Project 138

Final Presentation

Disclaimer

This design has been prepared by first year engineering and architect students at the University of Toronto and does not present a Professional Engineering or Architecture design. A Professional Engineer or Architect has not reviewed this presentation for technical accuracy or adequacy. The recommendations of this design may not be implemented in any way unless reviewed and approved by a licensed Professional Engineer or Architect where such review and approval is required by professional or legal standards, it being understood that it is the responsibility of the recipient of the design to assess whether such a requirement exists.

The Presentation may not be reproduced, in whole or in part, without this Disclaimer.

How many of you are feeling sleep deprived?

In Canada…

83% of adults are sleep deprived

More than 15% of adults have insomnia

10% of adults have undiagnosed sleep disorders

[1] [2] [3]

Project Background

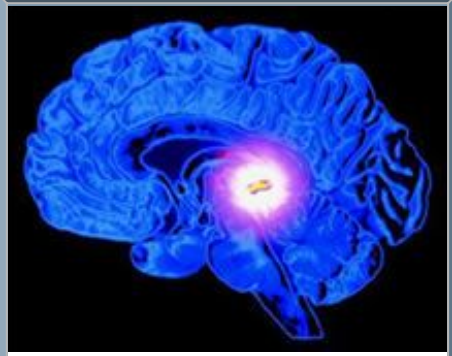
Clients: An affiliate scientist and a biomedical engineer from UHN whose identities will be kept anonymous

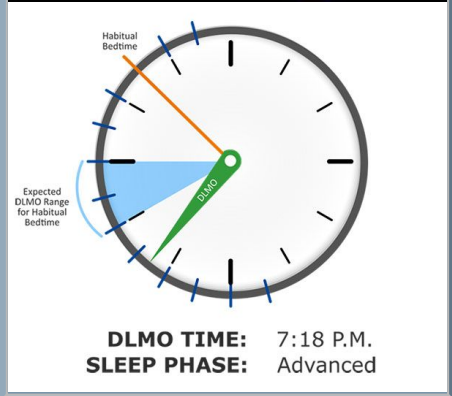
Project: Develop a design to record data regarding desynchronization of patients with circadian rhythm sleep disorders (CRSDs)

[4] [5] [6]

Misdiagnosis of CRSDs

- More than a third of CRSDs go undiagnosed
- CRSDs are a new field of study, thus analysis procedures are crude and inefficient
- One method currently in use is DLMO test, which involves the patient chewing cotton **every 30 minutes for 7 hours**. [4]
- Other methods are subjective and rely on symptom observation and asking for family history

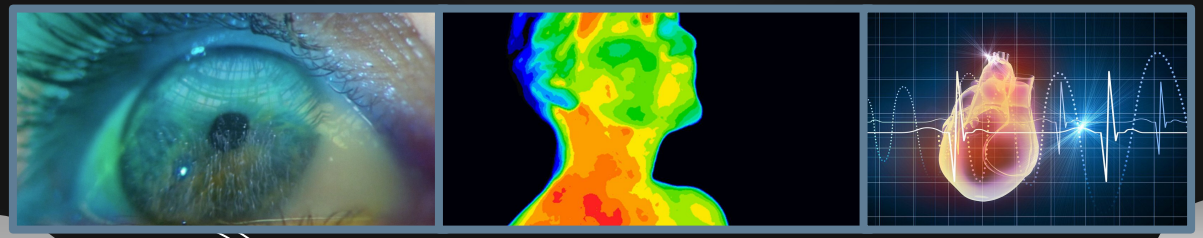




[7] [8]

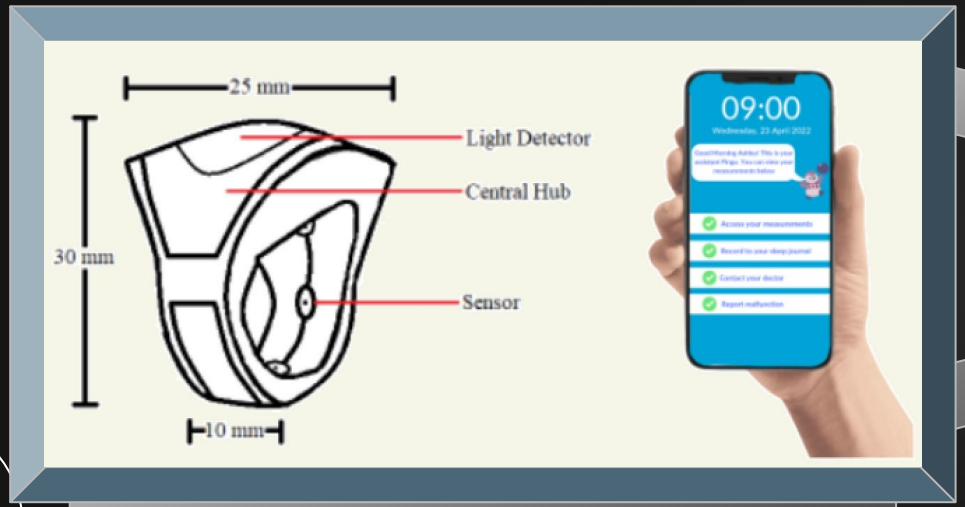
Urgency of the Project

- The absence of an objective means to measure the core body temperature, light-darkness exposure, and sweat rate
- The need for a design that would use objective metrics to assess the criteria of core body temperature, light darkness exposure and sweat rate
- The project has been narrowed down to measure these three parameters to make it more manageable and less complex

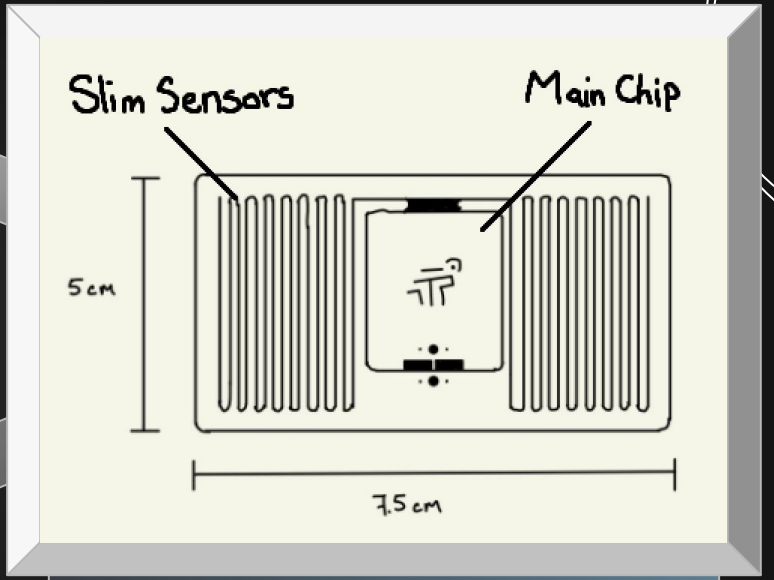


[9] [10] [11]

Alternative Designs



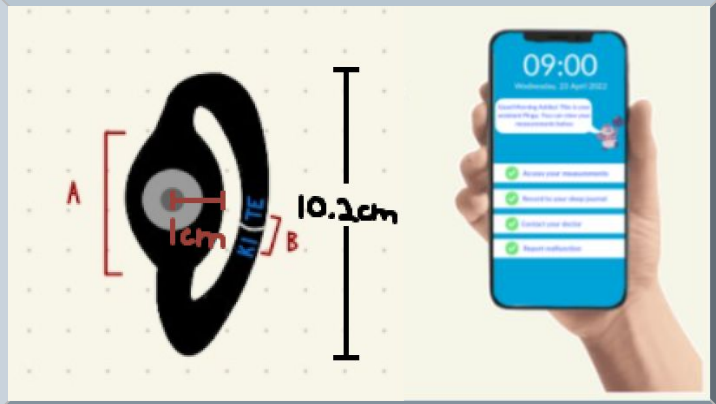
- Requires charging every two weeks
- Data cannot be tracked during charging time

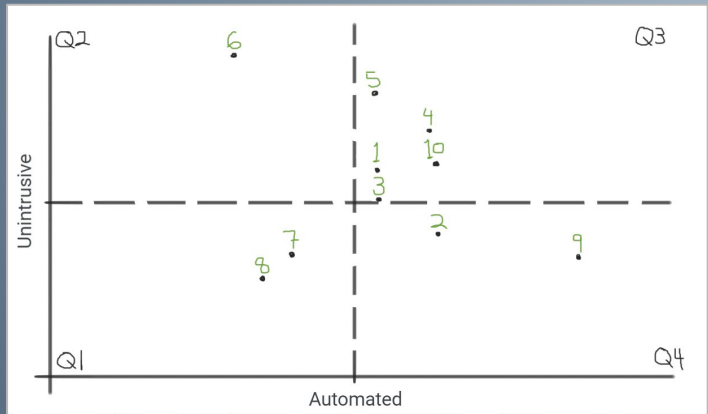


- Newly developing technology
- Visually unappealing
- May be publicly controversial

Proposed Conceptual Design

- Designs were compared via decision matrix and Pugh method chart
- Ergonomic Environment Bracelet (EEB) was chosen

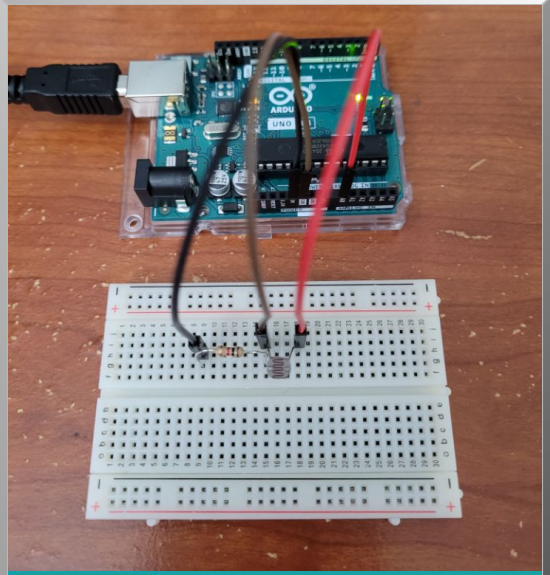




Objectives	EEB	SSR	Justification	WST	Justification
Automated	S	-	Battery life may be less since the design is miniature.	-	Has to be removed for data reading.
Unintrusive	S	+	Much smaller and goes on the finger so it is less intrusive.	+	Miniature design allows for the chip to be stuck on to unnoticeable areas.
Affordable	S	-	Trying to compress technology into a ring-sized design is more expensive.	-	Same logic; trying to compactly fit desired components into a chip is very difficult. Newer technology as well.
User-friendly	S	0	Both designs require no user input and are equally user-friendly.	0	Both designs require no user input and are equally user-friendly.
Total	0	-1		-1	

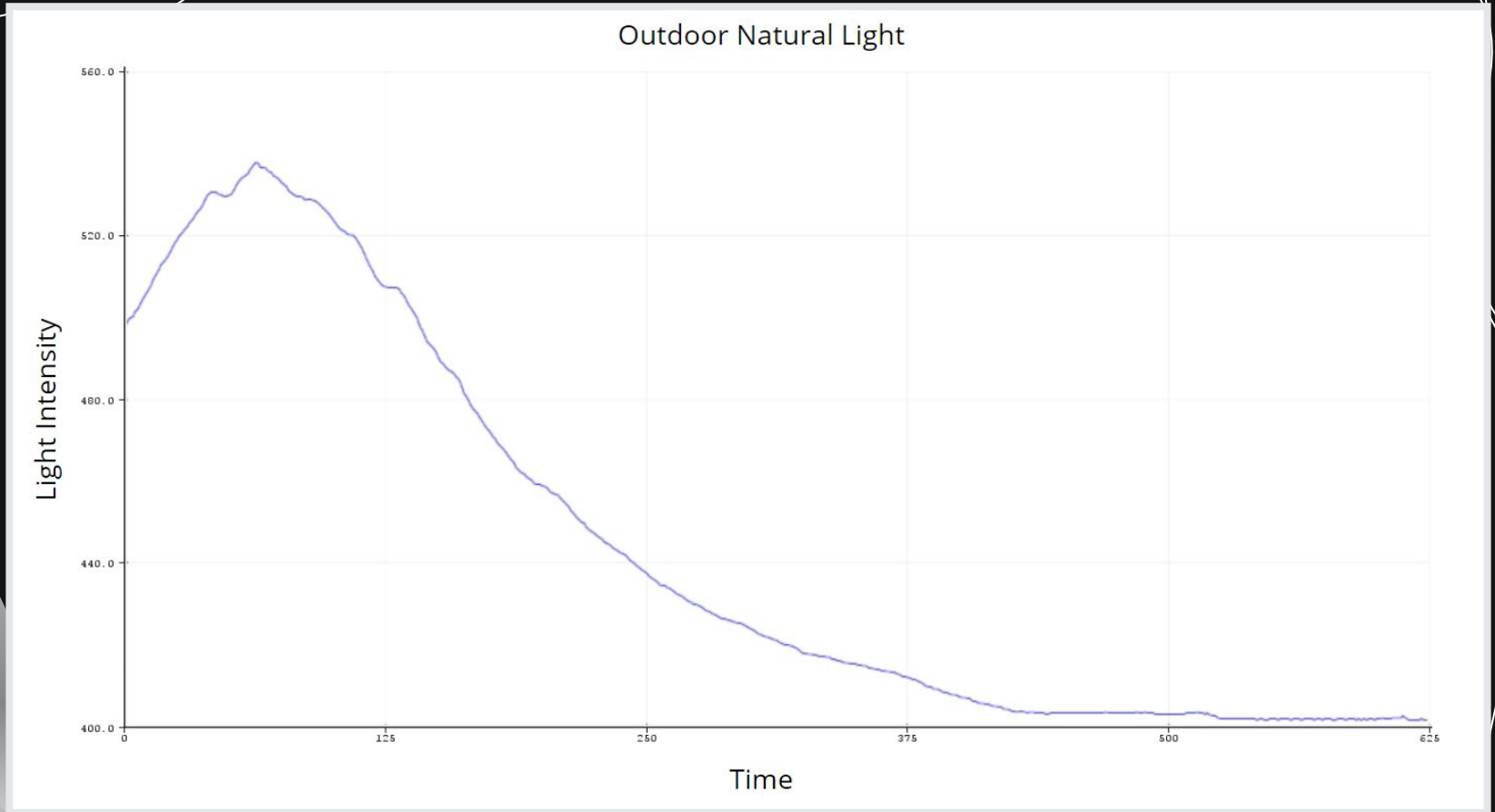
Tracks Light-Darkness Exposure

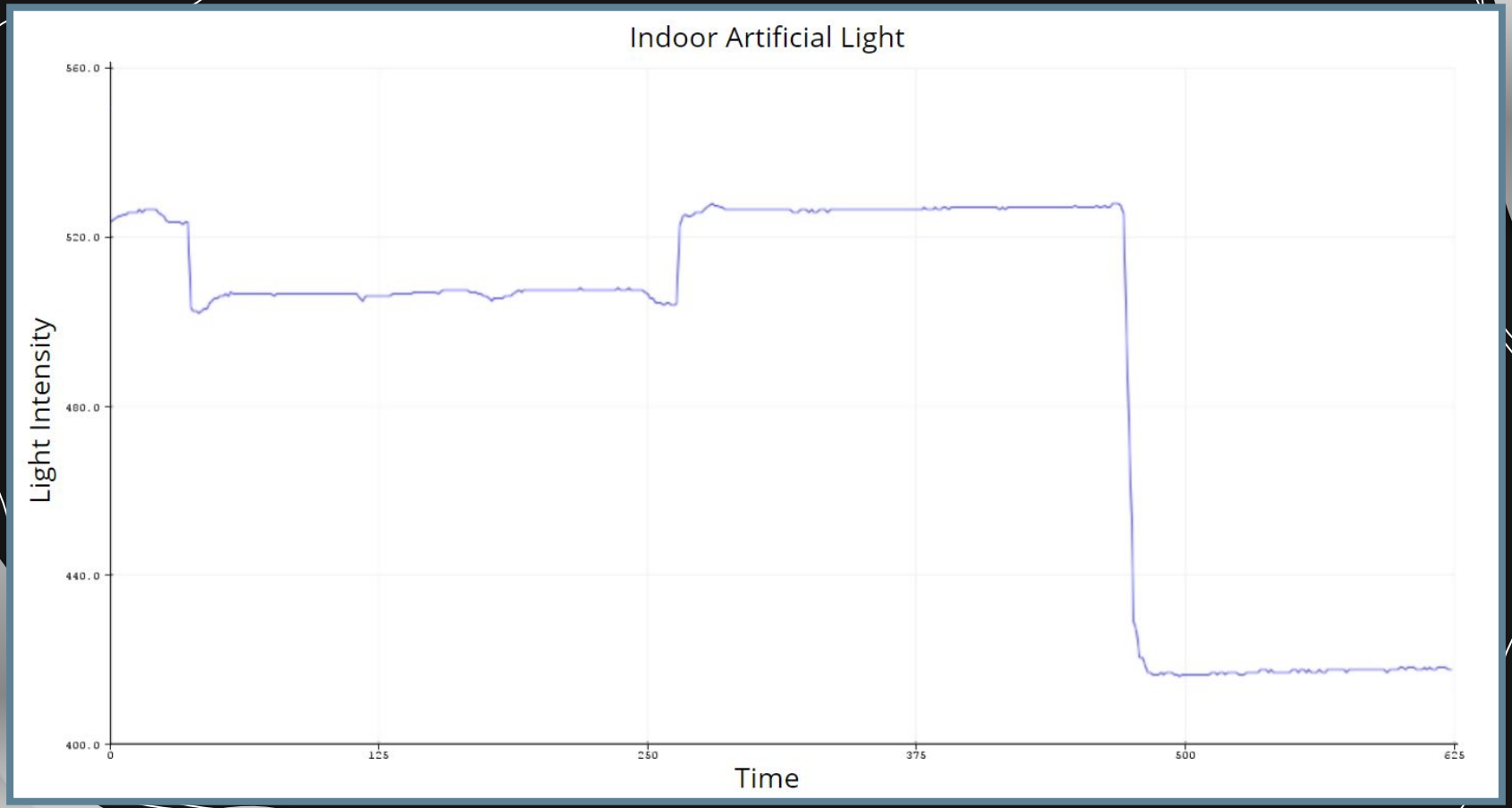
- Used Arduino connected to circuit with photoresistor
- Tested outdoor natural and indoor artificial light intensity
- Graphed readings against time using built-in plotting software
- Data compared with results of study with similar testing



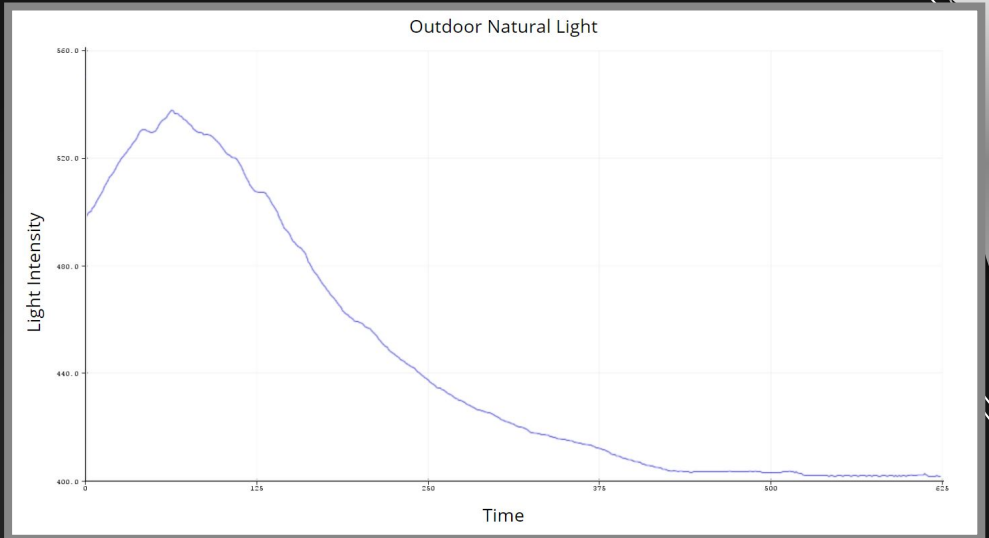
photoresistor §

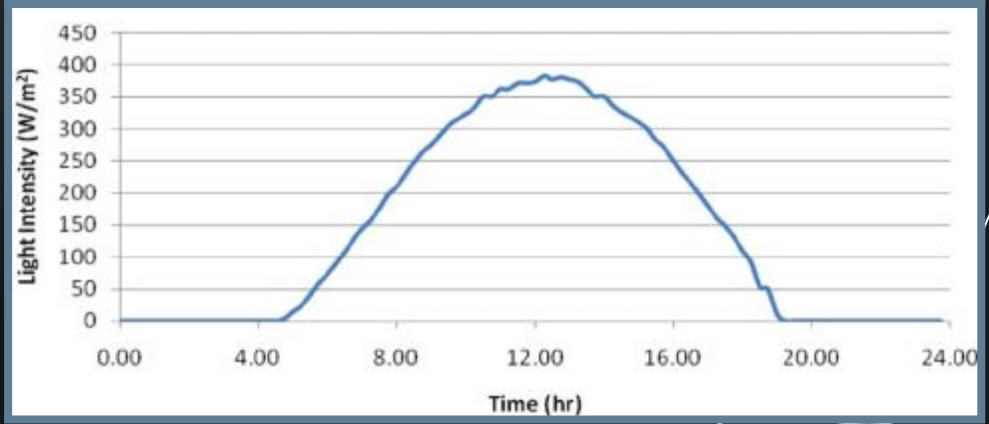
```
int light_intensity;

void setup() {
  Serial.begin(9600);
}

void loop() {
  light_intensity = analogRead(A0);
  Serial.println(light_intensity);
  delay(100);
}
```


Outdoor Natural Light
Light Intensity
560.0
520.0
480.0
440.0
400.0
0
125
250
375
500
625
Time


Indoor Artificial Light
560.0
520.0
480.0
440.0
400.0
Light Intensity
0
125
250
375
500
625
Time

- Study models transport of bacteria in oceans [9] which involved light intensity measuring
- Phase shift due to tests starting at 11:00 AM
- General trends are similar and behaviour is cyclical for both samples

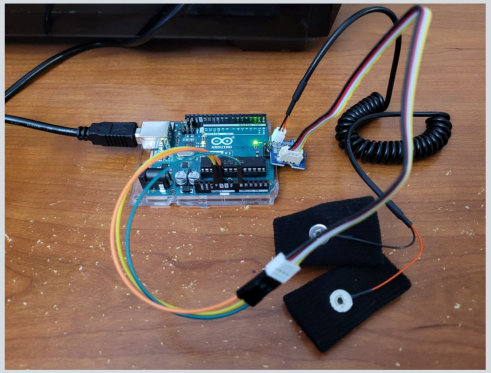


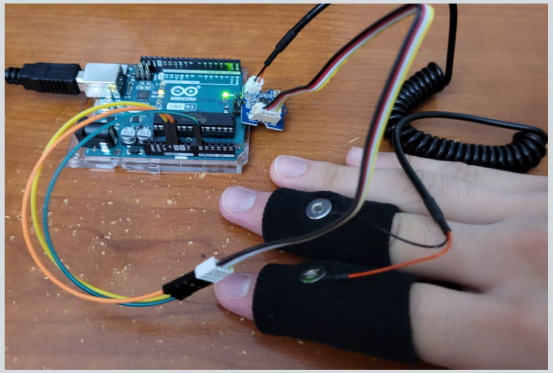


[12]

Tracks Sweat Rate Effectively

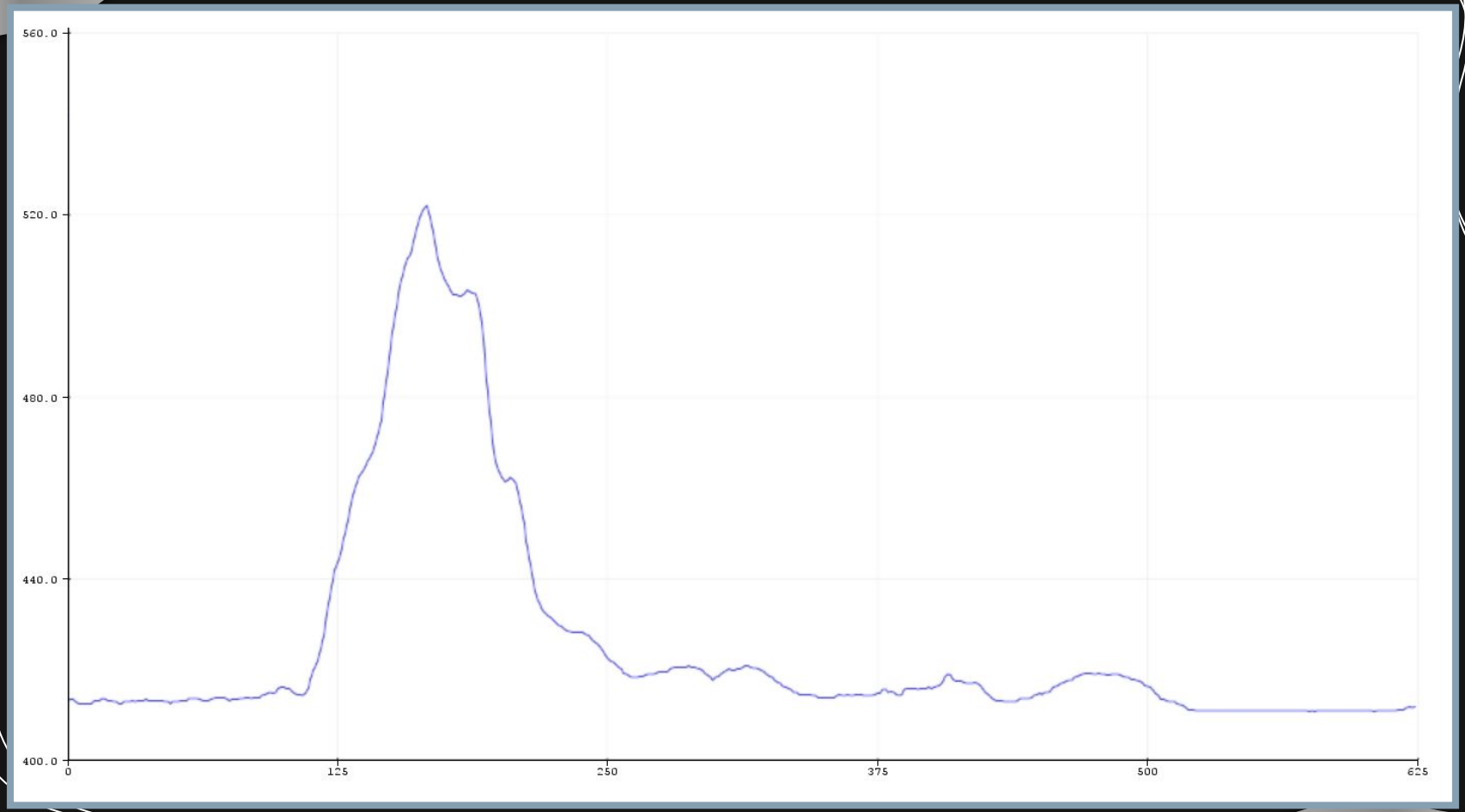
- Galvanic Skin Response (GSR) sensor connected to Arduino, measuring skin conductance, an electrical measure of sweat rate
- Observations recorded for approximately 10 hours and plotted against time while user performs regular daily tasks
- Data was annotated and compared with results of routine test for sweat rate

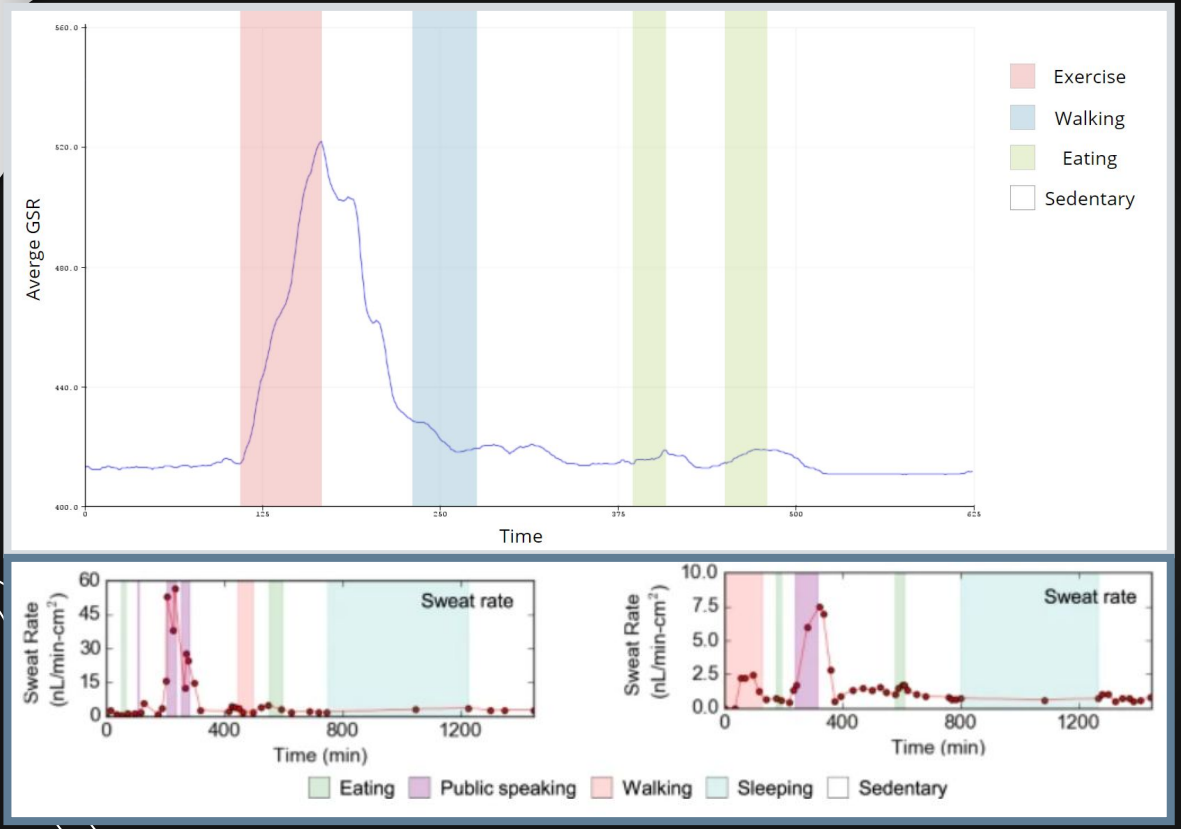




gsr §

```
const int GSR = A0;
int sensor = 0;
int gsr_avg = 0;

void setup() {
  Serial.begin(9600);
}

void loop() {
  long sum = 0;
  for(int i = 0; i < 10; i++) {
    sensor = analogRead(GSR);
    sum += sensor;
    delay(10);
  }
  gsr_avg = sum / 13.27;
  Serial.println(gsr_avg);
  delay(50);
}
```


560.0
520.0
480.0
440.0
400.0
0
125
250
375
500
625

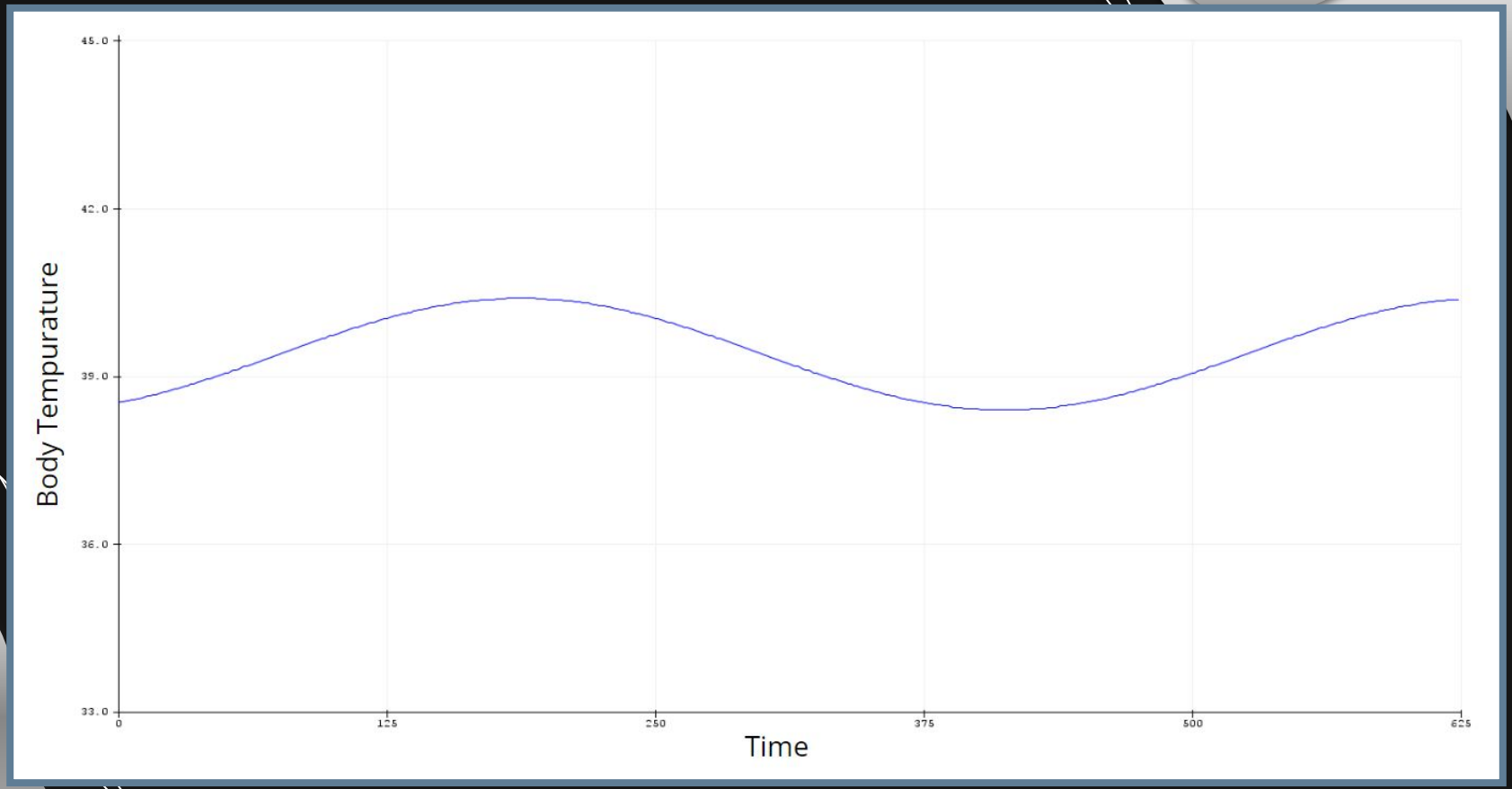


- Sweat rate and average GSR are proportional
- Sweat rate rises as the task is ongoing and decays when done
- Sample sizes vary but general trend is similar for activities that require different levels of physical work

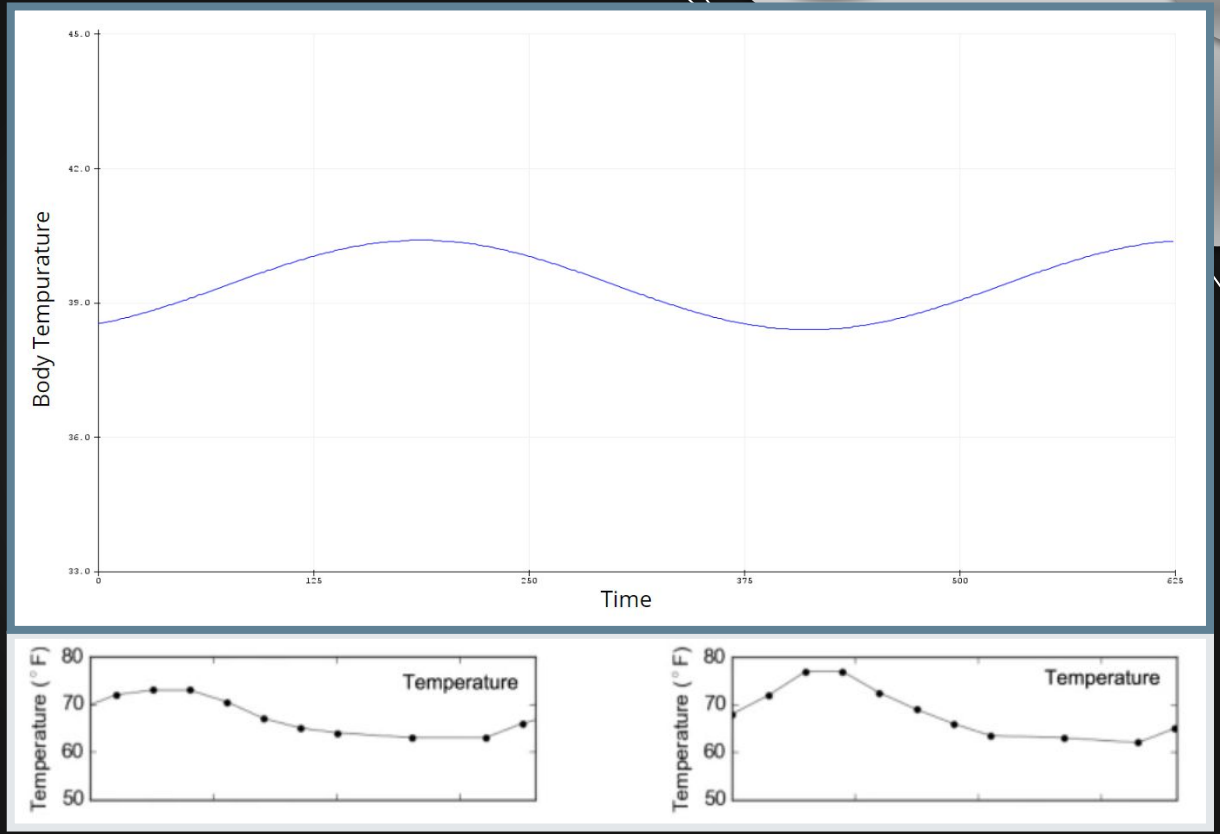
[13]

Tracks Core Body Temperature

- Slim watch that reads skin temperature manually used to record data
- Not done via Arduino due to complexity of measuring body temperature
- Temperature recorded once every half hour and general trend plotted against time with offset of 3 ℃ due to skin and body temperature variance [11]
- Observations compared with study involving analysis of sweat during rest


45.0
42.0
39.0
36.0
33.0
Body Tempurature
0
125
250
375
500
625
Time

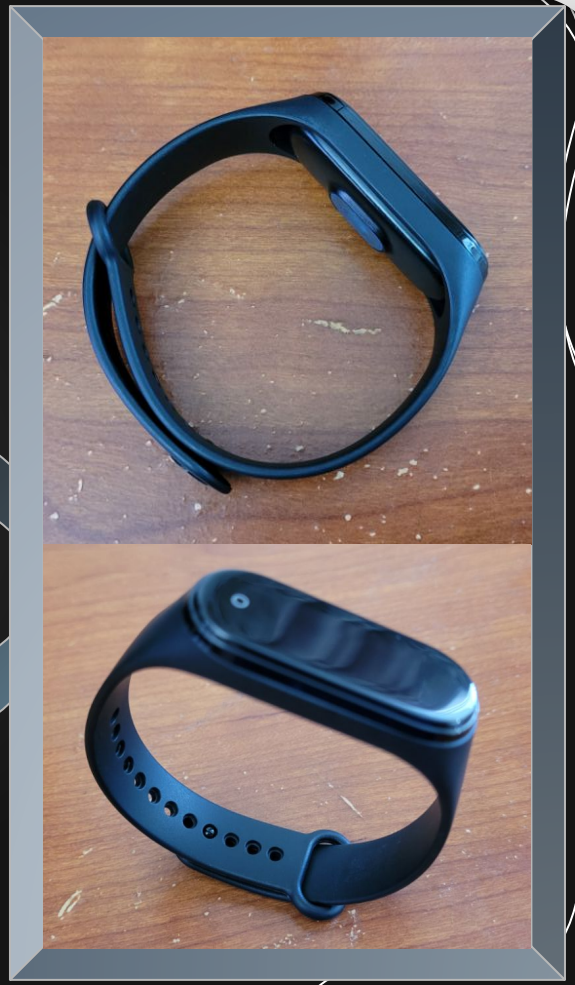
- Study measures ambient temperature around user in ℉ [10]
- Samples vary slight but general trend is similar
- Temperature rises during an ongoing task
- Behaviour is cyclical and will repeat for larger samples



[14]

Design is Non-intrusive

- Watch used for temperature also tested non-intrusiveness
- Provides desired material sensation due similar dimensions and properties of ideal design
- Worn by multiple users for long sessions who were surveyed for their experience afterwards



Observations & Results

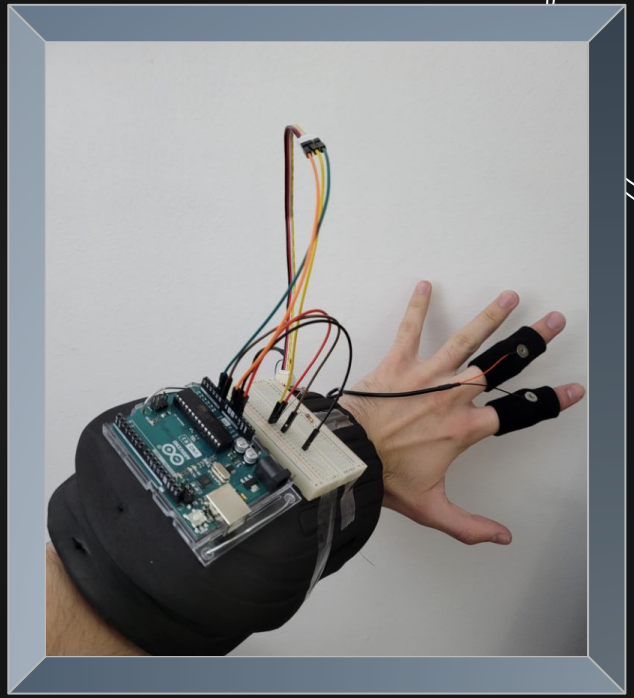
- Users had no issues other than some sweating in the wrist area
- No irritation was reported and some claimed that they had no awareness of having the watch on after a while
- One user proclaimed that the strap of the watch did not tug on and was quite friendly to arm hair
- It can be concluded that the design is successful in terms of being non-intrusive towards the user

Possible Limitations

- Inaccurate readings if bracelet is exposed to different light intensity that the retina of the user
- Current design requires the use of button cell batteries that must be replaced after their service time
- Temperature module requires direct contact with skin to provide measurements, if any at all

Conclusion

- With the tests we have conducted for all parameters and intrusiveness, we have created an automatic and effective prototype
- The fact that observations matched results of several credible studies suggests that the design is successful
- With the limitations addressed, we can help with possibly reducing the misdiagnosis of CRSDs overall



References

[1]“Are Canadian adults getting enough sleep? ,” Public Health Agency of Canada, 06-Sep-2019. [Online]. Available: https://www.canada.ca/en/public-health/services/publications/healthy-living/canadian-adults-getting-enough-sleep-infographic.html. [Accessed: 15-Apr-2022].

[2]J.-P. Chaput, J. Yau, D. P. Rao, and C. M. Morin, “Prevalence of insomnia for Canadians aged 6 to 79,” Statistics Canada, 19-Dec-2018. [Online]. Available: https://www150.statcan.gc.ca/n1/pub/82-003-x/2018012/article/00002-eng.htm. [Accessed: 15-Apr-2022].

[3]C. Morin , “Prevalence of insomnia and its treatment in Canada,” Canadian journal of psychiatry., Sep-2011. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/21959029/. [Accessed: 19-Apr-2022].

[4] Kite, “Tatyana Mollayeva Kite,” Kite. [Online]. Available: https://kite-uhn.com/scientist/tatyana-mollayeva. [Accessed: 15-Mar-2022].

[5]“César Márquez Chin, Phd,” César Márquez Chin | UHN Research. [Online]. Available: https://www.uhnresearch.ca/researcher/cesar-marquez-chin. [Accessed: 15-Mar-2022].

[6] Kite, “Kite logos,” Kite. [Online]. Available: https://kite-uhn.com/resource/logo. [Accessed: 15-Mar-2022].

[7] “Our services,” Toronto Sleep Clinics, Ontario Sleep Clinics - For a Better and Healthier Sleep. [Online]. Available: http://www.sleepontario.com/services_dlmo.php. [Accessed: 17-Apr-2022].

[8] “Shift right: Assessing circadian rhythm sleep disorders and associated health concerns based on salivary melatonin and dim light melatonin onset (DLMO),” Salimetrics, 14-Mar-2022. [Online]. Available: https://salimetrics.com/salivary-melatonin-and-dim-light-melatonin-onset-dlmo/. [Accessed: 15-Mar-2022].

[9]"Harmful blue light: Transitions lenses," *Harmful Blue Light | Transitions Lenses*. [Online]. Available: https://www.transitions.com/en-us/blue-light/. [Accessed: 16-Mar-2022].

[10] C. Delbert, "Our bodies have gotten colder with each passing decade," *Popular Mechanics*, 02-Nov-2021. [Online]. Available: https://www.popularmechanics.com/science/a30459459/body-temperature-decrease/. [Accessed: 16-Mar-2022].

[11] M. M. H. Shandhi, W. K. Wang, and J. Dunn, "Taking the time for our bodies: How wearables can be used to assess circadian physiology," Cell Reports Methods, 23-Aug-2021. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2667237521001193. [Accessed: 15-Mar-2022].

[12] R. Falconer, "Typical summer day light intensity variation near ribble ...," *Typical summer day light intensity variation near Ribble Estuary.* . [Online]. Available: https://www.researchgate.net/figure/Typical-summer-day-light-intensity-variation-near-Ribble-Estuary_fig3_282046640. [Accessed: 15-Apr-2022].

[13] H. Y. Y. Nyein, M. Bariya, B. Tran, C. H. Ahn, B. J. Brown, W. Ji, N. Davis, and A. Javey, "A wearable patch for continuous analysis of thermoregulatory sweat at rest," *Nature News*, 23-Mar-2021. [Online]. Available: https://www.nature.com/articles/s41467-021-22109-z. [Accessed: 15-Apr-2022].

[14] "Skin temperature," *Skin Temperature - an overview | ScienceDirect Topics*. [Online]. Available: https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/skin-temperature#:~:text=At%20neutral%20(24%E2%80%9325%C2%B0,et%20al.%2C%201997). [Accessed: 13-Apr-2022].