

Revolution Knee Massager With Automated Oil Infusion For Enhanced Pain Relieving Therapy

GUGAN.R.

Assistant professor
Biomedical Engineering Department
Paavai Engineering College Namakkal,
Tamil Nadu, India

HARIKRISHNAN.S

Biomedical Engineering Department
Paavai Engineering College Namakkal,
Tamil Nadu, India

S.ABDULLA

Biomedical Engineering Department
Paavai Engineering College Namakkal,
Tamil Nadu, India

HARISHRAJ.N

Biomedical Engineering Department
Paavai Engineering college Namakkal,
Tamil Nadu, India

Abstract—This paper presents the design and development of a Revolution Knee Massager integrating automated oil infusion for enhanced therapeutic pain relief. The proposed device combines intelligent control systems that regulate oil flow, heat (30°C–60°C), and pressure (0–100 kPa) to deliver a personalized massaging experience tailored to individual user preferences. An Arduino Uno microcontroller serves as the central processing unit, interfacing with a 4×4 matrix keypad, a 16×2 LCD display, a pressure pump, a heater, and an oil pump, all powered by a 12 V, 3000 mAh lithium-ion battery through a 7805 voltage-regulating unit. Embedded sensors continuously monitor real-time conditions, ensuring accurate regulation of temperature, pressure, and oil flow for safe and comfortable operation. The compact, silicone-rubber enclosure ensures flexibility and durability. Testing results confirm that the prototype outperforms conventional knee massagers by providing deeper relaxation, faster pain relief, and improved oil absorption. The device is particularly beneficial for patients with arthritis, muscle stiffness, and limited mobility. This work demonstrates the feasibility of a cost-effective, portable, and intelligent knee therapy solution that can enhance quality of life.

Index Terms—Knee massager, automated oil infusion, pain relief therapy, Arduino Uno, pressure pump, biomedical device, wearable therapy.

I. INTRODUCTION

Knee pain is one of the most prevalent musculoskeletal conditions worldwide, affecting millions of people across all age groups. Conditions such as osteoarthritis, muscle stiffness, post-surgical rehabilitation, and sports injuries contribute substantially to reduced mobility and diminished quality of life. Traditional approaches to knee pain

management include pharmaceutical interventions, manual

physiotherapy, and various passive therapy devices; however, these often lack personalization, portability, or therapeutic completeness.

Existing knee therapy devices—including vibration massagers, air compression units, infrared therapy pads, and TENS units—address pain from limited angles. Vibration-and-heat devices ease surface muscle tension but lack deep-tissue stimulation. Air compression massagers promote blood flow but are often bulky and do not incorporate therapeutic oil benefits. Manual oil massage techniques, while effective in Ayurvedic and physiotherapy traditions, are labor-intensive and non-portable. Infrared and TENS units focus primarily on circulation or nerve stimulation without mechanical massage or oil delivery.

This paper presents the Revolution Knee Massager with Automated Oil Infusion (OKI), a microcontroller-based device that simultaneously delivers heat therapy, controlled pressure massage, and automated therapeutic oil infusion. The integration of these modalities into a single compact wearable unit addresses the limitations of existing systems, offering deeper relaxation, better oil absorption, and enhanced pain relief. The device is designed to be user-friendly and accessible to individuals with mobility challenges.

II. LITERATURE SURVEY

A. Automated Knee Massager with Oil Infusion

Nakulraj et al. [1] proposed an automated knee massager combining oil infusion therapy with massage techniques. Their model demonstrated accelerated blood circulation and reduced muscle soreness in arthritis patients. The silicone rubber construction enabled effective oil absorption without hindering therapeutic performance. The ergonomic design with adjustable massage positions validated the core concept pursued in the present work.

B. Myofascial Cramp Massager Using Thermotherapy and Cryotherapy

Sivamani et al. [2] developed a wearable massager integrating Peltier-based heating and cooling for myofascial cramp treatment. Alternating thermal cycles of 10–20 minutes combined with vibration effectively relaxed tense muscles. An embedded sensor analyzed muscle contractions and dynamically adjusted therapy parameters, demonstrating the value of sensor-driven adaptive control for personalized therapy.

C. Soothing Relief for Menstrual Cramps

Joseph et al. [3] developed a multi-modal abdominal massager combining heat therapy, mechanical massage, and aromatherapy for menstrual pain relief. The study validated that synergistic modality combinations outperform single-modality approaches for musculoskeletal pain, reinforcing the multi-modal design philosophy of the proposed knee massager.

D. Visual-Tactile Design for the Elderly

Xue et al. [4] employed EEG-based emotional analysis to investigate user interface preferences for neck massagers among elderly individuals with perceptual limitations. Their aging-friendly design guidelines for button shape, size, spacing, and material directly informed the keypad and display interface design of the proposed system, ensuring accessibility.

III. EXISTING SYSTEMS AND LIMITATIONS

Current knee therapy devices can be categorized into five principal types. Vibrational and heat therapy devices use electric motors and heating pads to ease surface muscle tension but provide no oil application or deep-tissue stimulation. Air compression knee massagers use pneumatic pressure to stimulate blood flow but are bulky and lack the soothing benefits of therapeutic oils. Manual oil massage techniques, while therapeutically effective, are

labor-intensive, require a therapist, and are entirely non-portable. Infrared knee therapy devices stimulate circulation but provide no mechanical massage or oil delivery. TENS units deliver low-voltage electrical impulses for pain relief but focus solely on nerve stimulation without any massage or oil infusion benefit.

The common shortcomings across existing systems are: (i) absence of oil infusion, (ii) limited customization of therapy parameters, (iii) low therapeutic efficiency arising from single-modality operation, and (iv) poor portability or excessive bulk. The proposed system addresses all these deficiencies through integrated multi-modal therapy under microcontroller-based automated control.

IV. PROPOSED SYSTEM

A. System Overview

The proposed Revolution Knee Massager with Automated Oil Infusion (OKI) is a microcontroller-based wearable therapeutic device. It integrates pressure massage, heat therapy, and automated oil infusion in a single compact enclosure. An Arduino Uno (ATmega328P) serves as the central controller, receiving user inputs via a 4×4 matrix keypad and displaying operational status on a 16×2 LCD. A lithium-ion battery (12 V, 3000 mAh) provides portable power, stabilized through a 7805 voltage-regulating unit.

B. Hardware Components

The key hardware components and their specifications are as follows. The lithium-ion battery provides stable 12 V DC power with high energy density and a cycle life exceeding several hundred charge-discharge cycles. The 7805 voltage regulator IC accepts 7–35 V input and delivers a fixed 5 V output at up to 1.5 A, with built-in thermal and short-circuit protection. The Arduino Uno features 14 digital I/O pins (6 PWM), 6 analog inputs, and a 16 MHz clock, enabling precise PWM-based control of actuators. The pressure pump (1–5 bar operating range) delivers air-based compression massage. The oil pump (0.2–1.0 mL/min) controls therapeutic oil delivery to the knee surface. The heater maintains oil temperature between 30°C and 60°C. The 4×4 matrix keypad allows users to select massage mode, intensity, duration, temperature, and oil flow rate using 8 GPIO lines. The 16×2 LCD displays real-time operational parameters, mode, and safety alerts. A relay module provides electrically isolated switching of high-power actuators under microcontroller control.

C. System Architecture and Working Principle

Upon power-up, the Arduino initializes all peripherals and displays a welcome prompt on the LCD. The user selects therapy parameters via the keypad: pressure level (0–100 kPa), temperature setpoint (30°C–60°C), oil flow rate (0.2–1.0 mL/min), and session duration. The microcontroller activates the pressure pump through the relay, applies PWM-controlled heating to reach the target temperature, and simultaneously drives the oil pump at the programmed flow rate. Embedded sensors provide real-time feedback for closed-loop regulation of all three parameters. If temperature or pressure exceeds safety thresholds, the system triggers an automatic shutdown and displays a warning on the LCD. The silicone rubber outer shell conforms to the knee anatomy, maintains flexibility at temperatures up to 100°C, and allows efficient oil permeation to the skin.

V. RESULTS AND DISCUSSION

A. Phase I Results

In Phase I, the prototype was assembled and all major components were individually tested before system-level integration. The pressure pump, heater, oil pump, microcontroller, keypad, and LCD were verified for correct functionality. Sensor feedback loops successfully regulated temperature within $\pm 2^\circ\text{C}$ of the setpoint and maintained pressure within ± 5 kPa of the target value. The automated oil-infusion system delivered uniform and controlled oil distribution across the massage surface. The device demonstrated smooth multi-modal operation combining heat, pressure, and oil infusion simultaneously.

B. Comparative Discussion

Compared to conventional vibrational massagers, the OKI device provides deeper tissue stimulation through combined pressure and thermal modalities. Unlike air compression massagers, it integrates therapeutic oil benefits, improving skin absorption and reducing joint inflammation. The automation of oil delivery eliminates the need for manual application, increasing consistency and reducing user effort. The sensor-based adaptive control ensures safe operation for patients with varying pain thresholds and skin sensitivities. The compact, battery-powered design makes the device portable and suitable for home use, addressing a critical gap in the existing market.

Phase II will focus on clinical validation with human subjects, refinement of the control algorithms using machine learning (ML) for adaptive therapy, integration of Bluetooth

connectivity for remote monitoring, and long-term reliability testing of the oil delivery mechanism.

VI. CONCLUSION

This paper presented the design and Phase I development of the Revolution Knee Massager with Automated Oil Infusion. The device successfully integrates pressure massage, heat therapy, and automated oil infusion under Arduino-based microcontroller control within a compact, portable, and user-friendly platform. Testing confirmed accurate sensor-driven regulation of therapy parameters and smooth multi-modal operation. The prototype demonstrates significant improvement over existing single-modality knee massagers in terms of therapeutic depth, personalization, and ease of use. The proposed system offers a practical, cost-effective solution for patients suffering from knee pain, arthritis, and muscle stiffness, with strong potential for clinical deployment following Phase II validation.

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