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Wearable Electronic Glove for Supported to the Diagnosis of Repetitive Strain Injury

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Abstract**—***In this work in developed a low-cost wearable electronic glove for supported to the diagnosis of repetitive strain injury (RSI). The repetitive strain injury is part of the musculoskeletal diseases involving several workers and players, affecting millions of people in the world. The electronic glove design uses resistive sensors, connected to a microcontroller, turning the results into kilogram-force, and shows the data in a graphical environment that can be visualized in a personal computer or mobile devices. From the results obtained for each finger, it is possible to evaluate the amount of force applied to an object, such as an ergonomic ball, giving the possibility of specialized treatment for each finger or associated tendon.*

Keywords**—Wearable electronic glove, support to the diagnosis, repetitive strain injury**.

I. INTRODUCTION

The repetitive strain injury (RSI) are part of the musculoskeletal diseases involving industrial workers, musicians, and athletes of electronic games, as well as users of mobile devices such as cellphones, tablets, among others [1-5]. According to [2] RSI "is an umbrella term for a group of disorders usually caused by repetitive movements that affect the muscles, tendons and nerves", in which patients may present various levels of pain, from minor discomfort to the impossibility of move the affected part.

Research on RSI related to the use of computer devices dates back to the 1980s, indicating causes and symptoms related to workers who used computer keyboards for several hours a day, and musicians [3-4].

In the 1990s and 2000s, several surveys were conducted to evaluate RSI cases in several countries, indicating concern about the increasing incidence of critical cases in patients of different ages, occupations, regardless of gender [5-8].

According to [9] with 2019 data, only in the United States, there are more than 1.8 million workers are afflicted by RSI per year. The risk of RSI cases is significant, and to according [10], the use of the computer more than five hours per day causes a risk of Repetitive Strain Injury. The increase in the number of electronic device users for a period greater, that is becoming common in the world today, do with that the number of the cases tends to grow, that indicating the need for the development of solutions that can help in the diagnosis and treatment of the problem.

Several works have developed gloves for the treatment and monitoring of patients with various pathologies. In [11] a Rutger glove was developed for the treatment of Carpal tunnel syndrome, used to improve rehabilitation exercises. A low-cost platform for testing in patients with Parkinson and ALS, with the use of resistive sensors, and one accelerometer was developed in [12]. In [13] was developed a glove to track fitness exercises by reading hand palm that uses force-sensitive resistors in the practice of the athlete. Other works use a force-sensitive resistor (FSR) to diagnose and treat various hand-related problems, including:

Hand function assessment and preliminary attempts at assessing hand coordination [14]; Hand rehabilitation monitoring system [15]; a multisensory glove to allow prosthetic and robotic hand to simultaneously feel the pressure, temperature, and humidity [16]; Sensing with a ball for monitoring hand rehabilitation therapy in stroke patients [17].

In this paper, a low-cost wearable electronic glove for support to the diagnosis of repetitive strain injury is developed. This paper is comprised of three more parts beyond this introduction. Section II presents the materials, methods and the theoretical fundamentals used in the

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development of the work. In section III the project of a low-cost electronic glove, and in section IV the final considerations of the work are addressed.

II. MATERIALS AND METHODS.

The experiments were performed on the Arduino microcontroller platform, using force-sensitive resistors, connected to a serial output Arduino and exported in CSV format for data processing and organization. Fig. 1 shows the project of the wearable electronic glove for RSI.

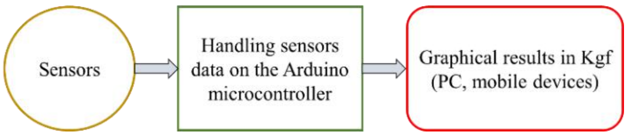


Fig. 1: Project of the wearable electronic glove for RSI.

The force-sensitive resistive sensors, FlexiForce marketed by the Tekscan industry, have a maximum compression support of 40 Kgf, with a length of 191 mm [18]. In the development of the project were used five sensors placed at the ends of the fabric glove, seeking to capture the amount of Kgf applied by each finger in an exercise ball with 110 mm of the radius. Fig. 2 shows the resistive sensor.

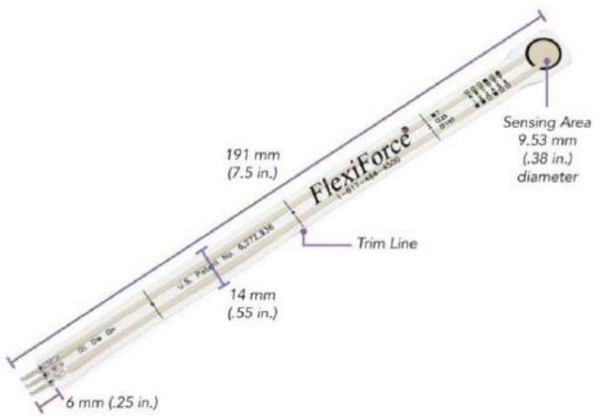
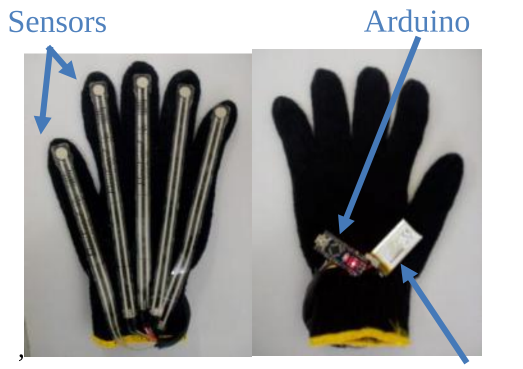


Fig. 2: Force-sensitive resistive sensor [1].

According to [19], "*Arduinos are based on Atmel microcontrollers and we mostly discuss the Arduino, where the main component is the ATmega 328p microcontroller from Microchip™. It is a controller with 8-bit-wide registers and operates at a clock frequency of 16 MHz. It has 32 kB RAM memory and 1 kB non-volatile EEPROM memory, which can be used to store persistent data that need to survive to the turn-off and on the supply voltage*", with output voltage and up to 5 V.

III. ELECTRONIC GLOVE FOR SUPPORTED TO THE DIAGNOSIS OF RSI.

The measurements of the wearable electronic glove were performed at the Signal Acquisition and Processing Laboratory (LAPS) of the State University of Maranhão (UEMA), Campos I, São Luís–MA, Brazil. In the measurements, the maximum pressure exerted on the ball has evaluated at intervals of 10 seconds and a maximum duration of 120 seconds, in which it has indicated that the experiment subject applied a different amount of force to each pressure range. Fig. 3 shows the prototype built with an indication of the sensors, microcontroller, and the graphical results.



(a) (b)

Fig. 3: Prototype of wearable electronic glove measurements: a) front vision; b) back vision.

Fig. 4 shows measured results of wearable electronic glove for the five fingers. As can be observed there is the variation of each finger by the measured time interval, so it can be evaluated which prototype was able to identify the pressure exerted at each moment of time, with minimum delay.

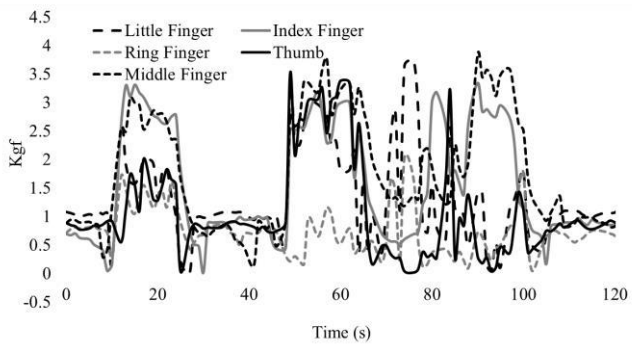


Fig. 4: Measures results of electronic gloves.

An assessment by each finger separately it can be visualized in Fig. 5. From the measured results it is possible to understand that each finger applies an amount of Kgf for the same time intervals, this is for the purpose of

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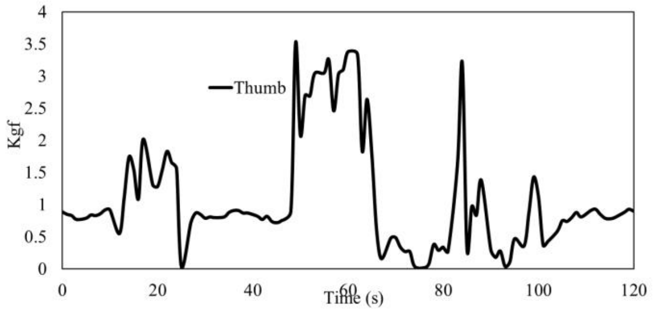
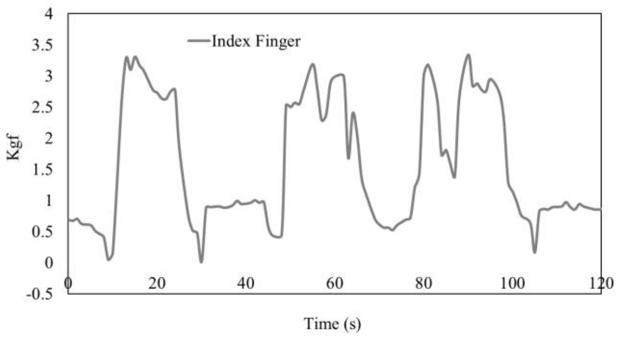
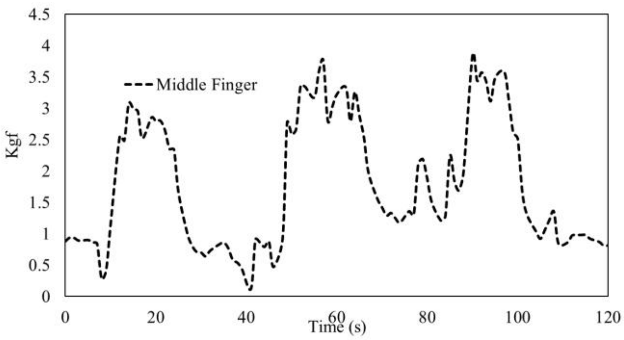
each part of the hand in the compression performed in the test, with monitoring in real-time.



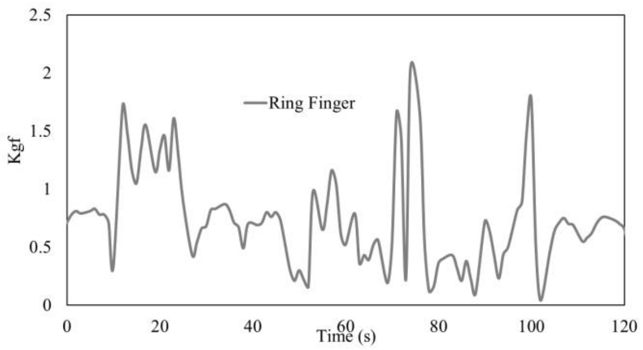
(a)



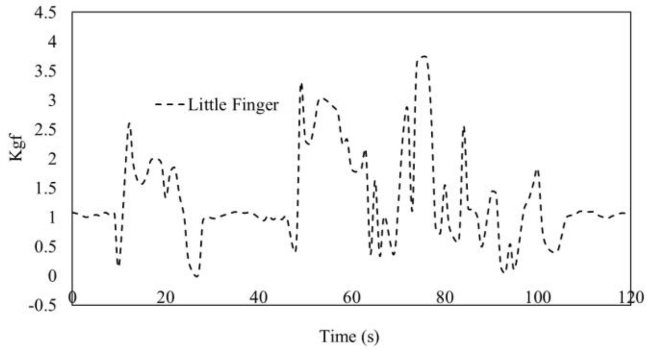
(b)



(c)



(d)



(e)

Fig. 5: Measures results of wearable electronic gloves for each finger: a) thumb; b) index finger; c) middle finger; d) ringfinger; e) little finger.

It is important to realize that with the use of the glove one can evaluate the force exerted by the set of fingers and each finger in isolation, allowing a specific evaluation of each finger in the exercise performed. This can be understood as indicative of the possibility of using the glove in the evaluation, possible diagnosis, and treatment of RSI or related diseases, being a low-cost solution and high sensitivity to the force exerted.

IV. FINAL CONSIDERATIONS

A low-cost wearable electronic glove for supported to the diagnosis of repetitive strain injury (RSI) was developed is described in this paper. Electronic glove design uses force-sensitive resistive sensors, connected to an Arduino microcontroller, whit graphical results into kilogram-force. In the results, it was evaluated the pressing of each finger on exercises ball, indicating the condition of the fingers, tendons and the total movement of the hand, which can be used as solution of the low-cost to the support to the diagnosis and treatment of RSI, and others related diseases.

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