International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

A Review Paper on Designing of Knee Support System for Elderly People

Hemil Prajapati[1], Harsh Ghediya[2], Aksh Patel[3], Yash Makwana[4], Rajdeepsinh Rajput[5], Kunalsinh Kathia[6]

[1,2,3,4,5]Student, Mechanical Engineering, Saffrony Institute of Technology
[6]Professor, Mechanical Engineering, Saffrony Institute of Technology

Abstract
Knee pain can now occur in people as young as their 30s, not just in their 60s and 70s. As the elderly population grows, hospitals will have a hard time accepting more patients due to the high demand for services. The focus will shift from post-accident care to preventative care, especially for people with knee pain. The first step in designing and developing a successful knee exoskeleton is to conduct high-quality research on the following topics: knee structure, the diseased state of osteoarthritis, knee kinematics, gait analysis, the existing market for knee exoskeletons, actuation methods, novel software, sensors, and more. The study found that applying heat to the knee increases tissue temperature, softens surrounding tissues, reduces tissue viscosity, increases connective tissue extensibility, reduces pain, and increases joint mobility. Flexible sensors are used in wearable devices such as electric skin, flexible strain gauge sensors, motion detectors, and self-repairing sensors. A self-adjusting knee joint is being developed to allow passive self-alignment with the ICR of the natural knee. Neoprene rubber is a synthetic closed-cell rubber used in medical devices, but it lacks breathability and restricts the movement of water vapor, moisture, and heat. Knitted stretch fabrics provide warmth and compression to injured areas, and foam provides shock protection and pressure points to promote healing. Test methods are used to evaluate the dimensional, mechanical, and thermo-physiological properties for material selection. A wearable suit design was studied using a Design of Experiments approach, with eight key parameters identified and an optimization method developed. Robotics and automation technology were used to address discomfort issues in the body-worn knee exoskeleton design.

Keywords: Knee braces, Inertial measurement unit, Wearable devices, FE model, Biomechanical, Knee flexion, Mechanism design, Neoprene, Locomotion.

1. Introduction

From UNDP, Sustainable Goal 3 aims to ensure healthy lives and promote well- being for all, at all periods. Health and well- being are important at every stage of one's life, starting from the morning. This thing addresses all major health precedents reproductive, motherly, invigorated, child and adolescent health; transmissible and non-communicable conditions; universal health content; and access for all to safe, effective, quality and affordable drugs and vaccines. The American Podiatric Medical Association states that the average person takes 8000 to 10,000 way daily, amounting to roughly 115,000 long hauls over a continuance or walking Earth's ambit further than four times. A medical

device is an instrument, outfit, machine, contrivance, implant, vitro reagent, or other analogous or affiliated composition intended for use in the opinion of complaint or other conditions or in the cure, mitigation, treatment or forestallment of complaint. Wearable biases are non-invasive medical biases that cover patient data and give immediate and nonstop feedback. They can be used throughout patient treatment and recuperation.

2. History

At Better Braces, knee braces are the large part of what we do.While knee braces are the common sight in sports, that hasn't always been the case. It might be interesting to know that the modern knee brace used to prevent injury has only been around since 1967.[S1] The late 60s were important for the evolution of knee braces.[S2] In 1967, a professor of physiology, Dr.Robert F. McDavid invented the first lateral knee brace designed to prevent injury or reinjury.[S1] His brace provided lateral protection of the knee.[S3] Then during the 1967 season and Super Bowl III, Hall of Fame New York Jets' Quarterback Joe Namath played with a now-famous knee brace. Jack Castiglia of the Lenox Hill Brace Shop along with noted sports physician Dr. James Nicholas designed the brace.[S3] This allowed Namath to keep playing despite being plagued by knee problems. Namath's knee brace was so iconic that it is now on display at the Pro Football Hall of Fame.[S4] In the early 1970s a few braces were available that were typically used for knee injuries. Some of these "functional" braces are still manufactured today and are recommended following certain types of knee joint injuries. Single-hinged knee brace that was positioned along the outside the knee brace, The goal is to protect the previously injured knee (Maclaren,1984). The flat splint was made of a durable polycarbonate (Lexan) sewn inside a flexible sleeve that was secured above and below the knee with Velcro straps and tapes.[1]

3. Research based on comfort

A Design Of Experiments approach was used to characterize the stiffness and comfort. Studies conclusions of Issues are Mechanical/we have highlighted physiological effects, but their level and Mechanisms remain poorly known. Only a few high-level clinical studies exist, no perceptible effect and mechanical action levels are too low. Patients do not comply with the orthopedic treatment and do not wear the device enough due to comfort issues. But study regarding these issues and find its answer. Mass-produced knee orthosis: usual commercially available model, Finite illuminating, Design Of Experiments 8 key parameters were identified. Finally, FE results using experimental means and developing an optimization method to contribute to the design of optimized orthoses.[2]

Body-worn knee exoskeleton design to overcome discomfort issues with help of ROBOTICS AND AUTOMATION technology. In this research, the main 3 parts are for comfort. First part is wearable suit design Suit Layout. In this part some points are rolling knee joints, frontal plane misalignment mitigation, anthropomorphically-customized thermoplastic brace. Second part is actuation and electronics. Some points are 2-Stage Timing Belt Transmission, Minimization of Distal Mass Distribution, Control Electronics and Communication. Third part is the experiment results. Some points are Torque Control Calibration, Mechanical Transparency Evaluation in Passive Mode, Torque Tracking Evaluation with Three Human Subjects. A new wearable structure design is analyzed, optimized and compared with conventional methods. Body-worn knee exoskeleton design to overcome discomfort issues.[3]

4. Research based on Analysis

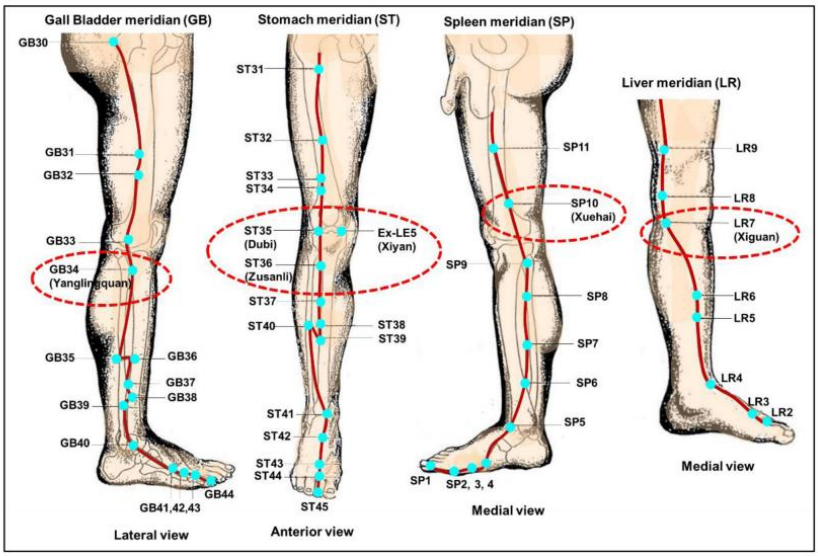

Figure 1. The identified acupuncture points along the leg [F1]

The following are the main 6 acupuncture points found in the knee, according to the study:

(1) SP10 (Xuehai), located on the Spleen Meridian, for promoting blood circulation.

(2) ST35 (Dubi), located on the stomach Meridian, is for motion improvement of the lower limbs.

(3) Ex-LE5 (Xiyan), an extra-Meridian point, for knee pain and inflammation relief.

(4) LR7 (Xiguan) is located on the liver meridians, posterior and inferior to the medial condyle of the tibia, in the upper portion of the medial head of the gastrocnemius muscle.[S5]

(5) ST36 (Zusanli), located on the stomach Meridian along the anterior aspect of the lower leg.

(6) GB34 (Yanglingquan), located on the Gall Bladder Meridian of the Lateral Aspect of the Lower Leg.[4]

4.1 Effect of applying heat pack on knee

According to the findings of the study, applying heat to the knee raises the temperature of the tissues and softens the surrounding tissues. Also, we find that by applying heat, it reduces tissue viscosity, increases connective tissue extensibility, reduces pain, and also increases joint mobility. In past studies, they have found that temperature significantly influences the mechanical properties of soft tissues. Also, connective tissue stiffness decreases and extensibility increases with increased tissue temperature. Furthermore, they noted that plastic deformation occurs with tissue extensibility. They studied 37 people. They first applied heat interventions to all 37 people and noted the range of knee flexion after applying heat or an intervention. After that, they apply the hot pack for 20 minutes and note the assessment of the passive range of the knee joint after applying the hot pack. And they find that the passive range of the knee joint has increased by 6.73%.[5]

5. Advancements in knee support system

From research paper technological advancements in motion capture using gait analysis.Use of kinect and viconsoftwares for marker and marker less analysis of skeleton,use of mobile application or wearable device for posture management.Inertial measurement unit sensors which comprises accelerometer, magnetometer, gyroscopes which provides assessment of biochemical motor function.[6]

There is a posture management screen, an electromagnetic system, and raster stereography. Nowadays, flexible sensors are used in wearable devices. like electric skin, which has pressure sensing with polymer-based switching, a flexible strain gauge sensor, a motion detector, and a self-repairing sensor.[7]

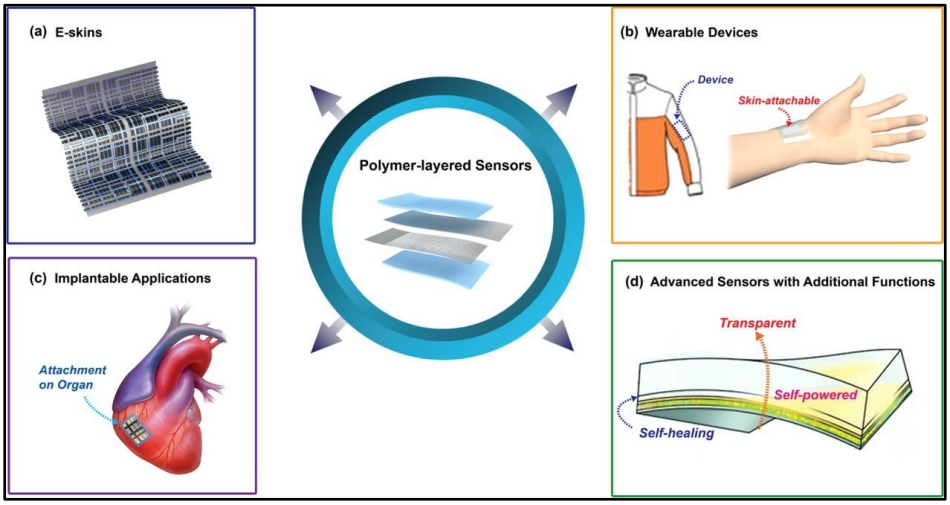

Figure 2: Flexible mechanical and electrical sensors: (a) E-skins, (b) wearable and skin-attachable sensors, (c)implantable devices for in vivo diagnostics, and (d) advanced sensors with additional functionalities.[F2]

Development and Testing of a Polycentric Knee Joint for Powered Walking Assist Exoskeletons Existing polycentric devices: iT-Knee includes a mechanism that allows passive self-alignment with the Intelligent character recognition (ICR) of the natural knee. This self-adjusting, isostatic exoskeleton moves flexion and extension, allowing passive motion in the frontal and transverse planes and passive ICR translation. The Human Universal Mobility Assistance (HUMA) device to use a knee joint to allow motion in the plane, including anterior/posterior translation, flexion, and extension.The Anthro-X is a powered mobility assistance exoskeleton with a polycentric knee joint to enhance kinematic compatibility. AssistOn-Knee actively assists with flexion and extension of the knee and passively allows for translational movements of the ICR[8].Samsung-Assist Device, lower-limb type, assistive exoskeleton with a self-aligning knee joint, means that the ICR undergoes passive translation.[8]

6. Research based on material selection

Materials used in knee braces are chosen based on their mechanical and comfort properties, temperature, neurosensory feedback, and circulation. 1.Neoprene rubber is a synthetic closed-cell rubber used in medical devices due to its high elasticity, recovery, thermal insulation, cost, and ease of production. However, it lacks breathability and restricts the movement of water vapor, moisture, and heat from the skin to the ambient environment. 2.Knitted stretch fabrics provide warmth and compression to injured areas and can be engineered to provide specific properties, both mechanical and thermophysiological.Knitted structures have better breathability than neoprene, but neoprene retains body temperature better. 3.Spacer fabrics are three-dimensional knitted structures that offer bulk, breathability, comfort, durability, and resilience under load. They can be produced on warp, flat, and circular weft knitting machines. 4.Foams are used in knee braces to provide shock protection as well as to provide pressure points to promote healing. Whether protection is required for an injured area or just

prevention against injuries, foam offers a good cushioning effect. However, they are uncomfortable for the wearer due to their closed cell structure.[9]

6.1 FABRIC TESTING

Standard test methods are used to evaluate the dimensional, mechanical, and thermo-physiological properties of knee braces and spacer materials.

6.2 Test method

1) Tensile Tests were performed on an Instron Tester Model 4303, and the specimen dimensions were 15 cm and 2.5 cm, respectively. Load-elongation curves determined tenacity, breaking extension, modulus, and specific modulus. 2)Thermophysiological Tests and comfort properties were determined on Alambeta, Permetest, and absorption and wicking equipment.[10]

7. Conclusions

The study found that a knee brace is effective in managing the discomfort of knee osteoarthritis. Knee braces are designed using various methods of manufacturing and incorporate technologies that ensure comfort and stability, giving the feeling that your knee is secure. They are simple and easy to put on and take off, allowing for customization of the fit to provide comfort and protection for the knee. The study also examined the parameters of comfort in knee brace systems, recognizing that comfort is crucial when choosing the right knee brace. Technological advancements in motion capture have introduced various tools and software such as Kinect and Vicon, inertial measurement unit sensors, posture management screens, electromagnetic systems, and raster stereography. Polycentric devices like iT-Knee and HUMA enable passive motion in the frontal and transverse planes, along with passive ICR (instantaneous center of rotation) translation. Assist On-Knee actively aids in flexion and extension of the knee while allowing for passive translational movements of the ICR. The Samsung-Assist Device incorporates a self-aligning knee joint, which allows for passive translation of the ICR. The study discovered that applying heat to the knee increases tissue temperature, resulting in the softening of surrounding tissues. This reduces tissue viscosity, enhances connective tissue extensibility, reduces pain, and improves joint mobility. Furthermore, the study observed a 6.73% increase in the passive range of motion of the knee joint. When selecting materials for knee braces, factors such as mechanical properties, comfort, temperature regulation, neurosensory feedback, and circulation are considered. Standard test methods include tensile tests, load-elongation curves, and thermophysiological tests. Knee braces can be either custom-made or purchased off the shelf, with price being a significant consideration. Neoprene and elastic knitted fabric are commonly used materials as they provide compression and warmth, while foam offers cushioning. Overall, the study highlights the effectiveness and importance of knee braces in managing knee osteoarthritis, emphasizing the significance of comfort, technological advancements, and appropriate material selection in their design and manufacturing.

8. Appendix

These are sites which we have refer:

(S1)https://enovis-medtech.eu/media/storage.djoglobal.eu/en_UK/9473-EN_Rev_D_UK_B_S_catalogue_2020_DIGITAL-compressed.pdf?no-cache-1744a7bccdc

(S2)https://www.betterbraces.com/blog/the-brief-history-of-knee-braces

(S3)https://www.tribstar.com/news/lifestyles/isu-prof-invented-first-lateral-knee-brace-designed-to-prevent-injury/article_1bf93047-d51d-5be1-bec5-f2dc873e78fe.html
(S4)https://www.profootballhof.com/news/2005/01/news-the-namath-brace
(S5)https://acupuncturenepal.com/xiguan-lr7-nomenclature-location-functions-indications.html

9. Acknowledgement

We express our deepest gratitude to you, Prof. Kunalsinh Kathia, for serving as our guide and Head of the Mechanical Engineering Department. Your dedication, expertise, and mentorship have been provided throughout to the successful completion of this project. We are obliged to staff members of the Mechanical Engineering Department, Saffrony Institute of Technology, Linch, Mehsana for valuable information provided by them in their respective fields. Our thanks also goes to our parents as well as our colleagues in developing projects and supporting us willingly.

10. References

1. Scriber, K., 1998. The History and Current Use of Knee Brace Technology. International Journal of Athletic Therapy and Training, 3(4), pp.7-11.
2. Pierrat, B., Molimard, J., Calmels, P., Navarro, L. and Avril, S., 2014. Efficiency and comfort of knee braces: A parametric study based on computational modeling. arXiv preprint arXiv:1409.5756.
3. Junlin Wang, X. L. T.-H. H. S. Y. Y. L. T. C. A. C. M. O.-P. and H. S. (2018). Comfort-Centered Design of a Lightweight and Backdrivable Knee Exoskeleton. IEEE, 1–8.
4. Gong, Z., Liu, R., Yu, W., Wong, T.K.S. and Guo, Y., 2022. Development and evaluation of acu-magnetic therapeutic knee brace for symptomatic knee osteoarthritis relief in the elderly. The Journal of The Textile Institute, 113(7), pp.1355-1371.
5. Lin, Y.H., 2003. Effects of thermal therapy in improving the passive range of knee motion: comparison of cold and superficial heat applications. Clinical rehabilitation, 17(6), pp.618-623.
6. Roggio, F., Ravalli, S., Maugeri, G., Bianco, A., Palma, A., Di Rosa, M. and Musumeci, G., 2021. Technological advancements in the analysis of human motion and posture management through digital devices. World Journal of Orthopedics, 12(7), p.467.
7. Pang, C., Lee, C., & Suh, K.-Y. (2013). Recent advances in flexible sensors for wearable and implantable devices. Journal of Applied Polymer Science, 130(3), 1429–1441. https://doi.org/10.1002/app.39461
8. Séguin, É., 2021. Development and Testing of a Polycentric Knee Joint for Powered Walking Assist Exoskeletons (Doctoral dissertation, Université d'Ottawa/University of Ottawa).
9. Pereira, S., Anand, S.C., Rajendran, S. and Wood, C., 2007. A study of the structure and properties of novel fabrics for knee braces. Journal of Industrial Textiles, 36(4), pp.279-300.
10. Wood, L.R., Peat, G.M., Mullis, R., Thomas, E. and Foster, N.E., 2011. Impairment-targeted exercises for older adults with knee pain: protocol for a proof-of-principle study. BMC musculoskeletal disorders, 12(1), pp.1-7.