SproutUp, An Assistive Standing Device

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***Abstract*— SproutUp is a wearable assistive device to aid the elderly, stroke survivors, and other patients with neurological or physical ailments. By focusing on wearability, automation, and adaptive engagement, we ensured usability and compatibility with a broad range of users. The team initially researched competing solutions and conducted user interviews to understand the existing ecosystem. This early research stage drove our ideation and design choices. The team followed a structured prototyping process: creating a morphological chart for divergent ideation, a Pugh chart to evaluate ideas for decision-making, and finally, prototyping to validate our product.**

I Introduction and Problem Framing

Walking deficits often characterize mobility impairment, yet safe sit-to-stand motion can be equally decisive for independence in older adults and post-stroke patients.

We initially explored a gait-correction exoskeleton applying counter-torsional torque at the hip to address pronation and supination. However, an expert interview with clinician Connie Leibow, whose expertise spans orthotics work under Dr. Jacquelin Perry and pediatric gait retraining at Seattle Children's Hospital, revealed that lower-limb gait deviations arise from complex, multi-joint compensation patterns. She cautioned that single-joint corrective torque is unlikely to resolve these issues effectively, prompting a strategic pivot towards a more constrained functional problem.

We then interviewed Zhenyu's grandparents to anchor the problem in a post-stroke context. His grandfather experienced a 2009 stroke, causing left-side paralysis and now requires assistance for bed-to-wheelchair transfers despite limited right-side control. The most pressing need identified was reliable assistance for repeated sit-to-stand movements during daily tasks. The couple noted a market gap: while non-wearable aids exist, they have not found a simple wearable solution for standing support.

Synthesizing both interviews, we framed the design as a wearable sit-to-stand assistive system prioritizing low weight, ease of use, assistive force, and comfort. We compared a knee exoskeleton and a rear-mounted push-up seat mechanism. Guided by timeline feasibility and complexity, we advanced the push-up seat approach for its simpler dynamics and alignment with stakeholder needs.

II Background and Anatomy

II-A Anatomy And Biomechanics

The sit-to-stand (STS) motion is one of the most mechanically demanding functional movements in daily life. To successfully stand up a controlled repositioning of the body's center of mass (COM) occurs. The COM is transferred from a balanced point above the seated to a base of support above the feet [1]. This movement can be divided into four distinct phases:

1) the flexion-momentum, where an initial trunk flexion and forward lean occur to wind up momentum
2) the momentum-transfer, where seat-off occurs and there is continued ankle dorsi-flexion to keep the COM above the feet
3) the extension, where the hip extension (mainly activating the Gluteus Maximus) and knee extension (mainly activating the Quadriceps and Hamstrings) to achieve a vertical body position
4) the stabilization, where core muscles and hip and ankle extensors are working to achieve a continuous upright posture balance

The trajectory of key anatomical landmarks follows characteristic patterns: the hip traces an S-shaped curve, the knee follows a cycloid path, and the shoulders follow an L-shaped trajectory as the body rises. The ideal trajectories of these anatomical landmarks during STS motion are well analyzed in literature and have helped us design the movement pattern of our SproutUp assistive seat. [2]

SproutUp interfaces with the upper body like a backpack, with straps for wearability and storage management in a passive state. The weight of the device is kept close to the body's COM to avoid disturbing balance. During active use the device acts like a push up mechanism from the user's rear, which directly loads the user's lower back as well as affects hip, knee and ankle orientation in an effort to support the user to achieve ideal STS motion without overloading the muscles and joints involved.

II-B Existing Solutions

Existing products that support sit-to-stand transfers are typically pieces of furniture or portable lift cushions rather than wearable seats. For home use, devices such as the Carex Upeasy Seat Assist provide a self-powered lifting cushion that is placed on top of an existing chair or sofa and can raise to about 70% of the user's body weight to make standing easier [3]. Battery-powered portable lift cushions, such as the SitnStand Lift Assist, similarly strap onto a wide range of chairs and use an air-bladder system to vertically elevate the user before standing [4]. These products share an important feature with SproutUp in that they provide lift forces under the pelvis. Additionally, both devices are powered to provide active assistance to their users. However, SproutUp is a wearable device that provides the user with more deployment flexibility.

There are also wearable chair exoskeletons for industrial workers, such as the Noonee Chairless Chair, which attaches to the legs and can lock into a semi-seated position to reduce fatigue during prolonged standing tasks [5]. This device demonstrates that an exoskeletal chair can be worn throughout the day. However, the chair is designed for healthy workers to support squatting postures rather than assisting the standing motion.

Finally, recent research on soft robotic exoskeletons and exo-suits shows that lightweight wearable actuation can assist lower-limb mobility and may eventually support sit-to-stand movements [6]. However, these systems are still largely confined to research laboratories and rehabilitation trials.

In the team's review, there were no portable assistive devices for people with mobility impairments commercially available. This gap in the market motivates our design: SproutUp aims to behave more like wearable equipment than furniture, offering an assistive seat that can be carried on the user's body and deployed when needed.

II-C Design Priorities

Considering our device is worn for extended periods of time, minimizing mass is definitely the constraining factor. Furthermore, the focus lies on an ergonomic design to ensure comfort and ease of handling. Another design requirement is automation, requiring little to no manual handling is deemed essential to match customer needs. Overall safety is paramount and should be a guiding priority through each stage of this product's design process. More subtle but essential is to make this device appealing to customers; therefore, ensuring an elegant appearance is key. As engineers designing for the human body, we realize functionality is not everything.

II-D Brainstorming & Concept Generation

After establishing our design priorities and conducting market research, we brainstormed our solution. Three full concepts were formed: power stand-alone seat, knee exoskeleton, and assistive push-up device (see Figure 1) . To determine which concept to pursue, we used a Pugh chart with the following criteria: feasibility, ease of adaptability to the user, prototype cost, novelty of the design, complexity of the design, and the projected cost of the actual product. The Pugh chart helped guide our discussion and selection process (see Table I). As we discussed ideas, we brainstormed which mechanisms were necessary to implement the device (motors, batteries, housing, frames, etc.). Based on our initial research and brainstorming, we decided to pursue the assistive seat. The idea was the most novel, the simplest to design, and the most convenient for the user if we were able to adjust reliably. After we created the initial concept, we started by identifying the subsystems and functions of our device. 7 subsystems were focused on: actuation, control, pushing interface, wearable, disengaging, design, and attachment. 5 solutions were devised for each sub-function, forming a morphological chart (see Figure 2). From there, the group had another discussion to decide on using a feedback-controlled linear actuator to control the seat's position, an aluminum frame, a foam cushion for the seat, and a backpack-like sliding mechanism to adjust the seat (see Figure 3).

III Prototyping

After ideation, the team defined two primary modules: the assistive seat and the wearable harness, each with its own design process.

For the harness, the team iteratively moved from strap-routing sketches and taped webbing on a teammate to a fully integrated system. Low-fidelity trials showed that forces should be carried through the shoulders and lower back, leading to the use of a commercial posture brace as a base, onto which nylon webbing, adjusters, and couplers were added and reconfigured until the straps could both connect to the SproutUp seat and fold away when not in use.

The assistive seat followed a similar cycle, starting with sketches, design reviews, and sizing a linear actuator for an 80 kg, 174 cm user before ordering the actuator, aluminum frame, and fasteners. While parts were in transit, the team built a cardboard look-alike model attached to a backpack to explore seat size, range of motion, and linkage-like behavior, which clarified ergonomics, connection geometry, and required displacement.

With a better understanding of geometry and dynamics, the team advanced to work-like models. The harness was resewn with denser stitching, cleaned up strap lengths, and user-tested on teammates to assess donning time and pressure points, leading to wider contact areas, more accessible buckles, and added slack so the system could store like a small backpack. For the seat, an aluminum frame with a wooden plate and foam was assembled and iteratively refined through group ergonomics discussions, ultimately reducing cushioning and expanding space for electronics.

Overall, the prototyping cycles for both modules underscored the value of structured discussion and quantifiable validation metrics, enabling verification of functionality and structural stability while maintaining comfort, adjustability, and quick disengagement. (see Figure 4).

IV Final Prototype

The final SproutUp prototype is worn by one of the team members in Figure 5, illustrating the real-world form factor of the system when integrated with a wearable torso harness. The full prototype combines an actuated seat module with back support to enable assistive sit-to-stand motion while maintaining a compact, body-conforming profile. In use, the seat detects sit-to-stand intent and activates a linear actuator to support the motion. When not in use, the seat can be pulled toward the lower back and stored in a low-profile position to reduce interference with everyday movement, as shown in Figure 6. The mechanical design of the seat subsystem is detailed in Figure 6. Components were modeled in CAD to define the linkage geometry, actuator placement, and load paths before fabrication. Then, the materials were cut and assembled using mechanical fasteners and brackets to enable quick adjustments across prototypes. After modeling, the team purchased the necessary materials. The padded seat structure is built around a compact linkage architecture mounted on a lightweight frame, with a 12V linear actuator providing the primary driving force and 4 force-sensing resistors supporting user intent or load detection. The frame uses modular 2020 aluminum alloy extrusions for stability and stiffness. Each part was selected for rapid iteration, low weight, and ease of assembly.

IV-A Mechanical design

The wearable subsystem is based on a commercially available posture correction brace for the upper body (Figure 7). This brace already provides a comfortable contact area along the shoulders and upper back, as well as a wide waist belt. We then sewed additional webbing straps, strap adjusters, buckles, couplers, and handles to the original textile structure. These changes are depicted on the right side in Figure 7. Extra vertical webbing was sewn along the spine of the brace and extended toward the lower back and the top of the pelvis. At these lower attachment zones, we stitched in reinforced loops that interface directly with the attachment points on the SproutUp seat, so that assistive forces are applied close to the user's hips rather than at the shoulders.

Besides ergonomics, quick disengagement and compatibility were considered. Adjustable shoulder and waist straps accommodate different body types while maintaining even pressure over the torso. Strap adjusters on the front and sides of the chest allow the user to adjust the height and width of the system's straps in small increments without excessive effort (Figure 8). Strap binding at key junctions prevents twisting and keeps the webbing flat against the body, which reduces local pressure points during repeated use. A front handle and strap couplers provide a simple way to connect and disconnect the user from the seat; pulling on the handle or releasing the couplers allows the user to step out of the system rapidly if they feel unstable or need to abort a transfer. This configuration aims to combine secure force transfer with comfort, intuitive engagement and removal, and a disengagement system in emergencies.

IV-B Assistive Seat Electronics

States were detected as shown in Figure 9 using various electronics. The full circuit diagram can be found in Figure 10. Four force-sensing resistors were used to determine a user's posture and intended motion based on thresholds derived from testing. Based on those thresholds, an Arduino microcontroller would determine whether the user was sitting, standing, or attempting to stand. When the seat is turned on, the microcontroller assumes that the user is standing, so the motor will remain at rest and turn on a green LED until the force sensors read a value above 160 kg. Once that threshold is reached, the microcontroller will switch to its sitting state and turn on the yellow LED. When the force on the sensors is below 80 kg again, the microcontroller will recognize that the user is standing. In this state, the microcontroller will begin the motor control sequence with a motor driver, while the red LED starts flashing. Then, when the user is fully standing, the motor will come to rest and wait for the user to sit again, fully illuminating the red LED.

IV-C Motor Control

A single degree of freedom dynamic model was used to calculate the required force and extension of the motor. The motor would follow the control path necessary to assist STS based on the ideal angle of the knee during stance [7]. The generalized coordinate $\alpha(t)$ for the Lagrangian dynamics is the seat angle relative to the base, the generalized force F_a is generated by the linear actuator and derived from the torque τ on the actuator; and the S-curve is an idealized trajectory for the knee angle during STS from a previous STS motion study [7]. The free body diagram used for the model, as well as these graphs, are portrayed in figure 11. This model was used to determine angular displacement, velocity, and acceleration during the seat's motion as well as create a force graph versus time. This force curve was then fed into our control loop, which autonomously switches between states to actuate based on sensor data and implements safety features that override the motor when necessary. A block diagram of this control logic is seen in figure 9, and the detailed code can be found in the appendix.

V Design Assessment

V-A Prototype Testing

User tests with classmates and course staff verify that the device can lift the user's hips and trunk and that the harness loads weight to the hips rather than the shoulders. During the build and test process, we also identified mistakes and clear opportunities for improvement.

Seat Electronics:
Limited resources forced the team to select incompatible electronics. In particular, the motor driver was not rated for the maximum motor current, leading to the motor driver failing unexpectedly. In future iterations, bulk capacitors and industry-rated components would be used to prolong the lifetime of the seat's components. Additionally, component wires were freely hanging, which could lead to components getting caught or disconnected while in motion. The next version of the device would contain a dedicated electric housing unit to house the internal controller, printed circuit

boards to downsize components, and secured wiring to restrict the electronics' movements.

Motor Control:
Time constraints required the team to downscale the motor control algorithm. Currently, the motor has a set trajectory that is independent of the user's position or orientation after the initial calibration and state change. This rigid system is not adaptive to the user's needs during motion, which could lead to the system over- or under-assisting the user. Prospective improvements would be to add a feedback system that incorporates position, orientation, and velocity data from an IMU to create an adaptive control algorithm.

Mechanical Design:
Our assistive seat was supported with a 2020 aluminum extrusion frame joined with metal hinges. This made the pivot joint thick and bulky, making it difficult for the cushion and linear actuator to lie as flat as possible when folded. The hinges were also not designed for non-normal direction forces (i.e., shear, horizontal) caused by sitting down on them. This caused the frame to pull apart slightly at the hinges when supporting full body weight. A clear next step, mechanically, would be to create a smoother pivot joint. That could be achieved through welding the joints or using stronger corner brackets at the pivot. This will make folding cleaner and more compact. Similar assistive seats use a curved cushion design, allowing for the seat to fold flat and not interfere with mechanical parts underneath.

Attachment and Portability System:
The main setback we got from our full wearable prototype was the friction around the straps and the buckle adjusters. The straps would pull in opposite directions during both the blocking and releasing phases, rather than applying force perpendicular to each other during the release phase like backpacks do. This design complicates accessibility and simplicity. An improvement would be to add a clip system around the forward shoulders to lock in place the straps, and an inverted buckle adjuster below to control the rate of release. Further testing revealed that this was a robust feature. Prototyping revealed the elasticity and movement that the wearable goes through when adjusting the seat onto the back. Thankfully, this was anticipated in the wearable design to a certain extent with the use of shoulder and pelvis straps to secure it in place.

V-B Design requirement validation

The final prototype was assessed against the initial requirements of safety, low-effort standing assistance with comfortable, easy-to-disengage wearability.

At under 4 kg—comparable to a medium backpack—the minimalist aluminum frame, lightweight motors, and batteries met mass constraints. Ergonomics prioritized padded shoulder/lower-back straps and a balanced, cushioned seat, with adjustable straps ensuring adaptability across body sizes.

The device operates fully autonomously, detecting sit-to-stand phases with fail-safes for safety and minimal manual handling. In passive mode, it folds to the lower back for full disengagement. The backpack-inspired design combines elegant simplicity with everyday usability.

V-C Future improvements

The harness is still visually bulky and takes time to put on correctly, and the number of straps and couplers can be confusing for a new user. Some strap terminations are hand-sewn and do not look robust enough for repeated clinical use. The interface between the harness loops and the seat attachment points also requires guidance from a helper and is not yet intuitive. In the next iteration, we would simplify the strap routing, reduce the number of adjustment points, improve the sewing and reinforcement of load-bearing joints, and choose connection hardware that can be operated easily with one hand.

Future work will also focus on testing and quantifying performance. We would like to instrument the device with angle and force sensors, recruit users that better match our target population, and measure assistance, comfort, and donning time in a structured way. These studies would guide further refinements of the harness shape, padding, and seat mechanism, and would help us evaluate whether the product can realistically meet the safety and reliability expectations of a commercial assistive standing device.

VI Conclusion

The team successfully prototyped SproutUp, showing functionality and structural stability while maintaining comfort, adjustability, and quick disengagement. This design project taught the value of human-centered design, ideation methods, and prototyping. While further iteration is needed to optimize force distribution, donning time, and long-term durability, we established a foundation for integrating the seat and harness modules into a cohesive assistive system. We believe our idea is promising and has the potential to become a viable product after undergoing iteration.

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Author Contributions

Our team worked in 3 main subteams:

- **Mechanical Design (Steph Akakabota)** Designed and built the physical frame of the assistive seat. Selected materials (e.g., aluminum extrusion, hinges, fasteners) based on theoretical calculations of seat forces, created the folding seat structure, and integrated the linear actuator with the frame and cushion.
- **Electronics and Controls (Darius Nguepi, Michael Rubin)** Selected and wired all major sensors and actuators (Force Sensitive Resistors, motor driver, linear actuator) and implemented the coding and logic required to detect sitting and standing, as well as follow the experimentally validated dynamic trajectory from sitting to standing.
- **Wearable Design (Tibault Dary-Alabaster, Zhenyu Hu** Designed the mechanism for how the device will fit and move with the user. Designed backpack-style shoulder straps and attachments, as well as a friction buckle that allowed the seat to be raised to the height of the backpack and lowered to the height of the seat.

Working prototype videos

`https://drive.google.com/drive/folders/1jXk_GFKaaY7INTiVWy8EMzFUkj7r1PFx?usp=share_link`

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[3] Carex Health Brands, "Carex upeasy seat assist standard manual lifting cushion," https://carex.com/products/carex-upeasy-seat-assist-standard, 2025, accessed: Nov. 24, 2025.

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VII Appendix

Appendix A: Figures

(a) Knee exoskeleton (b) Standalone swing seat (c) Wearable seat

Fig. 1: Concept solutions

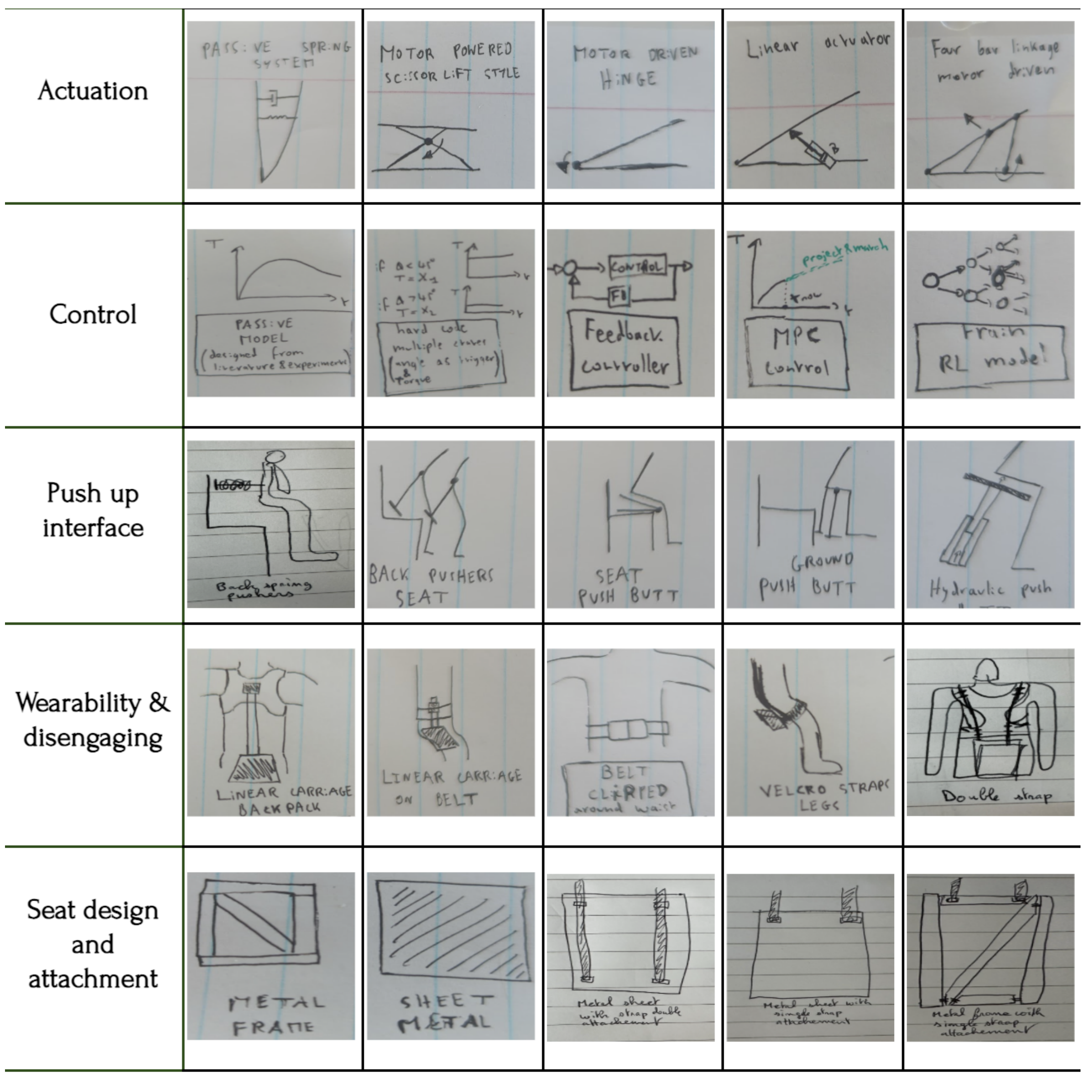

Fig. 2: Morphological chart

Fig. 3: Final prototype torso harness

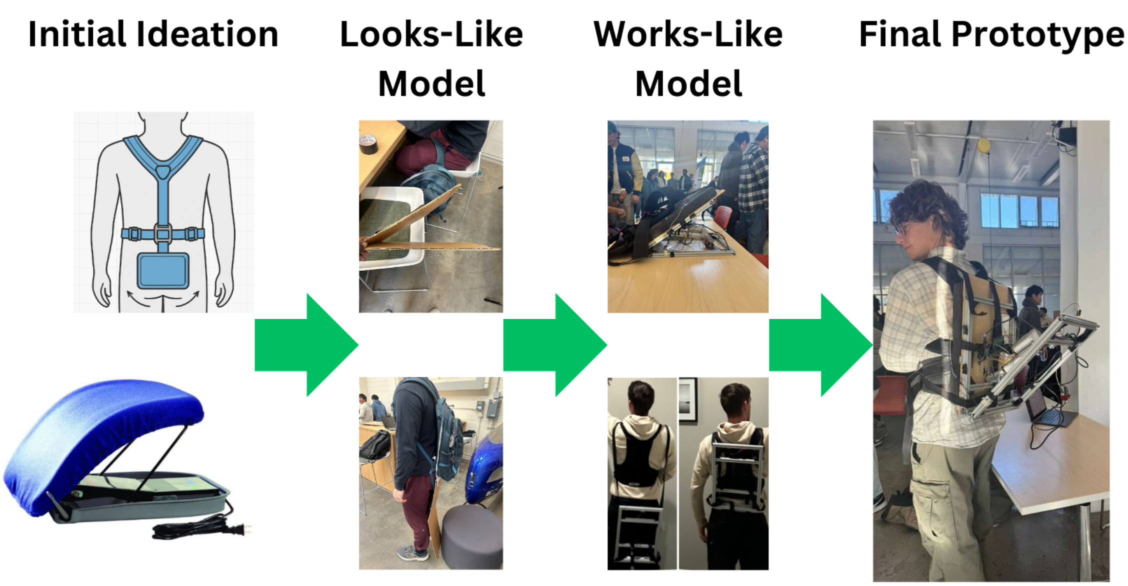

Fig. 4: Full Design Process

Fig. 5: Rear view of the final SproutUp design

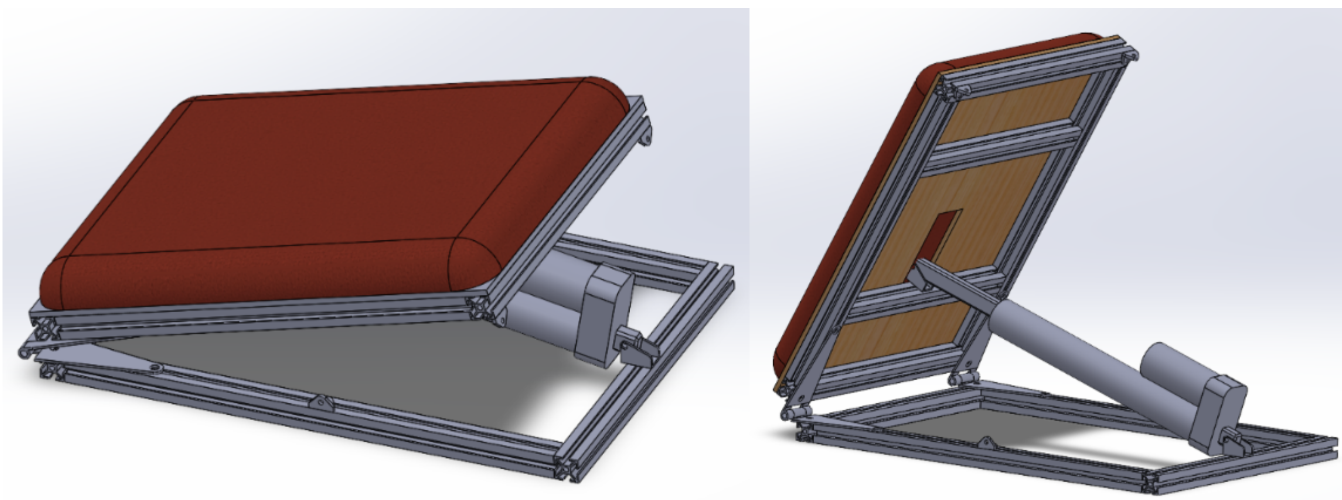

Fig. 6: CAD of SproutUp

Fig. 7: Wearability ergonomics

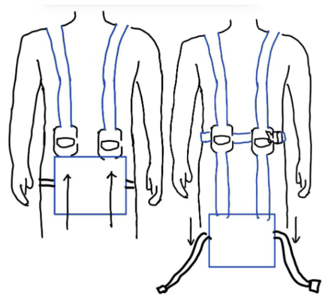

Fig. 8: Device disengagement

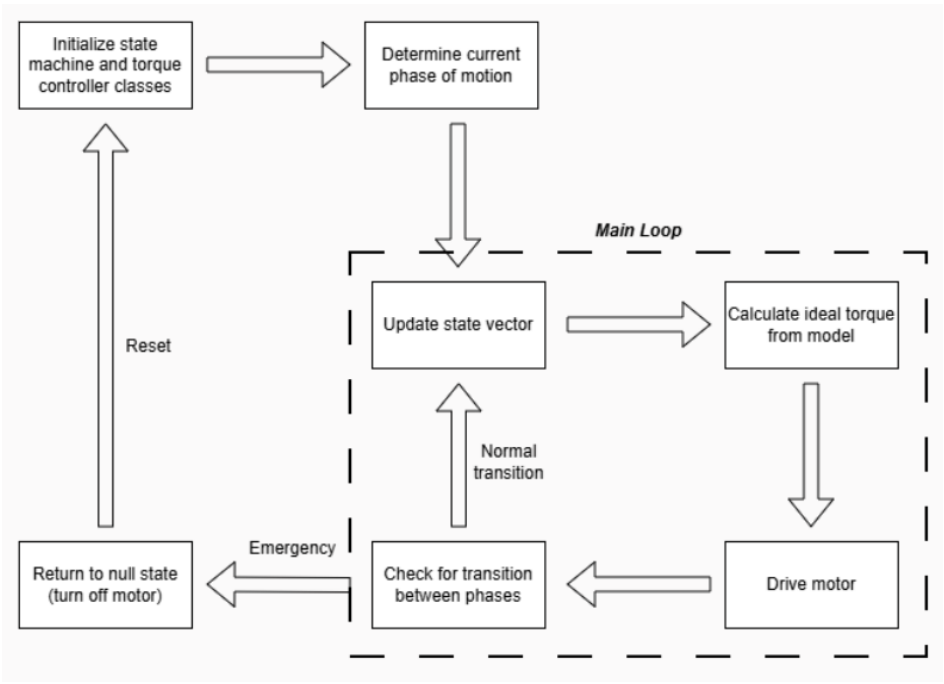

Fig. 9: Code block diagram

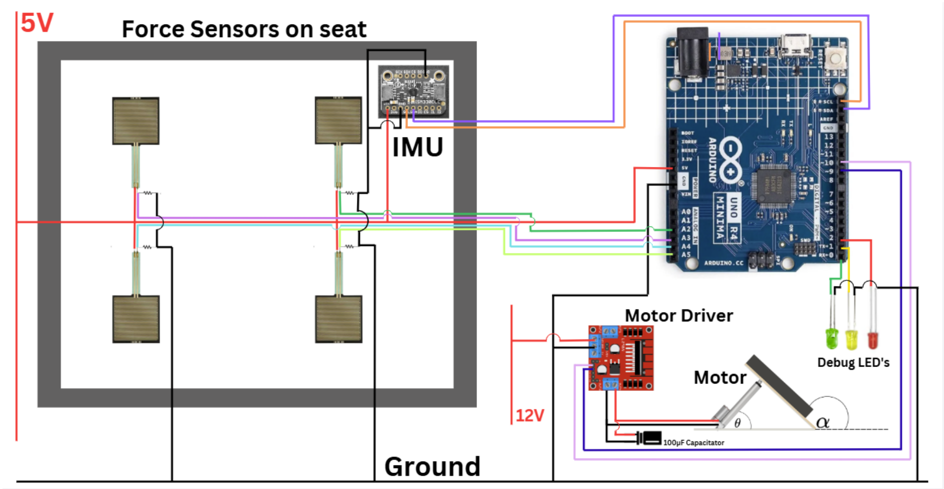

Fig. 10: Circuit diagram

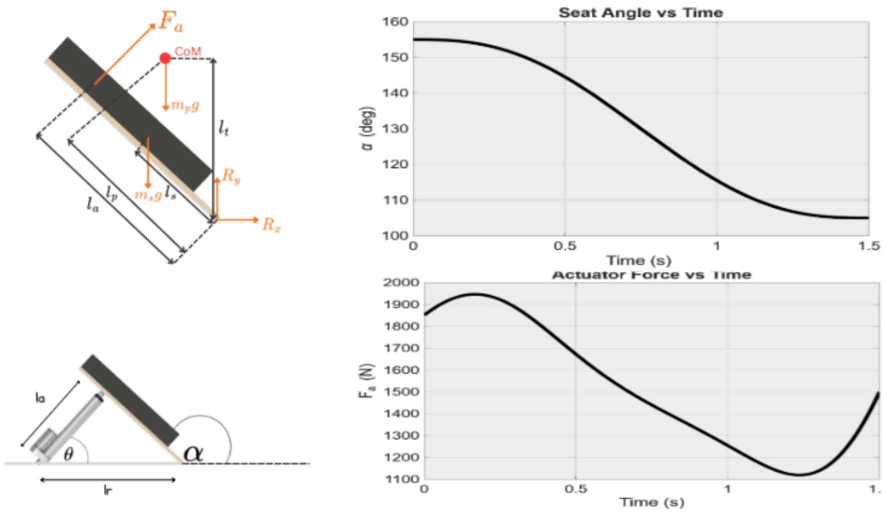

Fig. 11: Kinematics and idealized trajectory

Appendix B: Tables

TABLE I: Pugh chart for device concepts

(bad) 1-5 (good) score	weight	Knee exoskeleton	Push up seat	Powered stand alone
Feasibility (10 weeks)	0.2	2	3	2
Ease of adaptability to user	0.2	4	5	4
Prototype cost (budget $700)	0.1	3	3	1
Novelty design	0.1	3	4	2
Complexity design	0.2	4	4	2
Cost final device	0.2	3	4	2
Total score Pugh chart	**1**	**3.2**	**3.9**	**2.3**

Appendix C: Motor Control Code

Listing 1: Arduino motor control code

```
// --- Configuration ---
const int PIN_IN1 = 9;
const int PIN_IN2 = 10;
const int red = 0;
const int green = 2;
const int yellow = 1;

// Gompertz Parameters
const float A = 0.2655;
const float B = 3.3096;
const float C = 0.6884;
const float D = 0.1378;

// FSR pins defined
#define FSR_PIN_1        A0
#define FSR_PIN_2        A1
#define FSR_PIN_3        A2
#define FSR_PIN_4        A3

// Motor Model: dX (mm/s) per PWM unit
const float MOTOR_K = 0.0379110699397;

// Safety Settings
const int MAX_CURVE_PWM = 220; // Max speed allowed during the curve
const unsigned long PAUSE_DURATION_MS = 500; // 5 seconds pause
```

```

// Global Variables
int count = 0;
float timeStretch = 1.0;
unsigned long startTime;
unsigned long pauseStartTime = 0; // To track when the pause began
int phase = 0;  // 0 = waiting, 1 = traj, 2 = pause, 3 = max speed

void setup() {
  pinMode(red, OUTPUT);
  pinMode(green, OUTPUT);
  pinMode(yellow, OUTPUT);

  Serial.begin(9600);
  pinMode(PIN_IN1, OUTPUT);
  pinMode(PIN_IN2, OUTPUT);

  // --- Automatic Scaling Calculation ---
  float theoretical_peak_v_m_s = (abs(A - D) * B) * 0.367879; // Peak of Gompertz
  float theoretical_peak_v_mm_s = theoretical_peak_v_m_s * 1000.0;
  float max_motor_v_mm_s = MAX_CURVE_PWM * MOTOR_K;

  timeStretch = theoretical_peak_v_mm_s / max_motor_v_mm_s;
  if (timeStretch < 1.0) timeStretch = 1.0;

  delay(1000);
  Serial.println("Starting Phase 1: Trajectory...");
  startTime = millis();
}

void loop() {
  unsigned long currentMillis = millis();
  int f1 = analogRead(FSR_PIN_1);
  int f2 = analogRead(FSR_PIN_2);
  int f3 = analogRead(FSR_PIN_3);
  int f4 = analogRead(FSR_PIN_4);

  // Calculate average force for FSRs 2 and 3
  int avg_f2_f3 = (f2 + f3) / 2;

  // Debug Prints
  Serial.print("FSR 2: "); Serial.print(f2);
  Serial.print(" | FSR 3: "); Serial.print(f3);
  Serial.print(" | AVG (F2+F3): "); Serial.println(avg_f2_f3);
  Serial.print(" | PHASE: "); Serial.println(phase);

  // PHASE 0: wait for someone to sit
  if (phase == 0) {
    if (avg_f2_f3 > 300) {  // "sitting" condition
      Serial.println("Detected SIT. Wait for avg< 150 to begin phase 1.");
      phase = 1;
      startTime = currentMillis;
      pauseStartTime = 0;
    }
    delay(50);
    return;
  }

  // Calculate Time
  float t_real = (currentMillis - startTime) / 1000.0;
  float t_traj = t_real / timeStretch;

  // Phase debug
  Serial.print("PHASE: ");
  Serial.print(phase);
  Serial.print(" | t_traj: ");
  Serial.println(t_traj);

```

```
  // Phase dispatch
  if (phase == 1) {
    phase1(t_traj, avg_f2_f3);
  } else if (phase == 2) {
    phase2();
  } else if (phase == 3) {
    phase3();
  }

  delay(10);
}

void phase1(float t_traj, int avg_f2_f3) {
  digitalWrite(red, HIGH);

  // Wait until avg < 150 to "start moving"
  if (avg_f2_f3 >= 150 && t_traj <= 1.0) {
    Serial.println("Phase 1: WAITING for AVG < 150 to start trajectory.");
    stopMotor();
    return;
  }

  if (t_traj <= 1.0) {
    // Calculate Gompertz velocity
    float term1 = exp(-B * (t_traj - C));
    float velocity_orig_m_s = (A - D) * B * term1 * exp(-term1);

    // Apply Time Stretch
    float velocity_real_m_s = velocity_orig_m_s / timeStretch;
    float velocity_real_mm_s = velocity_real_m_s * 1000.0;

    // Convert to PWM
    float req_pwm = velocity_real_mm_s / MOTOR_K;
    int pwmOutput = (int)req_pwm;

    // Drive Motor (Positive PWM for Forward)
    driveMotor(pwmOutput);

    // Debug
    Serial.print("Phase 1: TRAJ PWM: ");
    Serial.println(pwmOutput);
  } else {
    phase = 2;
    pauseStartTime = 0;
    Serial.println("Phase 1 complete     Phase 2.");
  }
}

void phase2() {
  digitalWrite(yellow, HIGH);
  unsigned long currentMillis = millis();
  if (pauseStartTime == 0) {
    pauseStartTime = currentMillis;
    stopMotor(); // Ensure motor stops immediately on transition
    Serial.println("Phase 2: PAUSE_STARTED");
  }
  // Check how long we have been paused
  if (currentMillis - pauseStartTime < PAUSE_DURATION_MS) {
    stopMotor();
    Serial.println("Phase 2: PAUSED PWM:0");
  } else {
    // transition to max speed
    phase = 3;
    Serial.println("Phase 2 complete     Phase 3.");
  }
}

void phase3() {
```

```
  digitalWrite(green, HIGH);
  // PHASE 3: Retract at max speed (forever)
  digitalWrite(PIN_IN1, LOW);
  analogWrite(PIN_IN2, -150);
  delay(3000);

  Serial.println("Phase 3: Retracting PWM:-255");
  stopMotor();
  Serial.println("Motor Stopped.");
}

// Helper to drive motor and handle direction
void driveMotor(int pwm) {
  if (pwm >= 0) {
    // Forward
    if (pwm > 255) pwm = 255;
    analogWrite(PIN_IN1, pwm);
    digitalWrite(PIN_IN2, LOW);
  } else {
    // Reverse (Negative PWM)
    pwm = abs(pwm);
    if (pwm > 255) pwm = 255;
    digitalWrite(PIN_IN1, LOW);
    analogWrite(PIN_IN2, pwm);
  }
}

void stopMotor() {
  digitalWrite(PIN_IN1, LOW);
  digitalWrite(PIN_IN2, LOW);
}
```