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Beneficial effect of isometric device therapy in overcoming sprain injuries in the ankle due to sports using the arduino uno pro mini and load cell device design

Efecto beneficioso de la terapia con dispositivos isométricos en la superación de las lesiones por esguinces en el tobillo debido a los deportes con el diseño de dispositivo arduino uno pro mini y célda de carga

*Anton Komaini, *Aidil Syaputra, *Donal Syafrianto, *Gusril, *Syamsuar, **Novadri Ayubi
*Universitas Negeri Padang, (Indonesia), **Universitas Negeri Surabaya, (Indonesia)

Abstract This study aims to create an isometric exercise therapy tool in overcoming sprain injuries on the digital-based ankle that is valid, reliable, practical, effective and efficient. This type of research uses a Research and Development design, this research involves 3 experts who are competent in their fields, namely instrumentation physicists, exercise physiologists, and physiotherapists. A total of 30 men who were selected using the Purposive Sampling technique with ages ranging from 20 to 28 years and had sprain injuries in the ankle participated in this study. The testing of the tool was carried out using a questionnaire, test and retest. Statistical analysis of the data used is r-correlation. The results of the reliability test of the alpha coefficient, the results of the first day and the second day have a «high» correlation. The results of the product practicality test by the three experts show the product has a «very good» level of practicality, and the results of the product effectiveness test are obtained with an effectiveness level of «very good». Therefore, design an isometric therapy device for ankle sprain injuries due to sports using Arduino Uno and load cells which are effective for treating sprain injuries.
Keywords: Sprain; Injury; Isometric Exercise.

Resumen Este estudio tiene como objetivo crear una herramienta de terapia de ejercicio isométrica para superar las lesiones por esguince en el tobillo digital que sea válida, confiable, práctica, efectiva y eficiente. Este tipo de investigación utiliza un diseño de Investigación y Desarrollo, esta investigación involucra a 3 expertos que son competentes en sus campos, a saber, físicos de instrumentación, fisiólogos del ejercicio y fisioterapeutas. En este estudio participaron un total de 30 hombres que fueron seleccionados mediante la técnica de muestreo intencional con edades comprendidas entre los 20 y los 28 años y que tenían lesiones por esguince de tobillo. La prueba de la herramienta se realizó mediante un cuestionario, prueba y reprueba. El análisis estadístico de los datos utilizados es la correlación r. Los resultados de la prueba de confiabilidad del coeficiente alfa, los resultados del primer día y el segundo día tienen una correlación «alta». Los resultados de la prueba de practicidad del producto realizada por los tres expertos muestran que el producto tiene un nivel de practicidad «muy bueno», y los resultados de la prueba de efectividad del producto se obtienen con un nivel de efectividad de «muy bueno». Por lo tanto, diseñe un dispositivo de terapia isométrica para las lesiones por esguince de tobillo debido a los deportes utilizando Arduino Uno y células de carga que sean efectivas para tratar las lesiones por esguince.
Palabras clave: Esguince; Lesión; Ejercicio isométrico.

Introduction

Ankle sprain are one of the most common injuries for athletes in sports (Halabchi and Hassabi 2020; Herzog, Kerr, et al. 2019; Herzog, Mack, et al. 2019). Ankle sprain occur due to excessive strain during physical activity with adduction and inversion movements, causing a large amount of pressure that results in tearing of the ligament or damage to the structure of the ankle ligament (Lee et al. 2020; Mugno and Constant 2020).

It is estimated that about 85% of ankle sprain involve the lateral ligaments, 65% of the anterior talofibular ligament and 20% of the calcaneofibular ligament (Halabchi and Hassabi 2020). In this case, about 40% of ankle sprains cause chronic symptoms such as pain, swelling, decreased strength and impaired mobility (ROM) during the 12 months post-injury (Chen, McInnis, and Borg-Stein 2019).

Ankle sprains according to statistical data from several countries in the world explain that Indonesia has an incidence rate of 27.5%, Hong Kong 33%, the Netherlands 73%, and the United States 70% (Tulaar et al. 2017; Halabchi and Hassabi 2020). The US Emergency Department reports that 2 million people a year experience ankle sprains (Doherty et al. 2017). 16% to 40% of these cases occur due to exercise (Aslan, Sofu, and Kirdemir 2014). In addition, the incident is

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Anton Komaini
antonkomaini@fik.unp.ac.id

more concerning since around 55% of individuals who experience ankle sprains do not look for alternatives to the post-injury rehabilitation process, this will clearly have a negative impact on performance in carrying out physical activities, especially among athletes (Tricia Hubbard 2010; Mitsiokapa et al. 2017).

Alternative solutions need to be found to overcome these problems, one of the recommended interventions to improve the post-injury rehabilitation process is isometric exercise therapy (Taufik et al. 2019; Halabchi and Hassabi 2020). Isometric exercise therapy has the potential to minimize complications and speed up the recovery process (Padulo et al. 2020; O'Neill et al. 2019). Recently various sensor technologies are combined with sports devices (Li et al. 2016). It is also driven by technological advances and lower costs. Some of the sensors that can be used are arduino pro mini and load cells. Arduino pro mini is an ATmega328 microcontroller board which has 14 digital inputs/ outputs of which 6 can be used as Pulse Width Modulation (PWM) outputs and load cell is a sensor designed to detect pressure or a load (Smreczak, Rubbert, and Baur 2021). The use of the arduino pro mini device has been designed in a tool to measure muscle fatigue (Toro et al. 2019). The use of load cells has also been widely used as a sensor for measuring muscle strength (Taborri et al. 2020). However, until now, the effectiveness of Arduino and load cell technology has not been tested for the recovery process after an ankle sprain injury.

To answer that question, it is necessary to do isometric device therapy using Arduino pro mini and load cell device designs to treat ankle injuries due to sports. Therefore, the purpose of this research is to design a valid, reliable, effective, efficient isometric therapy device using Arduino pro mini and load cell device design to treat ankle sprain due to sports.

Methods

Study Design

This research uses Research And Development research design. This study involved 3 experts who are competent in their fields, namely instrumentation physicists, exercise physiologists, and physiotherapists who aim at the validation test stage, knowing the weaknesses and strengths of the products that have been designed. After carrying out the validation test phase, the resulting product will be tested for use in the field. The working procedure of isometric exercise equipment is to apply isometric pressure to the injured leg. The working principle of this tool is based on the basic movements found in the feet, namely inversion, eversion, plantar flexion and back flexion. Each isometric resistance (spring and elastic) is attached to the sensor to determine how much pressure the injured subject can exert. After the tool was tested, 3 experts conducted a reliability test to assess whether the tool that had been designed was reliable in data collection. Next, the expert conducts Practicality and Effectiveness tests to assess whether practical and effective tools are used as therapeutic tools.

Tool sketch

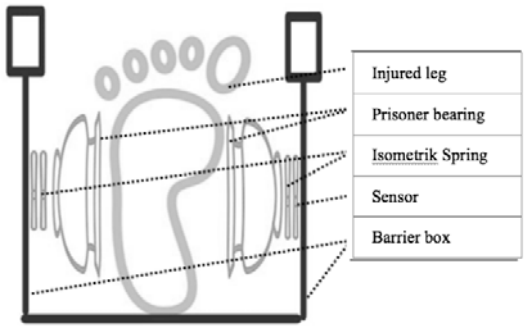

Figure 1. Isometric therapy device sketch

Product Design

1. Tool name: Isometric Training Therapy.
2. Tool prototype form: box, tool height 45 cm, width 25 cm, tool weight 1.5 kg.
3. Materials used: wood, and eva foam.
4. Electronic components: Arduino uno pro mini, load cell, LCD, switch button and USB cable.

Arduino pro mini and load cell working

Arduino pro mini is designed where users allow to use reset with software running on the LCD connected to the arduino. One of the pins on the six-pin header is connected to the ATmega328's reset line via the 100 nF plugin. This pin connects to one of the hard-wired control lines of the USB-to-serial converter connected to the header.

The way a load cell works is similar to a pressure sensor, which is to measure the pressure of a substance. the given load causes a reaction to the metal elements in the load cell which results in elastic deformation. The force generated by this strain (positive and negative) is converted into an electrical signal by the strain gauge.

Participants

A total of 30 men who were selected using the

Purposive Sampling technique with ages ranging from 20 to 28 years and had sprain injuries in the ankle participated in this study.

Statistical Analysis

Statistical analysis using SPSS application with r-correlation method.

Ethics

This research protocol has been declared ethical in accordance with 7 (seven) WHO 2011 standards, namely 1) social value, 2) scientific value, 3) distribution of burdens and benefits, 4) risk, 5) seduction / exploitation, 6) confidentiality and privacy 7) Approval after explanation, which refers to the 2016 CIOMS guidelines. This is shown by the fulfillment of indicators for each standard. Declaration of ethics was approved by the Research Ethics Committee of the Universitas Negeri Padang.

Results

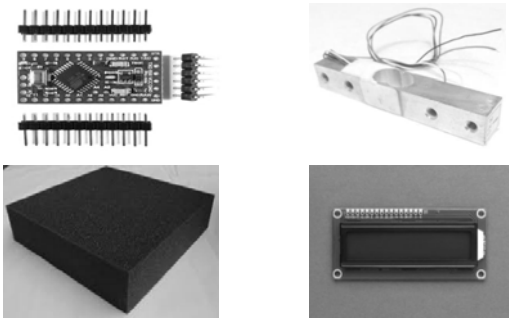

Figure 2. Arduino, load cell, eva foam, and LED used in the Tool OJO LA FIGURA 1 ESTÁ DOS VECES

Figure 3. Results of isometric therapy tools using Arduino and load cell design tools

Table 1.
Questionnaire scores for the validity of isometric therapy devices using Arduino and load cell designs by experts

Expert	Aspect	Score	Relative Frequency
Instrumentation Physics	Suitability	10	14%
	Accuracy	25	36%
	Convenience	15	21%
	Practicality	20	29%
	Amount	70	100%
Sports Physiology	Suitability	17	20%
	Accuracy	11	13%
	Convenience	16	19%
	Practicality	17	20%
	Kinesiology	7	8%
	Amount	85	100%
Physiotherapy	Suitability	22	29%
	Accuracy	18	24%
	Convenience	13	17%
	Practicality	15	20%
	Amount	77	100%

Expert Validity Test

Based on the assessment by the three experts, the isometric therapy tool for ankle sprain injuries can be tested on research subjects.

Table 2.
Expert Validity Percentage and Level

No	Expert	Percentage	Validity level
1	Instrumentation Physics	100%	Very good
2	Sports Physiology	80%	Well
3	Physiotherapy	91%	Very good

Table 3.
Analysis of the Alpha Coefficient of Reliability Test

Day	n	Alpha coefficient	Reliability
First day	30	0,79	High
Second day	30	0,78	High

Reliability

Based on the results of the alpha coefficient of the reliability test, the isometric therapy tool for foot sprains is said to be reliable and consistent in retrieving data.

Practicality

Based on the results of the three experts, it was found that the isometric therapy tool for ankle sprain injuries has a «Very Good» level of practicality.

Table 4.
Practicality Percentage Results from Expert Assessment

No	Expert	Presentase	Eligibility level
1	Instrumentation Physics	100%	Very good
2	Sports Physiology	85%	Very good
3	Physiotherapy	88%	Very good

Table 5.
Effectiveness Percentage Results from Expert Assessment

No	Expert	Presentase	Eligibility level
1	Instrumentation Physics	100%	Very good
2	Sports Physiology	85%	Very good
3	Physiotherapy	100%	Very good

Effectiveness

Based on the results of the effectiveness by the three experts, it was found that the isometric therapy tool for ankle sprain injuries has an effectiveness level of «Very Good».

Discussion

Based on the results of our study, it was explained that the validity test by instrumentation physicists obtained a level of validity which was included in the very good category, the validity test by the Sports Physiologist obtained a level of validity with the level of validity included in the good category, and the validity test by the Physiotherapist obtained a level of validity which included in the very good category. Validity in research is something that shows the truth or accuracy (Chander 2018). The resulting tool with a good level of

validity will help in acceptance in the wider community (Tunis, Stryer, and Clancy 2003).

The results of the alpha coefficient reliability test, the results of the first day and the second day with a high correlation, so it can be said that the isometric therapy tool for ankle sprain injuries using Arduino Uno and the resulting load cell is reliable and consistent in data collection. The results of the product practicality test by the three experts showed that the isometric therapy tool for ankle sprain injuries had a «very good» practicality level, and the results of the product effectiveness test by the three experts obtained results with an «excellent» effectiveness level. On research (Henderson et al. 2021) explained that one of the components that play an important role in tool design is the sensor, his research found that smart glove technology uses sensor technology to be effective in measuring range of motion (ROM).

The results of another study with research (Sousa et al. 2015) explain the use of load cell components as a measuring tool to develop repeated sprint abilities. A load cell (CSL/ZL-250 mounted on the prototype's tall front pole and attached to a cable was used to measure the athlete's drag force. The load cell has a height adjusted for the runner's height to maintain its horizontal orientation. Four evenly spaced magnets on the The tricycle front wheel is used to measure the horizontal displacement of the system. Another study (Toro et al. 2019) found that the use of sensor technology which also includes Arduino components provides valid results in detecting fatigue, in this research it is necessary to combine Arduino and data storage devices, in this case Arduino plays a role in spreading the code.

The main results of our study indicate that the device that has been designed is effective and has the potential to treat sports-induced ankle sprain.

Conclusion

Design an isometric therapy device for sports-related ankle sprains using Arduino Uno and load cells that are valid, reliable, effective, efficient for treating sprain.

Acknowledgements

The authors have no conflicts of interest to declare. This research has complied with all applicable Constitutions of the Republic of Indonesia and the ethical statement was approved by Ethics Committee, Universitas Negeri Padang. The data set generated during and/or analyzed during the current study is not available but is available from the first author who was the team leader for the study. Anton Komaini is the principal investigator and correspondent author

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