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# DEVELOPMENT OF FORCE PLATE FOR BIOMECHANICS ANALYSIS OF RUNNING AND JUMPING

**Dr.S.Koteswari,** Professor & Head, Department of ECE, Pragathi Engineering College , Suramapalem, Kakinada. Permanently Affiliated to JNTUK, Andhrapradesheshwari.ngr@gmail.com
**Nallagangula Mary Leena,** Assistant Professor, Department of ECE, DNR College of Engineering and technology, Bhimavaram. Permanently Affiliated to JNTUK, Andhrapradesh leenaprasad414@gmail.com
**Dr.M.Aravind Kumar,** Professor & Principal, Department of ECE, West Godavari Institute of Science and Engineering, Affiliated to JNTUK, Andhrapradeshdrmaravindkumar@gmail.com

**ABSTRACT:** The kinematics and dynamics of motion can be demonstrated using force plates, which are also frequently used in biomechanics labs to assess ground forces involved in human motion. It is made out of a rubber plate on which sensors are mounted in order to produce an electrical output proportionate to the force acting on the plate. Force plates are also helpful for analyzing the kinetics of an athlete's movement. They offer details on the outside forces at play during movement, which can help a coach or sports scientist quantitatively assess the athlete's progress in terms of skill. In this study, we create a force plate prototype at a lower cost than the one that already exists by utilizing a flexible force transducer that is attached within a rubber mat in the shape of square blocks, with the highest load. The hand-made force plate was put to the test while standing and walking using biomechanics analysis. At the university of Cenderawasih's department of physical education, health, and recreation, the testing was conducted on participants in experimental "soccer courses." We'll talk about the force plate system's design and biomechanics analysis. Similar quality data on vertical component ground forces can be obtained using this kind of force plate. In order to decrease external distortion that could interfere with the measurement, this firm, solid ceramic was employed. These two aren't present in Existed One. An extension of an existing force plate is present today.

**KEYWORDS**: Force plate sensors, DAS, Adriano, Interface, LCD/PC

## I. INTRODUCTION :

The role of science and technology in sports are becoming very important. Over the last 25 years there has been a significant growth in the importance of sports science in assisting, improving, and monitoring athlete preparation, specifically for the Olympic Games. List of Summer Olympic Medals shows countries which has evolved science in sports were those who accomplished highest number of medals. United States, France, Russia, England and Germany were top five, while China, Japan and South Korea were the top three Asia countries in the list. Contrarily, Indonesia is standing in 56th position. Limited development of sports science in Indonesia, both national level and regional level, was the main reason. Therefore, it is important for Indonesia to concern on this issue.

Sport science is concerned with applying the study of movement. The main purpose of sport science is to assist an athlete in maximizing his potential with the least possible risk of injury. The branch of science in sport is biomechanics, which study the forces and their effect on living systems. Force plate, most common tool in biomechanics laboratory, applied the biomechanics principle to demonstrate the kinematics and dynamics of motion by measuring forces involved in the motion of human or animal subjects. Force plate also can be used as teaching aid in undergraduate physics classes to demonstrate relationships between force, acceleration, velocity, and displacement. Moreover it is very ideally to be used in physical education or sports science classes in giving illustration and improving the athletes or students performances.
In order to provide an electrical output proportionate to the force on the plate, a force plate typically

comprises of one or more sensors mounted to the plate. While serving the same purpose as a bathroom scale, it provides a different scale. When standing, walking, running, or jumping, a force plate is used to measure the ground response force on each foot. Given the force wave shape in time function, the force plate for the walking process observed that the force increases from zero to a maximum value of around Mg, then dips below Mg, climbs again to approximately Mg, and then decreases to zero. The reader could examine the magnitude and direction of the force on each foot when walking as well as other activities like standing, jumping, etc. using the curve.

Commercial force plate devices unfortunately cost more. Which indicates that universities and sports scientists in poor regions like Papua face very high costs? It's interesting to note that a team from the University of Sydney created a force plate utilizing five piezoelectric sensors manufactured of PZT ceramic, which came at a relatively high cost overall. They created a homemade force plate with 4 piezo-sensors that can provide vertical component ground force data of comparable quality to commercially available force plates. In this study, we outline the more affordable new force plate construction. The construction's specifics and the use of analysis for running and jumping.

**OBJECTIVE OF THE SYSTEM:**

Over the past 25 years, there has been a substantial increase in the significance of sports science in supporting, developing, and monitoring athlete preparation. Science and technology are playing an increasingly crucial role in sports. In order to assess a person's plans for improving his performance at the next level of competition, or by making a comparison between a standard, well-known athlete and the current athletic contender. He can determine whether to boost his preparation or not by examining the athletic evaluation requirements.

**PROPOSED SYSTEM:**

**BLOCKDIAGRAM**

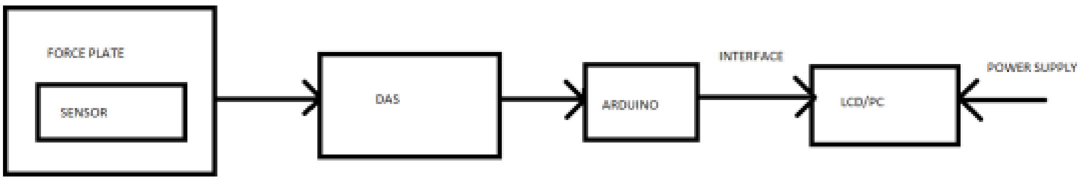


**FIG 1.1: Gait Analysis System**

**BLOCK DIAGRAMDESCRIPTION:**

Here we have mainly four blocks Force plate, DAS, ARDUINO, LCD/PC. Sensor is placed on Force plate which can sense the moments on the force plate from that data is given to the DAS where DAS can provide end users with better performance than networked storage because the server does not have to traverse the network in order to read and write data. Hence DAS is used for certain types of applications that require high performance. From DAS output is given to the ARDUINO where the calibration process is done and given to LCD through interface where ever evaluations are shown. From that we can analyze the strategies of a person.

**MAINCOMPONENTS:**

- Forceplate
- Sensor
- ARDUINO
- Pc or LCD

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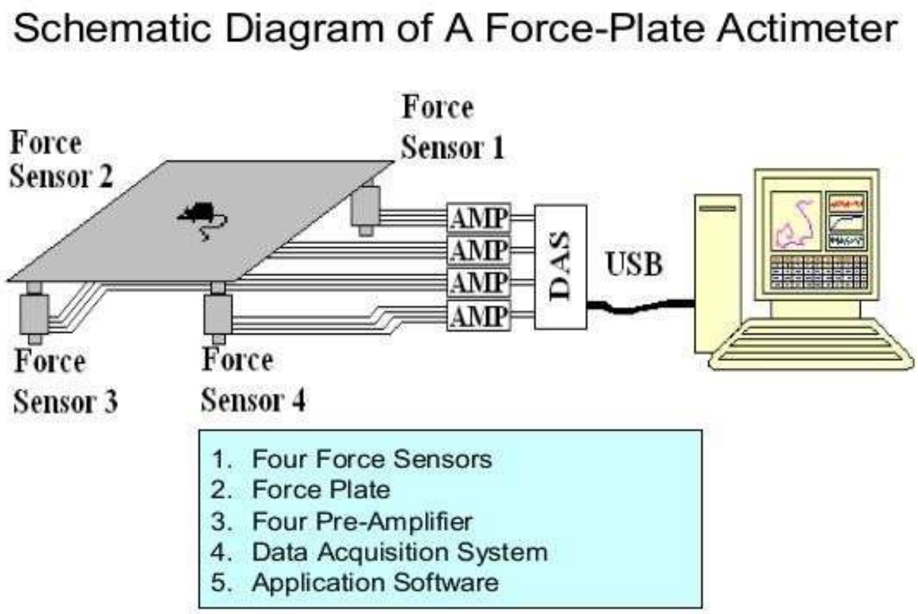



**FIG 1.2**: Schematic Diagram

As force is applied on the force plate the forcible sensors sense the moment of the person on the plate. Further it is amplified and fed to DAS which converts the digital to analog. Interface system is used between the ARDUINO and pc. In which the calibrated values of a person are shown. By this we can analyze the strategies of a pc.

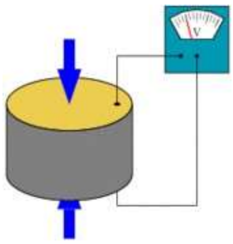
## LITERATURESURVEY

| PUBLISHER | DURATION (YEAR) | WORK DONE | METHOD |
|---|---|---|---|
| Rod Cross | (4th June – 18th August) 1998 | Standing,Walking, Running and Jumping | Strainguage |
| Sooksirimuch Tangwongsaa | 2015 | anding and Walking analysis of Canines | Piezo eltric |
| S Wardoyo ' T Hutajulu O Togibasa | 2016 | tanding and Walking | Piezo electric |

**Existing method:**

They created a force plate utilizing a piezoelectric sensor constructed of PZT ceramic. Which can only give information on ground forces with vertical components? Costs are very expensive. Due to their low cost and high output voltage, piezo buzzer discs were explored for the force plate application, but they were determined to be inappropriate since their output saturates at loads greater than roughly 0.5 kg. Sensors and force plate materials were previously utilized to build the force plate for the analysis of standing and walking. Piezoelectric transducers and strain gauge transducers are two examples of sensors in use. Steel plate and ceramic plate are two examples of force plate materials. Utilizing a piezoelectric transducer has the benefit of being unaffected by ambient magnetic fields. The disadvantage of crystal is that it can break if it gets too hot.

**PROPOSAL METHOD:**
Flexy force pressure sensor from TEKSCAN was used in this. A 50mv per Newton output voltage



was produced. This force waveform can be explained by the centre of mass moving vertically. Also without cost. To solve the drawbacks of the Piezo Electric Transducer and Strain Gauge Transducer, we propose using a flexible force sensor. The benefits of employing a flexible force sensor include:
1. Very flexible and thin.
2. Where there are no issues with electrical current. 3. A number of kilometer-long remote sensing.
4. Combining multiple sensors on a single cable
For the forceplate's construction in this, we employed rubber plates.
The benefits of rubber plates include: 1. Costless ness
2.Rich in readily accessible nature.

**RECENT DEVELOPMENTS INTECHNOLOGY:**
Technology developments have made it possible for force platform to play a new part in the kinetics industry. Because traditional laboratory-grade force plates are so expensive (sometimes in the thousands), they are incredibly unsuitable for use by the average practitioner. However, Nintendo changed the design of the force plate in 2017 when it unveiled the wii balance board (WBB) (Nintendo, Kyoto, Japan). In 2010, it was discovered that, when directly compared to the "Gold-standard" laboratory-grade force plate, the WBB is a valid and trustworthy tool to evaluate weight distribution and costs less. This has also been confirmed in groups that are healthy and clinical. The four force transducers that are located in the corners of WBB make it possible for this. These experiments are carried out with the aid of specialised software, such as lab view (National Instruments, Austin, TX, USA), which may be coupled with the board to quantify the length of the COP path or the amount of body wobble during timed trials. Another advantage of having a portable petrography equipment, like the WBB, is that practitioners may evaluate body sway quantitatively rather than depending on the existing subjective clinical balance assessments.

FIG 4: FORCE PLATE

**KINETIC EVALUATION**:
Force plate analysis can be conducted on static balance tasks, gait, and jumping and landing tasks to help identify right-left movement asymmetries. The force plate used in the biomechanical research

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(e.g., mainly strain gauge or piezo electric and flexible force sensor) have the ability to measure three orthogonal ground reaction forces (fx, fy, and fz), moment components (Mx, My, and Mz) and center of pressure. Thus this instrument can be used across a number of movement tasks, for example

**GAIT ANALYSIS:**
Assessment of ground reaction forces between right and left foot steps is a well acknowledged method for evaluation of right-left asymmetries in walking and running.

**JUMPING AND LANDING TECHNIQUES:**
Testing vertical ground reaction forces in jumping has been identified as a valid and reliable tool for the assessment of bilateral strength asymmetry, demonstrating significant correlations with is kinetic strength testing. Similarly, testing the force profile of the right and left legs during landing can be identify potential injury risks or predict reoccurring injury.

**CENTER OF PRESSURE PROFILES IN BALANCEDTASKS:**
Measuring the center of pressure to provide an estimate of the center of gravity and a representation of balance is generally well accepted in the evaluation of static balance tasks (Benda, Riley, & Krebs). Thus the evaluation of center of pressure on the right and the left leg using single -leg standing tasks can help to identify balance asymmetries.

GROUND REACTION FORCES IN FORCE PLATE

| TYPES OF GROUND REACTION FORCES |
|---|
| • PEAK VERTICALFORCE<br>• VERTICAL IMPULSE<br>• RISING AND FALLINGFORCE<br>• BRAKINGFORCE<br>• BRAKINGIMPULSE<br>• PROPULSIVEFORCE<br>• PROPULSIVE IMPULSE<br>• MEDIOLATERALFORCE |

**Table 1: Types of Ground Reaction Forces**
**FIG 5: Forces Involved on a Force plate**

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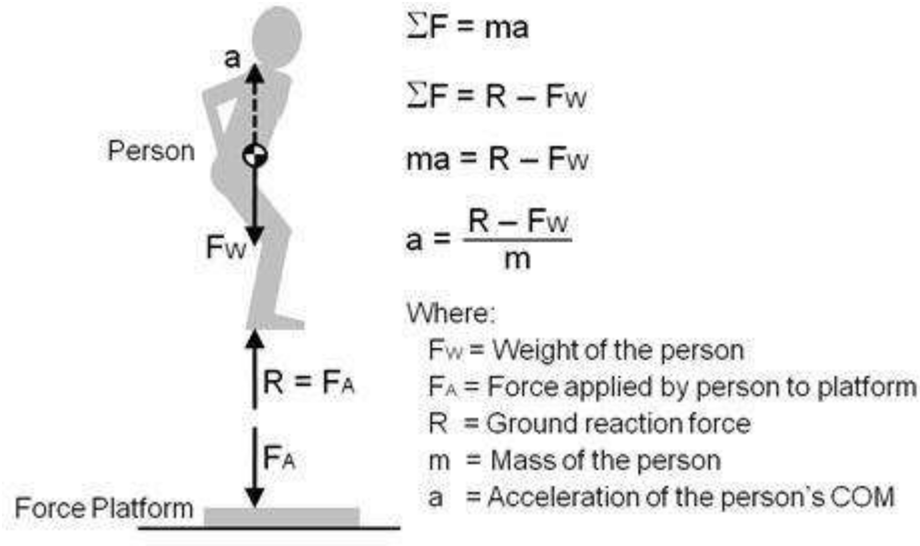


**CENTER OF PRESSURE:**

The centre of pressure is the point where the total sum of a pressure field acts on a body, causing a force to act through that point. The total force vector acting at the center of pressure is the value of the integrated factorial pressure field. The resultant force and centre of pressure location produce equivalent force and moment on the body as the original pressure field. Pressure field occur in both static and dynamicmechanics

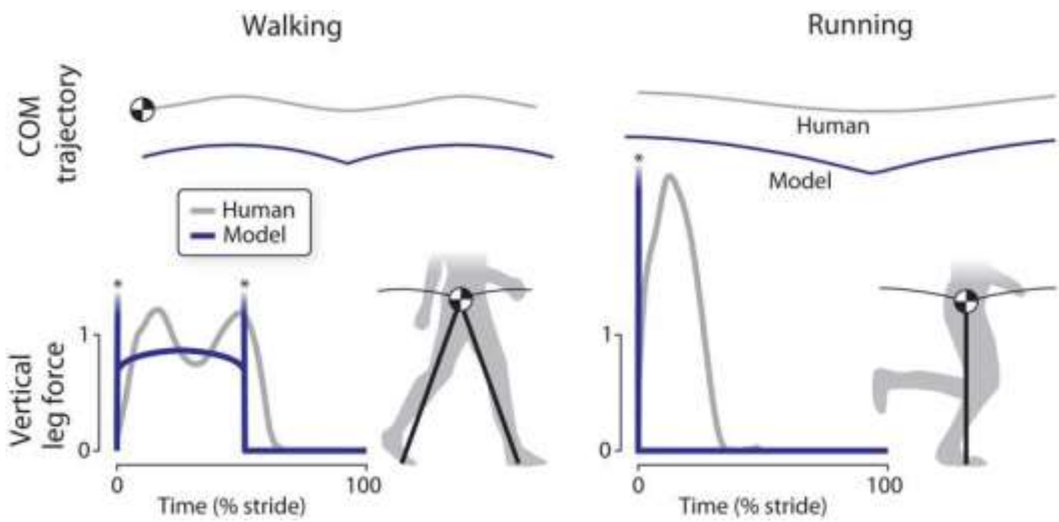


**FIG 6: Walking and Running analysis**

**PROPOSED ARCHITECTUREDESIGN**

**Architecture design of Force Plate**

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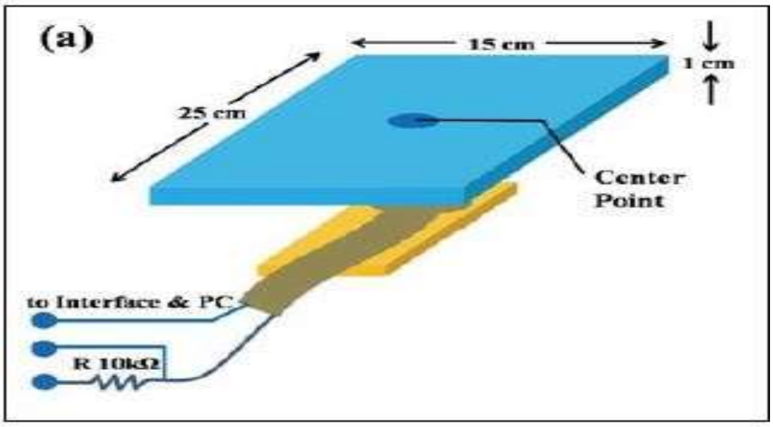



**FIG 7: Architecture of Force Plate**

Our developed prototype of force plate is simply a rubber plate with one sensor attached in the bottom to give an electrical output proportional to the force on the plate. The dimension of the plate is 250 mm ×150 mm × 10 mm, about 50% smaller than the commercial ones but still sufficient to locate two feet on the plate. Insteadofpiezodiskssensor, weusedflexy-forcepressuresensorfromTEKSCAN

Which connected to the interface based on chip microcontroller AT-mega 328? This configuration generated an output voltage of 50 mV per Newton. Other advantages of the prototype are flexible, light, and portable for outdoor usage. Hard and solid ceramic used as the home base of the whole systems to reduce external distortion that might interfered the measurement. Figure shows the schematic and the real image of the prototype of force plate.

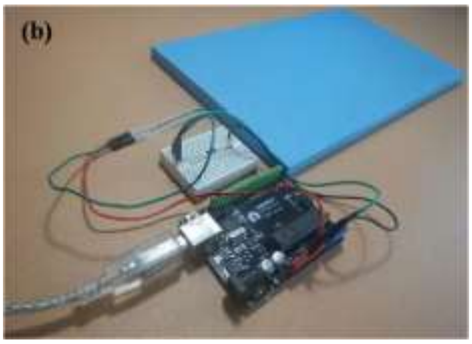



FIG 8: Experimental Connections of Force Plate

The developed prototype was testing on Experimental Soccer Courses students at the Department of Physical Education, Health and Recreation, University of Cenderawasih. A student with a body weight of 60 kg was performed standing and walking motion on the plate. In the next section the biomechanics analysis for standing and walking will be described

**Bio mechanic analysis:**

A gravitational force on a body is a certain type of pull that is directed toward a second body [9]. Suppose a body of mass *m* is in free fall with the free-fall acceleration of magnitude *g*. If we neglect the effects of the air, and place a vertical y axis along the body's path with the positive direction upward, then the Newton's second law can be written in the form *Fg* (or *Fy* in –*y* direction):

$-fg=(-g)$ (1)

Or

$fy=(g)$ (2)

Walking or running analysis is ideally suited for a class of physical education or sports science students. It illustrates some interesting aspects of elementary biomechanics. When a person is walking or running at constant speed, no horizontal force is required. The main retarding force arises from the front foot pushes forwards on the ground, resulting in an impulse that is equal and opposite the impulse generated when the back foot pushes backwards. If a person stands with both feet on a force plate, the vertical direction will register $F = Mg$. But, when a person bending the knees, therefore the center of mass is lowered, resulted force decreases and then increases before settling back to $Mg$. Figure shows the wave form observed when a person steps onto the force plate, then stands up straight, then steps off the force plate. The saturated force in time history from 3 s up to 4 s shows the person stands up straight in balance position.

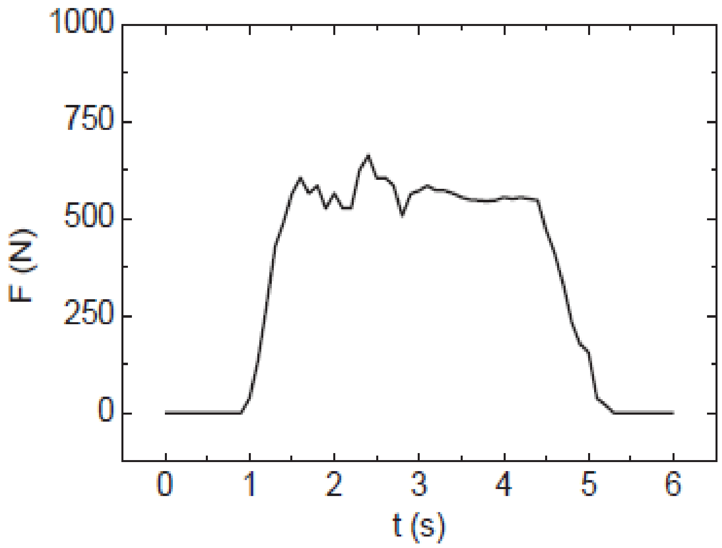



**FIG 9: The waveform observed when standing with**

The force wave form can be interpreted in terms of the vertical motion of the center mass. The vertical component of the force acting on one foot when walking on the force plate is shown in Fig. The Horizontal component was not measured with our prototype, due to its limitation. The vertical force wave form observed from slow- walking, has two distinct peaks similar like the previous version. Both peaks are similar in amplitude. The force rises from zero as weight is transferred from the back to the front foot, and returns to zero when weight is transferred back to the other foot at the end of the stride. However, it is hardly to distinguish two peaks from fast- walking wave form. Improvement of sensitivity, specifically for short periods, is needed in our machine.

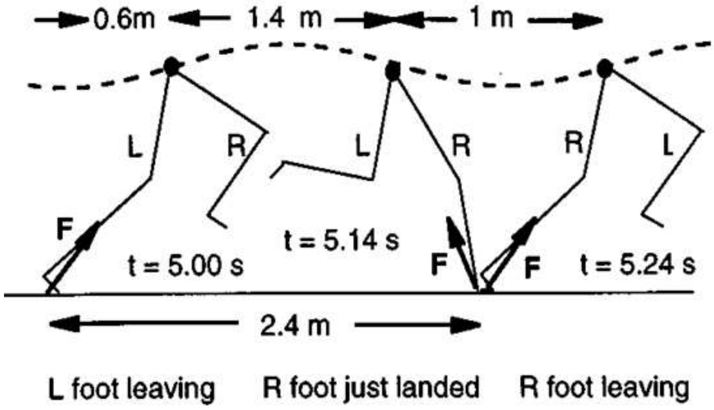



FIG 10: Observed movement of a person on Force Plate

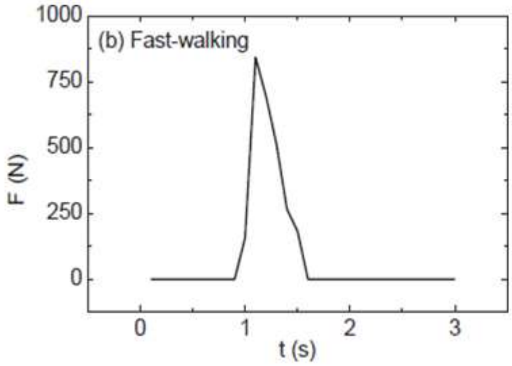
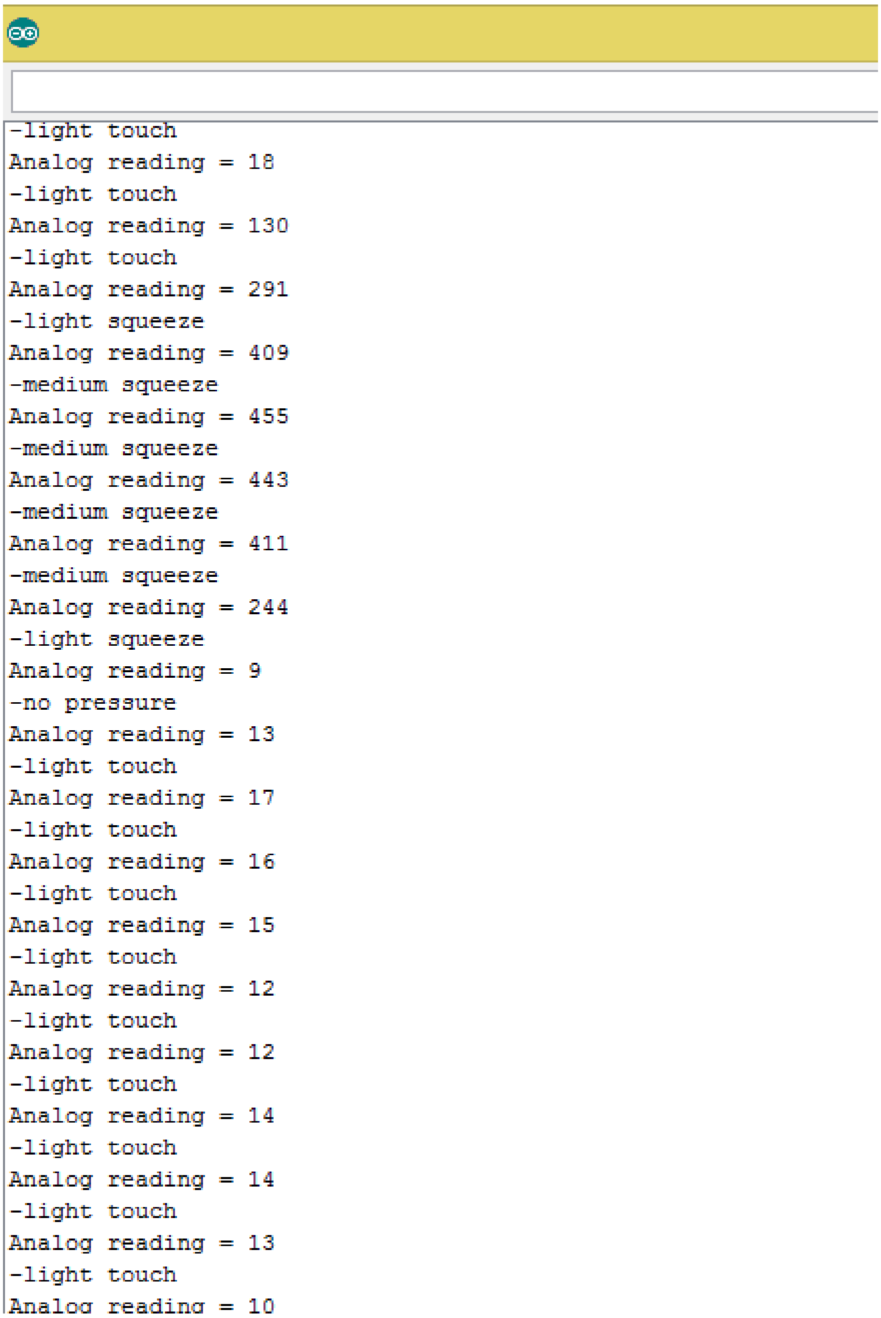



**FIG 11: Fast walking**

## RESULTS

```
-light touch
Analog reading = 16
-light touch
Analog reading = 16
-light touch
Analog reading = 16
-light touch
Analog reading = 16
-light touch
Analog reading = 357
-light squeeze
Analog reading = 430
-medium squeeze
Analog reading = 303
-light squeeze
Analog reading = 187
-light touch
Analog reading = 53
-light touch
Analog reading = 18
-light touch
Analog reading = 15
-light touch
Analog reading = 17
-light touch
Analog reading = 16
-light touch
Analog reading = 16
-light touch
Analog reading = 16
-light touch
Analog reading = 19
-light touch
Analog reading = 18
-light touch
Analog reading = 18
-light touch
Analog reading = 16
```

**FIG 12: Running Results**



**Jumping Results**


**Conclusion & Future Scope:**

It has been shown that a new and low cost budget of force plate can be constructed to provide vertical component forces data that is similar in quality to commercial version. Such a plate can be used as an aid in teaching experimental courses in physics education or sports science classes. Our first prototype of the force plate was able to give quantitative experiments in standing, running and jumping. For future works, improvement in sensitivity and sensors configuration may able to increase the quality of the plate and expand its application in other athletic games. The future scope is improving sensor configuration and by increasing number of sensors we can expand its applications in other athletic games. The sensor configuration is increased by using op-amp (MCP 6001U)

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