, at this stage the exercise was recorded and later analyzed, the idea is to use the webcam of the device within reach of the patient and that he sees in real time the feedback that the software provides to make the corrections at the time the exercise is executed. It is also expected to add more exercises available to the user.

III. Results

The results obtained are shown in Figure 3, where the four stages of the exercise are clearly appreciated. In these stages, the marks placed on the student's shoulders are observed, using the nose as a reference point to calculate the angle of inclination of the shoulders, one with respect to the other. You can also see a barbell placed at the elbows, which serves to evaluate how straight you stay during the exercise.

Figure 3(A) Stage 1: Initial Position - The patient begins the exercise in Position 1, showing the angles formed between the shoulders. If this angle is greater than five degrees, the program indicates that the exercise is poorly executed; if it is less, it is considered well done. In the upper right, the alignment of the elbows is shown. The program calculates the difference between the coordinates of the left and right elbows; if this difference is less than 10 pixels, the system sends the message that the elbows are not properly aligned.

Figure 3(A) shows the start of the exercise, the software indicates poor posture because the shoulders and elbows are not aligned, as the angles exceed the permissible value (±5°) and the difference between the elbows is also greater than the tolerance (±10 pixels) to be considered a good exercise.

Figure 3(B) Stage 2: Transition to Position 2 - The patient moves from Position 1 to Position 2, showing the midpoint of the exercise. At this point, the angle of the shoulders to the face is low, indicating good shoulder alignment, but elbow alignment is still lacking, suggesting that the student is leaning the body to the side.

Figure 3(C) Stage 3: Holding Posture 3 - The patient maintains Posture 3 for a specified duration, reaching the final part of the exercise. At this stage, good posture is achieved in both the shoulders and elbows.

Figure 3(D) Stage 4: Return to Initial Position - The patient returns to the starting position, Position 1. The exercise is restarted in the first posture, beginning with all the correct parameters to ensure optimal performance.

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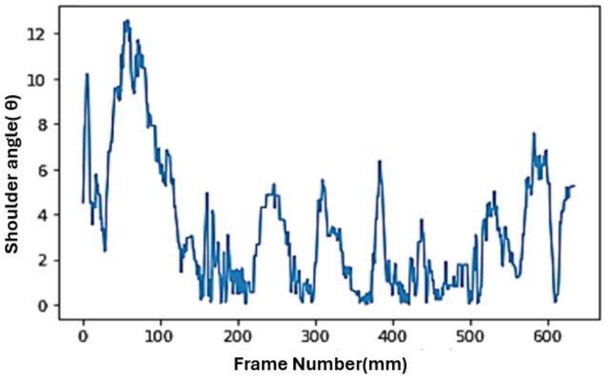

Fig. 4. Analysis of Shoulder Angles in Patient 1

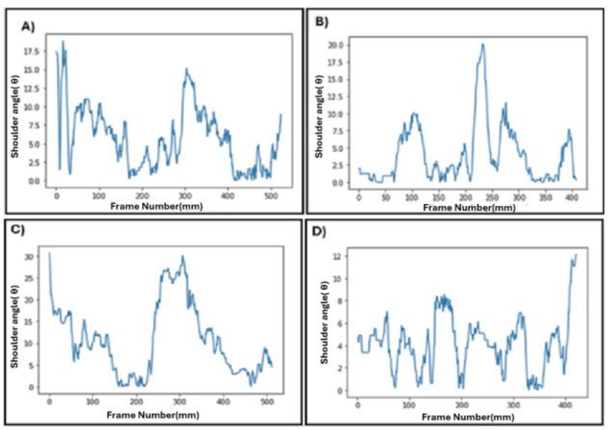

Fig. 5. Behavior of the shoulder angles of patients: A) P2, B) P3, C) P4 and D) P5

These results underscore the critical importance of proper alignment of the shoulders and elbows for the correct execution of the exercise. Proper alignment ensures that the exercise is performed accurately and safely, allowing for a precise and objective assessment through the use of specialized software. Figure 4, presented below, illustrates the graph obtained that measures the angle of the shoulders over time (in frames). This visual representation provides valuable insight into the dynamics of shoulder movement throughout the exercise, facilitating a deeper understanding and analysis of performance.

The results corresponding to each student are presented in Figure 5. The exercise was replicated with four additional students, allowing for a larger data sample. The behavior of the shoulder angles of the patients is depicted in the following manner: A) P2, B) P3, C) P4, and D) P5.

This study analyzes the variation and behavior of shoulder angles in four patients identified as P2, P3, P4, and P5. By examining possible differences in shoulder posture and movement, the study provides valuable data for the diagnosis and treatment of musculoskeletal conditions.

Figure 5(A) shows fluctuations with pronounced peaks and valleys, indicating significant changes in shoulder angle for patient P2. In Figure 5(B) it has a more marked peak around frame 200 for patient P3, suggesting a specific movement at that point. Figure 5(C) shows moderate fluctuations with fewer extreme variations for patient P4 compared to the previous graphs. Figure 5(D) shows a general increasing trend with some fluctuations for patient P5.

Differences between these graphs could indicate variations in shoulder movement patterns between patients during an activity or over time. These patterns may be relevant to medical professionals analyzing shoulder function or progress in rehabilitation. The analysis aims to identify patterns and anomalies in shoulder movement, which can contribute to developing personalized rehabilitation protocols and improving patient outcomes. Additionally, this study's findings could inform future research on biomechanics and physical therapy interventions.

IV. Conclusion

Preliminary results suggest that this approach not only improves diagnostic accuracy but also increases the effectiveness of postural rehabilitation treatments. This indicates a promising future where technology can play a crucial role in improving the postural health and general well-being of the population.

However, further research and clinical studies are required to fully validate the effectiveness and applicability of these solutions in clinical and community settings. Ultimately, effective integration of technology into medical practice can lead to significant improvement in the quality of life of people affected by postural problems.

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