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Wireless Sensory Feedback Device for Real-Time Knee Arthritis Gait Analysis and Training

J. Bharath[1], A. Satish[2] , F. Emerson Solomon[3]

[1, 2] UG Scholar, Department of Biomedical Engineering, BIST-BIHER, Chennai.
[3]Assistant Professor, Department of Biomedical Engineering, BIST-BIHER, Chennai

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ABSTRACT

A system is developed to monitor the gait movement of the patient under study remotely. Patients with problem in their legs after accidents or paralysis attack or minor injury can be monitored using this gait feedback system. Force Sensor Resistors (FSR) is employed in the system to measure the amount of pressure applied in the foot. Bluetooth is used to send an alert to the doctor thus allowing remote monitoring of the patients. The processor gets the reading from the FSR constantly to compare the obtained value. When there is an abnormal change in the readings obtained or the when the value is degraded, the processor send an alert to the physician in charge immediately to his mobile or personal computer that relates to the Bluetooth of the system

1. INTRODUCTION

The ability to walk is an essential motor function for normal human locomotion and transportation. Healthy ambulation is required of nearly all persons on a daily basis, and can be necessary for employment, recreation, and general movement. Due to the functional importance of walking, consideration must be given to the treatment and remediation of disorders affecting the ability to walk properly and without difficulty. There are many different methods for evaluating and diagnosing gait problems, with different classifications for severity of the disorder based on the level of functionality as compared to a healthy gait. Proceeding from the initial diagnosis, specialized rehabilitative techniques have been established and are used by clinical therapists to correct the abnormality. The objective of rehabilitation is to raise the functional walking ability of the patient to a level, where they are able to perform normal tasks and are not at risk for subsequent health defects. Current rehabilitation technology and techniques have proven effective at modifying and correcting gait abnormalities. They are however limited to laboratory and clinical settings, under the supervision of a specialist. Conventional techniques for quantifying gait asymmetries can be combined with sensory feedback methods to provide an intuitive and inexpensive feedback system for extra-clinical rehabilitation. A wireless feedback system has been designed to collect gait information, process it in real-time, and provide corrective feedback to the user. The corrective feedback can be presented through visual, audible, or vibrotactile methods, or a combination there of initial results have led to improvement in the sensory interface of the device to maximize the corrective influence on inexperienced subjects. These preliminary findings suggest that the wireless feedback device can influence the gait of the user, and effectively adapt to their personal feedback preferences.

2. DISCUSSIONS

2.1 EMBEDDED SYSTEM:

A general definition of embedded systems is: embedded systems are computing systems with tightly coupled hardware and software integration, which are designed to perform a dedicated function. In some cases, embedded systems can function as standalone systems. One class of embedded processors focuses on size, power consumption, and price. Therefore, some embedded processors are limited in functionality, i.e., a processor is good enough for the class of applications for which it was designed but is likely inadequate for other classes of applications.

Real-time systems are defined as those systems in which the overall correctness of the system depends on both the functional correctness and the timing correctness. The timing correctness is at least as important as the functional correctness.

2.2 APPLICATION OF EMBEDDED SYSTEM

- In real life we are using so many embedded systems for example
- Home application (microvan, washing machine, security system DVD, Mp3 player etc,)
- Air craft, missiles, automotive, nuclear research, personal use (mobile phone, I pod)

2.3 TYPES OF EMBEDDED SYSTEM

1. Embedded System is broadly categorized as Standalone embedded system.
Example: Washing Machine,
2. Networking embedded system.
Example: Network Printer

2.4 EMBEDDED SYSTEM NETWORK APPLICATIONS.

Embedded systems are designed to do some specific tasks, rather than be a general-purpose computer for multiple tasks. Some also have real-time performance constraints that must be met, for reason such as safety and usability; others may have low or no performance requirements, allowing the system hardware to be simplified to reduce costs. Embedded systems are not always separate devices. Most often they are physically built-in to the devices they control.

The software written for embedded systems is often called firmware, and is stored in read-only memory or Flash memory chips rather than a disk drive. It often runs with limited computer hardware resources: small or no keyboard, screen, and little memory.

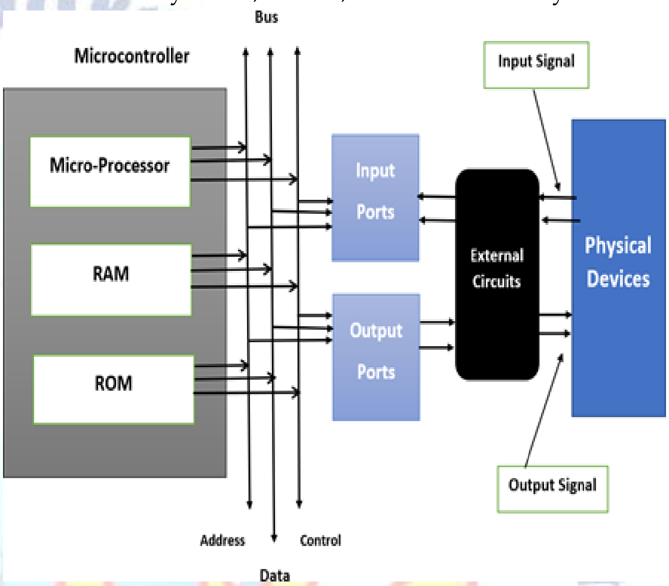

Fig: 1 Embedded System Design

3. METHODOLOGY

3.1 EXISTING SYSTEM

RF Based Monitoring:

At the present time, gait analysis is primarily carried out in one of two ways: in a motion laboratory, with full analysis of the motion of all body segments using highly accurate optical systems, or in a doctor's office with the physician making visual observations.

The first method is expensive, requires the maintenance of a dedicated motion lab, and uses cumbersome equipment attached to the patient, but produces well-quantified and accurate results for short distances. This system used in gait rehabilitation and training includes force plates, force mats, motion capture systems, instrumented treadmills, and insole sensor systems.

Force plates and force mats are ideal for use in stationary settings due to their high accuracy, but require training for use and are prohibitively expensive and large to be considered for implementation outside the clinic. Instrumented treadmills are able to gather large amounts of step data, but are limited by their controlled environment and prescribed walking pattern. In addition to stationary gait analysis systems, patient mounted systems are available to measure gait parameters.

The second method is inexpensive and does not require anything to be attached to the patient, but the results are qualitative and difficult to compare across multiple visits. So there is a need of a system that works in between the above two scenario that is, it should be cost effective and as well as shows effective results. Hence a system with force sensor resistors are designed that can be easily implemented in the shoes of the patients and monitored remotely from the office using Bluetooth technology.

3.2 PROPOSED SYSTEM

Bluetooth Based Monitoring:

The system consists of a processor which gets the data from the sensor and transmits it to the PC and the mobile phone of the physician using Bluetooth modem. The sensors used here is force sensitive resistor which are simple in implementation and to use.

The heart of this system is Microcontroller which has FSR (Force Sensitive Resistor) sensor interfaced with it. The sole is said to be divided into two halves first is fore foot section and second is hide foot section, both the sections are provided with FSR.

The data are sampled from the insole sensors by the microcontroller. The microcontroller is in turn connected to the Bluetooth module (AUBTM-20). This module is capable of wireless serial data transmission and receipt when paired with feedback application with smart phone.

3.3 WORKING

The Force-Sensing-Resistor (FSR) is made of a proprietary polymer thick film ink, typically screen printed on Mylar (PET) film, depending on the requirements of the application. As force is applied to the device, the electrical resistance decreases. The ink formulation can be customized for application-specific requirements, such as minimizing saturation with greater force, as well as for very low force needs. Temperature, humidity, and shear are some of the considerations. The Force-Sensing Resistor can be used for such applications as computer input devices, musical instruments, interactive toys, robotics fingertips, automotive, sports, or medical applications.

The two basic FSR configurations are the ShuntMode and the ThruMode. Both are constructed of two substrates, or film layers. The proprietary force-sensing resistor ink (FSR element) is screen printed on one film, while on the other film is printed the conductive, interdigitated electrode fingers. The two films are assembled with the printed surfaces facing each other and can be adhered together with a double-stick adhesive spacer around the perimeter.

The interdigitating conductive fingers can also be made on a printed circuit board. When a force is applied to the device, the shunt or shorting circuit is complete. The more force applied, the more conductive the output. The sensor can be read by connecting an ohmmeter to the two contact legs of the sensor and applying a force to the sensing area. The FSR device works best when mounted to a rigid or semi-rigid backed surface so that when the force is applied to the device, there is a surface to push against. The FSR device can be adhered to a surface with an adhesive.

The actuator system is critical for improving the part-to-part reproducibility of the FSR device. The actuator references the device, or means, in which the FSR device is "touched" or actuated. As the flexible upper substrate deflects and yields to the force applied to the actuator, initially there is a small area of contact between the FSR element and the circuit. As the force is increased, the area of contact also increases and the output becomes more conductive. These principles are minimized and a less dynamic range is accomplished when both substrates are rigid.

As long as the force is applied consistently, cycle-to-cycle repeatability is maintained. A thin elastomer, such as silicone rubber, placed between the actuator and the sensor, can be used to absorb some error from inconsistent force distribution.

3.4 BLOCK DIAGRAM

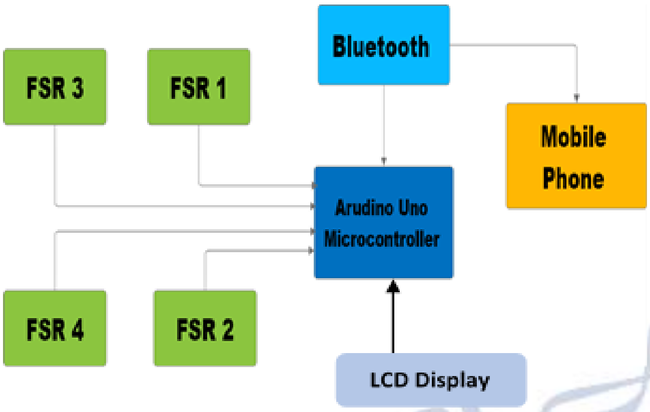

Fig: 2 Block Diagram of the prototype

3.5 PROJECT FEATURES

1. Low cost.
2. High speed networking.
3. Low power consumption.
4. Light weight network
5. Broadcast communication

4. HARDWARE DESCRIPTION

4.1 ARDUINO MICROCONTROLLER

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

4.2 DEVICE FEATURES

Depending on the device selected and features enabled, there are up to five ports available. Some pins of the I/O ports are multiplexed with an alternate function from the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin

4.3 MEMORY UNIT

Memory is part of the microcontroller whose function is to store data. For a certain input we get the contents of a certain addressed memory location and that's all. Two new concepts are brought to us: addressing and memory location. Memory consists of all memory locations, and addressing is nothing but selecting one of them. This means that we need to select the desired memory location on one hand, and on the other hand we need to wait for the contents of that location. Besides reading from a memory location, memory must also provide for writing onto it. This is done by supplying an additional line called control line. We will designate this line as R/W (read/write). Control line is used in the following way: if r/w=1, reading is done, and if opposite is true then writing is done on the memory location.

4.4 CENTRAL PROCESSING UNIT

Let add 3 more memory locations to a specific block that will have a built-in capability to multiply, divide, subtract, and

Move its contents from one memory location onto another. The part we just added in is called "central processing unit" (CPU). Its memory locations are called register.

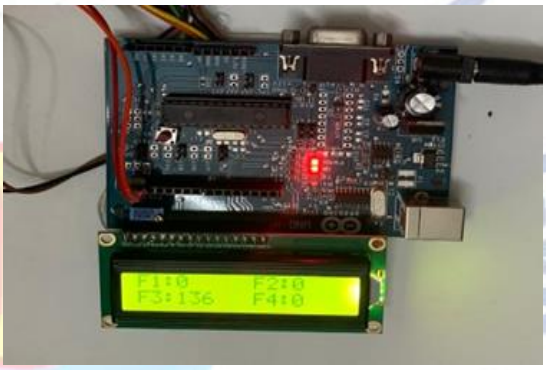

Fig: 3 Arduino UNO

4.5 BLUETOOTH

Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz from fixed and mobile devices, and building personal area networks (PANs).

Bluetooth operates in the range of 2400–2483.5 MHz (including guard bands). This is in the globally unlicensed (but not unregulated) Industrial, Scientific and Medical (ISM) 2.4 GHz short-range radio frequency band.

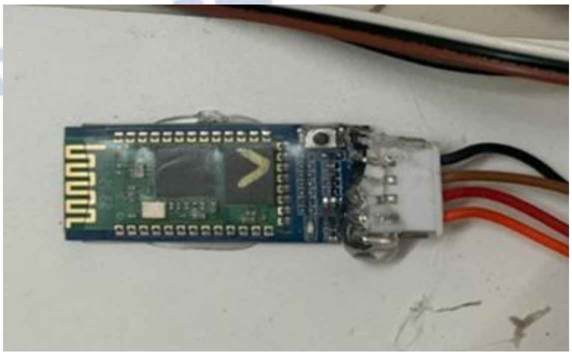

Fig: 4 Bluetooth

4.6 FORCE SENSITIVE RESISTOR (FSR)

The technology of force-sensing resistors was invented and patented in 1977 by Franklin Eventoff. In 1985 Eventoff founded Interlink Electronics a company based on his force-sensing-resistor (FSR). In 1987, Eventoff received the prestigious International IR 100 award for developing the FSR. In 2001 Eventoff founded a new company, Sensitronics that he currently runs.

Force-sensing resistors consist of a conductive polymer, which predictably changes resistance following applying force to its surface. They are normally supplied as a polymer sheet or ink that can be applied by screen printing. The sensing film consists of electrically conducting and non-conducting particles suspended in a matrix. The particles are sub-micrometre sizes formulated to reduce temperature dependence, improve mechanical properties, and increase surface durability.

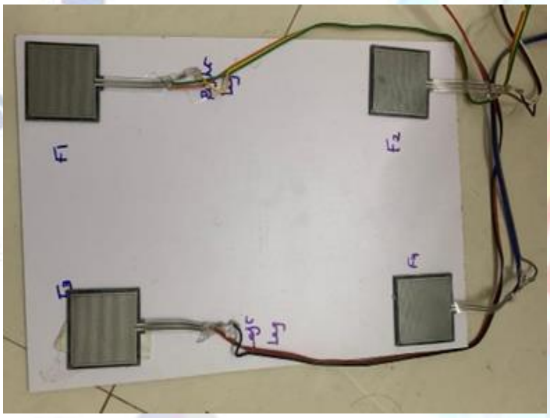

Fig 5: Force sensitive resistor

5. SOFTWARE DESCRIPTION

The software tools which are used for the implementation are listed below, they are

1. MPLAB IDE

MPLAB integrated development environment is a comprehensive editor, project manager and design desktop for application of development of embedded design using Microchip ARDUINO MCU and ARDUINO DSC.

MPLAB is a window operating system software program that runs on a PC to develop application for microchip microcontroller and digital signal controller. It is called an integrated development environment or IDE; it provides a single integrated environment to develop code for embedded microcontroller.

2. C18 COMPILER

The MPLAB C18 compiler is a free-standing, optimizing ANSI C compiler for the ARDUINO microcontroller unit. The compiler deviates from the ANSI standard X3.159-1989 only where the standard conflicts with efficient ARDUINO micro MCU support. The compiler is a 32-bit Windows console application and is fully compatible with Microchip's MPLAB IDE, allowing secure level debugging with the MPLAB ICE in circuit emulator, the MPLAB ICD 2 in circuit debugger or the MPLAB SIM simulator.

6. RESULTS AND DISCUSSION

6.1 RESULTS

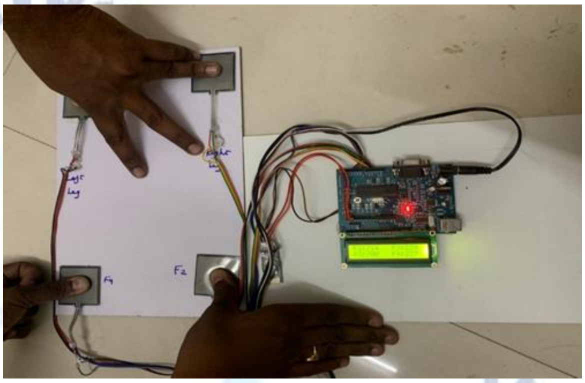

Fig 6: Experimental setup

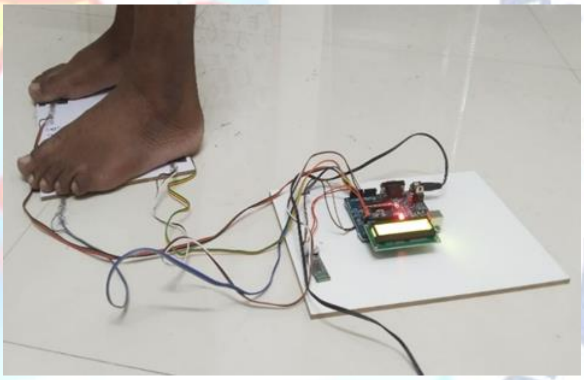

Fig 7: Patient with Normal Gait

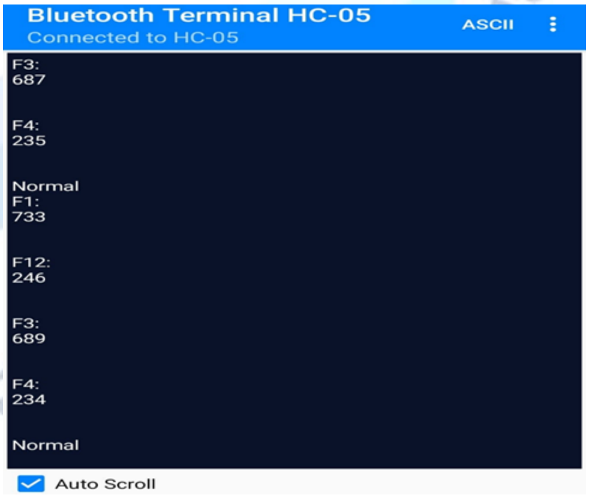

Fig 8: Normal Gait values

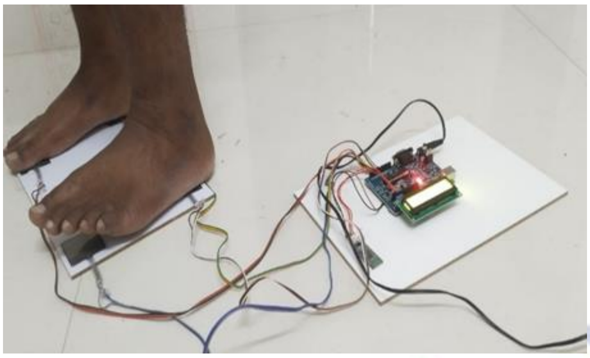

Fig 9: Patient with Abnormal Gait

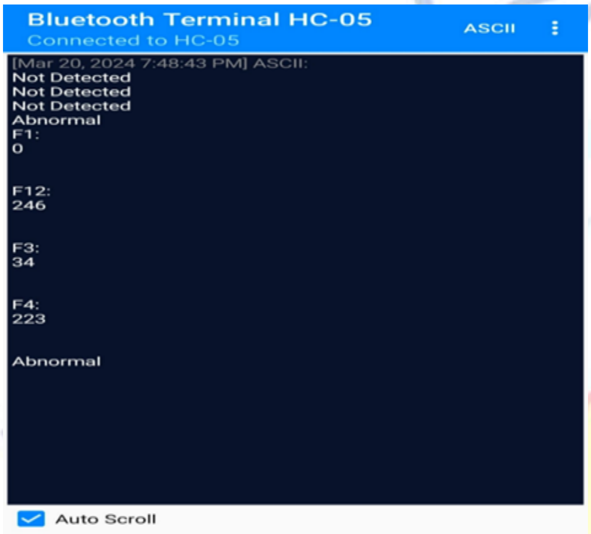

Fig 10: Abnormal Gait values

6.2 DISCUSSION

- The Experimental setup (fig-6) of the kit was tested with the Random peoples, in that we acquire Normal gait values for Normal Patients that i have included in fig 7 & 8.
- Randomly we acquire Abnormal Gait values for the patients who having abnormal gait that i have mentioned in the fig 9 &10.
- Finally Rehabilitation therapist analyses the values of the gait and states that the person having Arthritis are not.

7. CONCLUSION

The above system gives appreciable values under different conditions. It also allows to quantitatively analysing the gait values outside the motion lab. This system can be developed further in future to increase its accuracy and also can be improved so that it can be used to get other pattern analysis also. Thus, this system has a promising future for vast implementation and expansion in the medical fields.

8. FUTURE WORK

In future we can replace this blue tooth module with the help of GSM and IOT. IOT will help in continuous monitoring of the baby and old people and sensor values will be uploaded in cloud. GSM will help in sending SMS in case of any danger. Rehabilitation.

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Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Harshe K, Williams JR, Hocking TD, Lerner ZF. "Predicting Neuromuscular Engagement to Improve Gait Training with a Robotic Ankle Exoskeleton". IEEE Robot Autom Lett. 2023 Aug; 8(8):5055-5060. Doi: 10.1109/lra.2023.3291919. Epub 2023 Jul 3.PMID: 38283263

[2] . Spomer AM, Conner BC, Schwartz MH, Lerner ZF, Steele "Audio-visual biofeedback amplifies plantar flexor adaptation during walking among children with cerebral palsy". KM.J Neuroeng Rehabil. 2023 Dec 8; 20(1):164. Doi: 10.1186/s12984-023-01279-5.PMID: 38062454 Free PMC article.

[3] Huang X, Xue Y, Ren S, Wang F. Sensors "Sensor-Based Wearable Systems for Monitoring Human Motion and Posture: A Review". IEEE (Basel). 2023 Nov 8; 23(22):9047. Doi: 10.3390/s23229047.PMID: 38005436 Free PMC article. Review.

[4] . Ghai S, Ghai I, Narciss S. "Children Auditory Stimulation Improves Gait and Posture in Cerebral Palsy: A Systematic Review with Between- and Within-Group Meta-Analysis" IEEE (Basel). 2022 Nov 15; 9(11):1752. Doi: 10.3390/children9111752.PMID: 36421201 Free PMC article. Review.

[5] Deb R, an S, Bhat G, Shill H, Ogras UY.Sensors "A Systematic Survey of Research Trends in Technology Usage for Parkinson's Disease". IEEE (Basel). 2022 Jul 23; 22(15):5491. Doi: 10.3390/s22155491.

[6] Baram Y, Aharon-Peretz J, Badarny S, Susel Z, Schlesinger I.J "Closed-loop auditory feedback for the improvement of gait in patients with Parkinson's disease". Neurol Sci. 2016 Apr 15; 363:104-6. Doi: 10.1016/j.jns.2016.02.021. Epub 2016 Feb 10.PMID: 27000231

[7] Hamacher D, Hamacher D, Herold F, Schega L. "Effect of dual tasks on gait variability in walking to auditory cues in older and young individuals." Exp Brain Res. 2016 Dec; 234(12):3555-3563. Doi: 10.1007/s00221-016-4754-x. Epub 2016 Aug 17.PMID: 27534860

[8] Baram Y, Miller A.J "Auditory feedback control for improvement of gait in patients with Multiple Sclerosis". Neurol Sci. 2007 Mar 15; 254(1-2):90-4. Doi: 10.1016/j.jns.2007.01.003. Epub 2007 Feb 20.PMID: 17316692 Clinical Trial.

[9] . Baram Y. "Virtual sensory feedback for gait improvement in neurological patients" Front Neurol. 2013 Oct 14; 4:138. Doi: 10.3389/fneur.2013.00138.PMID: 24133478 Free PMC article. Review.

[10] Aboutorabi A, Arazpour M, Ahmadi Bani M, Saeedi H, Head JS. "Efficacy of ankle foot orthoses types on walking in children with cerebral palsy: A systematic review" Ann Phys Rehabil Med. 2017 Nov; 60(6):393-402. Doi: 10.1016/j.rehab.2017.05.004. Epub 2017 Jul 13.PMID: 28713039 Review.

[11] Ali SG, Wang X, Li P, Jung Y, Bi L, Kim J, Chen Y, Feng DD, Magnenat Thalmann N, Wang J, Sheng B. "A systematic review: Virtual-reality-based techniques for human exercises and health improvement" Front Public Health. 2023 Mar 23; 11:1143947. Doi: 10.3389/fpubh.2023.1143947. ECollection 2023.PMID: 37033028.

[12] Xuan C, Zhang B, Jia X.Int J "The Effect of Human Settlement Pedestrian Environment on Gait of Older People: An Umbrella Review". Environ Res Public Health. 2023 Jan 14; 20(2):1567. doi: 10.3390/ijerph20021567.PMID: 36674319

[13] Wang L, Peng JL, Ou-Yang JB, Gan L, Zeng S, Wang HY, Zuo GC, Qiu L. "Effects of Rhythmic Auditory Stimulation on Gait and Motor Function in Parkinson's Disease: A Systematic Review and Meta-Analysis of Clinical Randomized Controlled Studies". Front Neurol. 2022 Apr 15; 13: 818559.doi: 10.3389/fneur.2022.818559. eCollection 2022.PMID: 35493833

[14] Lopez WO, Higuera CA, Fonoff ET, Souza Cde O, Albicker U, Martinez JA. "Listenmee and Listenmee smartphone application: synchronizing walking to rhythmic auditory cues to improve gait in Parkinson's disease". Hum Mov Sci. 2014 Oct; 37:147-56.doi: 10.1016/j.humov.2014.08.001. Epub 2014 Sep 14.PMID: 25215623

[15] Wittwer JE, Webster KE, Hill K. "Rhythmic auditory cueing to improve walking in patients with neurological conditions other than Parkinson's disease--what is the evidence?" Disabil Rehabil. 2013 Jan; 35(2):164-76.doi: 10.3109/09638288.2012.690495. Epub 2012 Jun 8.PMID: 22681598

[16] Harrison EC, Earhart G M. Neurodegener "The effect of auditory cues on gait variability in people with Parkinson's disease and older adults: a systematic review". Dis Manag. 2023 Apr; 13(2):113-128. Doi: 10.2217/nmt-2021-0050. Epub 2023 Jan 25.PMID: 36695189