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Indicator Sensor for correction of the amplitude of Leg Press Exercise

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Abstract: *Press exercise for bodybuilders. The theoretical reference starts from the study of books and articles of kinesiology and biomechanics of the movement, and the consultation of professionals of the area. It's classified as a technological research who started as a bibliographic study and later on, in an exploratory manner, became a field research to verify the viability of the prototype. It was possible to build the desired prototype that met the necessary project requirements to be validated.*
Keywords: *Leg Press, Range of Motion.*

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I. INTRODUCTION

The importance of practicing physical exercises is well known to maintain the fitness and health of the body [1]. Bodybuilding is among the most practiced physical education modalities by the general population [2].

The gyms are favorable environments for the practice of bodybuilding, where the training of physical activities should perform under the supervision of professionals [3]. Without instruction, trainers make the exercises incorrectly, which can cause injuries to the limbs and cervical spine, making them irreversible [4].

The Leg Press, equipment used by individuals who attend gyms, consists of executing a movement in which the practitioner requests the strength of the muscles of the lower limbs, to push a surface away from it [5]. The Leg Press is a multi-joint exercise and develops the largest and most powerful muscles in the body. Leg Press has biomechanical and neuromuscular similarities with athletic movements, such as running and jumping [6].

The hip joint is of the spheroid type and consists of the fossa of the acetabulum and the head of the femur, being able to perform the movements of flexion, extension, abduction, adduction, medial rotation, lateral rotation, circumduction [7-8]. Adduction and transverse abduction of the joint are possible when the hip is flexed [8].

The average amplitudes for the main movements are flexion 125°, extension 10°, abduction 45°, and adduction 10°. The knee joint is of the modified gingival (or hinge) type, being able to perform flexion movements (whose amplitude is 140°), extension, medial rotation, and lateral rotation.

The rotation occurs during the knee flexion and extension movements and is performed between the tibia and the femur. With the femur fixed, the change that accompanies flexion is a medial rotation of the tibia over the femur; with the tibia set, the movement that accompanies flexion is a lateral rotation of the femur over the tibia. With the femur set, the change that accompanies the extension is an oblique rotation of the tibia over the femur; with the tibia fixed, the movement that accompanies the expansion is a medial rotation of the femur over the tibia [9].

The ankle joint can perform inversion and eversion movements, considered ankle movements even though they occur in the subtalar joint, and the dorsiflexion (dorsal flexion) and plantarflexion movements, which occur in the sagittal plane on the frontal axis [10].

The dorsiflexion movement is performed in an average range of 15° - 20° (15° with the knee extended and 20° with the knee flexed). The range of motion for plantar flexion is approximately 45° [11]. The muscles involved in the execution of the Leg Press are quadriceps, glutes, hamstrings, and adductors [12].

The femoral quadriceps is located at the front of the thigh and consists of the rectus femoris (originating in front of the pelvic bone), vast medial (originating in the inner edge of the femur), vast lateral (originating in the outer edge of the femur), and vast intermediate (originating on the frontal surface of the femur, below the rectus femoris). The gluteus maximus originates in a large area in the posterior part of the pelvic bone, passes behind the hip joint, and inserts itself in the upper part of the femur. This powerful muscle promotes hip extension [13].

The posterior thigh muscles form a group of three muscles originating from the ischial bone of the pelvis. They are the biceps femoris, the semimembrane, and the semitendinosus. They are located on the inner part of the thigh and classified into gracilis and long, short, and high adductors. They originate in the pubic bone [13].

Biomechanics is the study of the structure and function of biological systems using mechanical methods. Amplitude is the angular displacement of a joint. When this displacement is maximum, it is defined as the complete range of motion. However, when the movement is performed at smaller amplitudes, the range of activities will be called partial [14]. The individual who performs the exercise should sit and position himself on the platform in such a way that his feet are as wide as his shoulders. After that, you should flex your knees until they reach an angle of approximately 90° and extend them again.

As discussed with instructors from different academies, the extension should not be complete. The eccentric (muscle relaxation) and concentric (muscle contraction) phase of the movement, therefore, the project's main problem was to find the necessary means to develop a device that would prevent injuries and help gym practitioners to create body awareness. The device will indicate the amplitude of the movement taking into account its correct execution; thus, the presence of a professional will be necessary to teach the trainer.

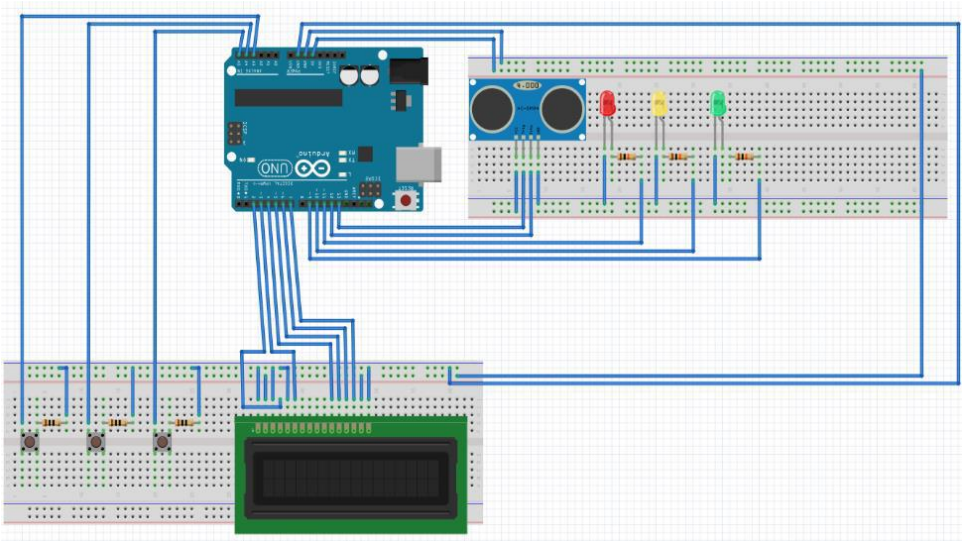
II. MATERIALS AND METHODS

The first component selected was Arduino, a simple, relatively inexpensive, and easy to program a microcontroller, used to process the information the project needs. The next step was to choose a device that would be effective in measuring the distance between the beginning of the legs (hips) and the Leg Press mobile platform. The ideal sensor was the hc sr04 ultrasonic sensor, capable of measuring the distance with an accuracy of centimeters and a response time of milliseconds. Green, yellow, and red LED lamps chosen because if the audible signal used, the individual's hearing capacity should take into account, and, as there is usually music playing in the environment, the sound could be confused or not heard.

The first part of the prototype built in which the functionality of the sensor and the real effectiveness of LED lamps test occurs. In the Arduino program, value ranges predefined in which the LED's should light up (Fig. 1). A 16x2 LCD panel was installed and then three buttons without retention (NC).

In the prototype the predefined value ranges of the program from the previous phase were replaced by the following developed formulas: return (sqrt (pow (DC, 2) + pow (DP, 2) + 2 * DC * DP * 0.9397) * cos (AP)) -10 and (sqrt (pow (DC, 2) + pow (DP, 2)) * cos (AP)) - 10, which are responsible for determining the distances during leg extension and flexion, respectively. SD = leg distance [mm], DC = thigh distance [mm] and AP = feet height [degrees]. At the end of installing the two contact matrices on the same Arduino and updating the program.

Figure 1. Complete circuit in the Fritzing software.



For the tests, the prototype was fixed (using double-sided tape) on the side of the mobile platform of the equipment. At the same time, the sensor directed to a stop located next to the seat and 10 centimeters in front of the hip of the individual who had positioned himself correctly in the equipment, as shown in Fig. 2.

Figure 2. Prototype testing.

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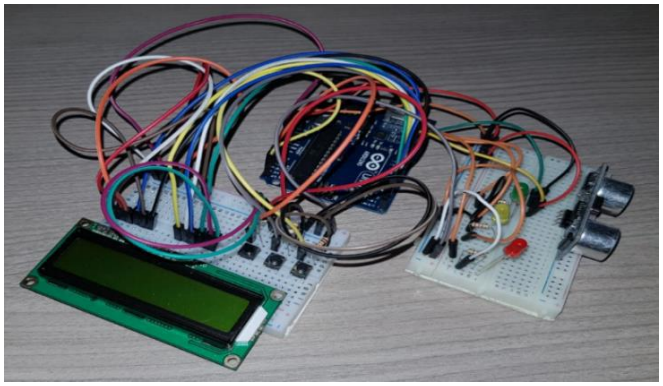
III. RESULTS AND DISCUSSIONS

After completing all the steps described in the methodology, the main result of the project was to obtain the prototype in its final model, shown in Figure 3.

Figure3. Prototype testing.



After completing all the steps described in the methodology, the main result of the project was to obtain the prototype in its final model, shown in Figure 3.

The results obtained at the end of making and testing the prototype point to the viability of the prototype, with easy maintenance, low-cost replacement for small components, and useful in indicating the amplitude for the exercise studied.

The prototype is still subject to changes and occasional improvements, for example, in its fixation on the equipment, that in the test performed, the double-sided tape was used because no structural alteration of the material and the visibility of the indication is allowed. The contact matrix must also be transferred to a plate on which the components can be welded, thus compacting the prototype and building a package to hold it. With the prototype created and with some adaptations, it is possible to use it in other equipment and exercises such as a straight, inclined and declined bench press, squat, and sink in the Smith equipment and in the horizontal Leg Press itself. To adapt the sensor in the exercises mentioned above, we would only need to reformulate the formulas for calculating the distance and adjust it to the bar facing towards the ground or another reference surface.

IV. CONCLUSION

The results obtained by the researcher at the end of the making and testing of the prototype show the feasibility of the same, which is easy to maintain, low-cost replacement for small components, and useful in indicating the amplitude for the exercise studied. O final product price will depend on the location where the parts will be purchased.

All the project's objectives were achieved and problems solved, even though we understood that the prototype must be subject to changes and specific improvements, for example, in its fixation on the equipment, that in the test performed, the double-sided tape was used because it is not allowed any structural changes to the computer and the visibility of the indication. The contact matrix must also be transferred to a plate on which the components can be welded, thus compacting the prototype and building a package to hold it. With the prototype created and with some adaptations, it is possible to use it in other equipment and exercises such as a straight, inclined and declined bench press, squat, and sink in the Smith equipment and in the horizontal Leg Press itself. To adapt the sensor in the physic exercises, it occurs the necessity o reformulate the formulas for calculating the distance and adjust it on the bar facing towards the ground or another reference surface.

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