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Down Syndrome
Sensory Support

Down Syndrome Sensory Support

by

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Submitted in partial fulfillment of the requirements for the degree of

Bachelor of Industrial Design

Faculty of Applied Sciences &Technology
Humber Institute of Technology and Advanced Learning

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April 20, 2022

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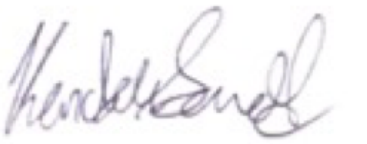
Student Signature : 

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Abstract

Sensory processing difficulties impact many people, but is often overlooked, especially in individuals with Down syndrome, often chalked up to the child being bored and behaving badly. However, the sensory issues these individuals face cause physical and emotional stress and the behaviors expressed are just ways of attempting to cope. The goal of this thesis proposal is to determine ways to mitigate the sensory issues for people with Down syndrome in a way that empowers the users and improves their quality of life. One major issue with current products in the market today is the infantile design and lack of research into how older users interact with them. User research including observational studies and interviews with professionals who specialize in child development, as well as with parents of teens with Down syndrome will give insight and detail into how these issues arise and how to develop healthy ways to cope. Additionally, a one-to-one model will be developed to understand ergonomics and human scale and will be given to targeted users to test the feasibility of the solution. Results from this analysis will realize a design solution that sheds light onto the issues of this problem area and most importantly provide a stress-free experience for people with Down syndrome that helps cope with sensory processing difficulties and does not create a negative perception of the user by others.

Keywords: Sensory Processing, Down syndrome, Teens, Child Development, Hyposensitivity, Wearable Technology

Acknowledgements

There are so many people I want to thank and acknowledge.

First off, my mom and gramps, thank you for believing in me and supporting me through all my craziness, ups and downs. I love you both more than words can express.

The next shoutout is to my ID family, love you guys. And to Jo, Nathan, and Mai, not sure I would've made it through without you guys to rant too.

Special shout out to the people who inspired me, Ben, and Cole, you two are such amazing people and I'm so lucky to have both of you in my life.

And last but not least, thank you to my professors, shout out Dennis Kappen I don't think I would have gotten this far without the support from you in earlier years. And thank you Sandro and Catherine for all your support and knowledge especially during this crazy time of Covid.

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1.1 Problem Definition

Figure 1 - Child with Down syndrome

Every one in seven hundred babies born are born with Down syndrome. Down syndrome (DS) is the most common genetic chromosomal disorder in children, and approximately half of all these individuals face issues with sensory processing in their everyday life. Sensory Processing Disorder (SPD) can cause an individual a monumental amount of physical and emotional stress. There are two types of Sensory processing difficulties: hyposensitivity, and hypersensitivity. Hyposensitivity is known as sensation under-responsivity meaning the individual has a harder time getting the sensory feedback they need, whereas with hypersensitivity the sensory feedback is felt at overwhelming levels. Children with Down syndrome often have other medical conditions such as Hypotonia which is the term for decreased muscle tone. Hypotonia can impact grip strength and motor control, as well as posture, breathing, stability, endurance, and speech. It is also widely linked with the proprioceptive sense, the sense of how an individual's body exists relates to the space surrounding it. Because of this,

often these children are left to develop their own way of coping which generally results in disruptive/ antisocial behaviours (Will et al., 2019). This is an issue that causes physical and emotional stress to these individuals. This thesis report investigates the different methods of sensory stimulation to better determine ways to mitigate the sensory processing issues for people with Down syndrome.

1.2 Rational & Significance

Key information to be determined

- Biggest pain points
- The cause of sensory processing difficulties
- Sensory therapy techniques
- E-textile opportunities
- Specific ergonomics

Key questions to be answered

- Which muscles are best targeted for proprioceptive feedback?
- Does a targeted approach to stimulating the muscles work better than a full-bodied approach?
- What products are currently used to help with sensory processing?
- Will this product need to be weather and waterproofed?
- Who will be maintaining the product when not in use?

Investigation approach planned

- Interviews
- Literature reviews
- Blogs / Medical institutions webpages
- Educational videos on sensory therapy

- Ergonomic study

1.3 Background / History / Social Context

Down syndrome is the most common genomic disorder and results from a trisomy of the human chromosome 21 (Hsa21), a chromosomal condition characterised by an additional chromosome (Antonarakis et al., 2020). Normally humans have a total of 46 of chromosomes, 2 of which determine sex and the other 44 control development. In Down syndrome there is one additional copy of the chromosome 21, resulting in three chromosome 21's rather than two. There are 3 types of Down syndrome all classified by how the extra chromosome appeared, the first and most common encompassing with 95% of all Down syndrome cases is Trisomy 21. In Trisomy 21, the extra chromosome is inherited from the parent's genes. Next is Mosaic Down syndrome, this is when the extra chromosome spontaneously appears in the embryo. Lastly is Translocation Down syndrome which is caused by rearranged chromosomal material (*Trisomy disorders* 2019). People with Down syndrome face many difficulties both emotionally and physically, as shown in Figure 1.1, as well as are at risk of developing numerous other medical conditions such as risk of early offset Alzheimer's, congenital heart defects, and developmental delays.

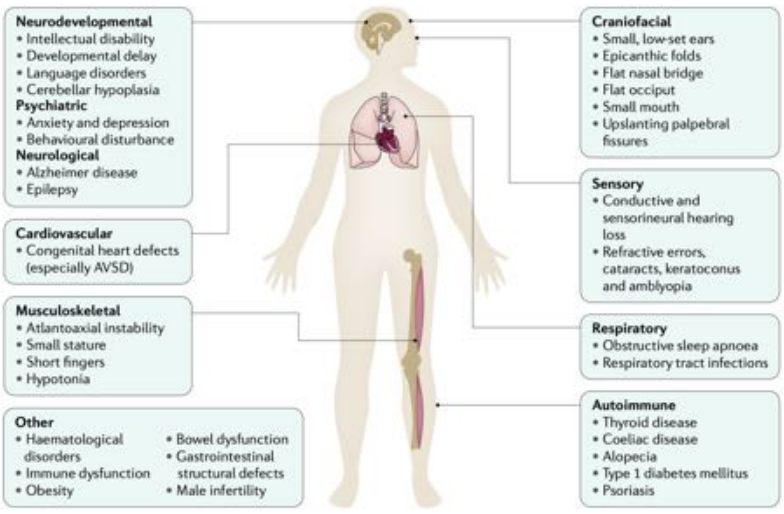


Figure 2 - Down syndrome Medical Conditions (Antonarakis et al., 2020)

CHAPTER 2: Research

2.1 User Research

2.1.1 User Profile – Persona

User Groups:

Below are the three user groups that are expected to encounter the product.

Primary Users: **Youths with Down Syndrome**

Figure 3 - Boy with Down Syndrome

Primary users of this product are preteens with Down syndrome, aged 12-18. These users will be coming into direct contact with the product daily. These users are also the ones to control the mechanisms and receive the sensory feedback firsthand. These youths are also specifically experiencing hyposensitivity, seeking sensory stimulation.

Secondary Users: **Parents and Family Members**

Figure 4 - Couple (https://unsplash.com/photos/1tyzfcJri2g)

Parents and Family members are classified as Secondary users as they interact with the product in a multitude of ways. The family members encounter the product when the Primary User is wearing or is done wearing the product.

Tertiary Users: **Teachers, PSWs, Occupational Therapists**

Figure 5 - Teacher (https://unsplash.com/s/photos/teacher)

Lastly are the Tertiary users, these are the Teachers, PSW's, and Occupational or Physiotherapists. These users encounter the product when they encounter the child. They often are involved with the primary user through education. They indirectly come in contact with the product although occasionally they will assist the primary user in the operation of the product.

Demographics

Age and Gender: **12-16, Male.**

Studies have concluded there is a slightly higher chance of a male being born with Down syndrome than a female. There ratio is 1.15:1 male to female (Kovaleva et al., 2001).

Education: **Elementary School – High School**

Many people with Down syndrome remain in high school till age 21, many do not go on to post-secondary education and instead try to find work after high school.

Ethnicity: **Caucasian**

A study of demographic differences in Down syndrome live births concluded that there is a higher likelihood of giving birth to a child with Down syndrome for Caucasian people (Egan et al., 2011). However, this study also noted that there was an increase in maternal age of the white mothers which might correlate to the higher percentage in this group as studies have shown that the risk of Trisomy 21 increases with maternal age. However current studies are beginning to suggest that the father may be the determining factor in some of these cases, but not enough research has been done to prove this is conclusive.

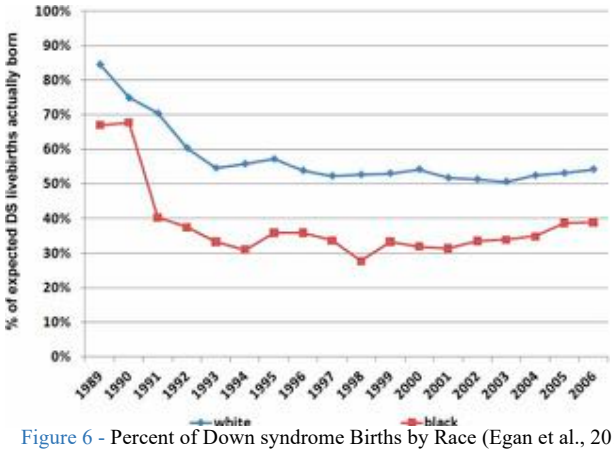


Figure 6 - Percent of Down syndrome Births by Race (Egan et al., 2011)

Persona

Milo Perkins

Age: 12

Sex: Male

Type of DS : Trisomy 21

Race : Caucasian

Lives: With his parents

Education : Entering grade 7. He is in the mainstream classes, but often works on separate assignments than his peers

Figure 7 - Boy with Down syndrome

User Behavior

Milo is most happy when with friends, he attends clubs at the local activity center and is on the accessible basketball team. Milo often disrupts class and can get frustrated easily leading to physical outbursts such as refusal to sit during lessons and occasionally throwing items or tearing bits of his clothing. These behaviors are mainly caused by Milo's hyposensitivity as he seeks more sensory feedback. At this age Milo is noticing the differences between himself and his peers causing him to feel isolated. He doesn't like using his old fidget products due to their size and inconvenience but he when he doesn't use them, he ends up tearing things around him. He doesn't understand the impulses he is facing and often gets upset and frustrated when he isn't able to properly cope with the impulses.

2.1.2 Current User Practice

The goal of gathering this information is to learn what the user does with the product, how they use it, and why they use it. This data will aid in the creation of the final product's design.

Goals

1. To determine daily key activities
2. Determine frequency of use
3. Determine 'trigger' scenarios

By reading blogs of parents with children with disabilities, as well as school class schedules it is observed that many children with disabilities such as Down syndrome follow daily routines. Most frequently the routine is as following, the child wakes up, has breakfast with family and then proceeds to care for their hygiene such as showering and brushing teeth. Next, they don the outfit they or their parents lay out and gather their school supplies. Afterwards they are driven, walk, or take the bus to school. Once dropped off at school they meet with their EA and join their peers in the classroom. Often class is from 8:30 to 3:30 with two snack breaks and lunch. The child often participates in certain class activities such as music or PE but may work on different assignments in classes such as math. Depending on the child, they may have an IEP that allow for more breaks during the day that allow the child to take a walk or leave the room with a supervisor if they become overwhelmed.

2.1.3 User Observation – Activity Mapping

Issues with Sensory perception and regulation can be triggered at any time or any place, that is why for this study rather than observing a user operate a system the users daily routines will be analysed. Milo lives a relatively normal life of going to school, spending time with friends, playing

video games, and is on the school's basketball team. These are all normal routine activities that Milo is used to. Most days he follows a set of routines that his parents help enforce. In the morning he goes about waking up, eating, dressing, then waiting for the bus to get to school. Milo is taking a mix of class types as he spends the majority of time in the mainstream class but often will sit to the side of the class with his EA working on different assignments from his peers. He is widely accepted by his peers but is self-conscious about his disability as he's been bullied in the past. He also struggles to understand why he had been bullied or is different from his peers. At the end of the day, he gets picked up by his father instead of taking the bus home. When home he does his assigned work, eats dinner, and likes to play video games such as Pokémon on his Nintendo. He really enjoys watching sports such as basketball with his family but often he will get frustrated after prolonged periods of time with large groups of people.

2.1.4 User Observation – Human Factors of Existing Products

This map goes through the journey of receiving the new weighted vest to using it with their child with ASD who is also sensory seeking. There are very few in depth videos of youths with Down syndrome so observing a child with ASD and similar sensory issues was the best comparison.

Table 1- User Observation
Photos from (https://youtu.be/_SQnMzXxv-8)

Activity	Picture	Description
Receiving the Package		Parents talk about the vest, discuss how their son is becoming stronger and his sensory seeking behaviours are starting to become "less cute" and more of a bad habit. They are

		hoping this vest will help over the week for their “sensory seeking” son. The package was very nice as well instilling confidence in the company and product
Checking Instructions		Weighted vests can be very dangerous is used incorrectly that’s why having a solid and easy to understand guide is important.
Introducing it to the child		Children can be very unsure about anything new, and the parents played around with the vest before introducing it to the kid in order to make it seem fun and make the child want to come use it.
Inserting the weights		They did 5% of his body weight which was about 1.75 lbs They inserted it into the front and back pockets without difficulty. The child tried to add more weights as he found this task fun.
Wearing it		They put it on at about 6 pm which seemed to be when he was seeking the most sensory input and “running around and crashing into things”. They also only use it for 15 mins at

		start to observe how the child reacts and judge if they need to adjust the weights.
Reactions		They had to judge how much does he protest vs is this helping or is this pushing him too far out of his comfort zone. After watching him play while wearing it they decided that the protesting seemed just to be to the new addition and not actually anything causing distress. They decided it is worth “pushing through the mental boundary in order to reap the benefits”.

2.1.5 User Observation – Safety and Health of Existing Products

This section will discuss different existing products and their safety and health impact on the user. The first product that will be investigated is the weighted vest. Weighted vests provide a sense of deep touch pressure that helps promote self-regulation; the deep touch pressure (DTP) helps the body naturally decrease the levels of cortisol which is a stress hormone (Ford-Lanza, 2018). Research has also found that the use of weighted vests increases attention and following tasks. The study also saw a significant decrease in maladaptive behaviour from participants diagnosed with sensory processing difficulties (Olson & Moulton, 2004). However, users with any pre-existing neck and spinal issues can be harmed using a weighted vest and it regularly stated that users consult with a doctor or occupational therapist before using any weighted vests (*Wearable weights: How they can help or hurt* 2021).

This is crucial as many people with Down syndrome as many children with Down syndrome are at increased risk of developing spinal issues such as atlantoaxial instability, a compression of the spinal cord (Bull, 2016).

Next are compression shirts, these are much simpler than weighted vests and can be worn as undershirts, often these are made of a nylon spandex blend that keeps its material soft and gives it the ability to retain its form. Compression shirts are often recommended over weighted vests for children with lower muscle tone, and they can be worn all day (Wild, 2019).

2.2 Product Research

This section features in depth research into a wide range of different sensory products currently on the market. The research done in this section will assist in the development of features as well as determine gaps in the market for exploration.

2.2.1 Benchmarking – Benefits and Features of Existing Products

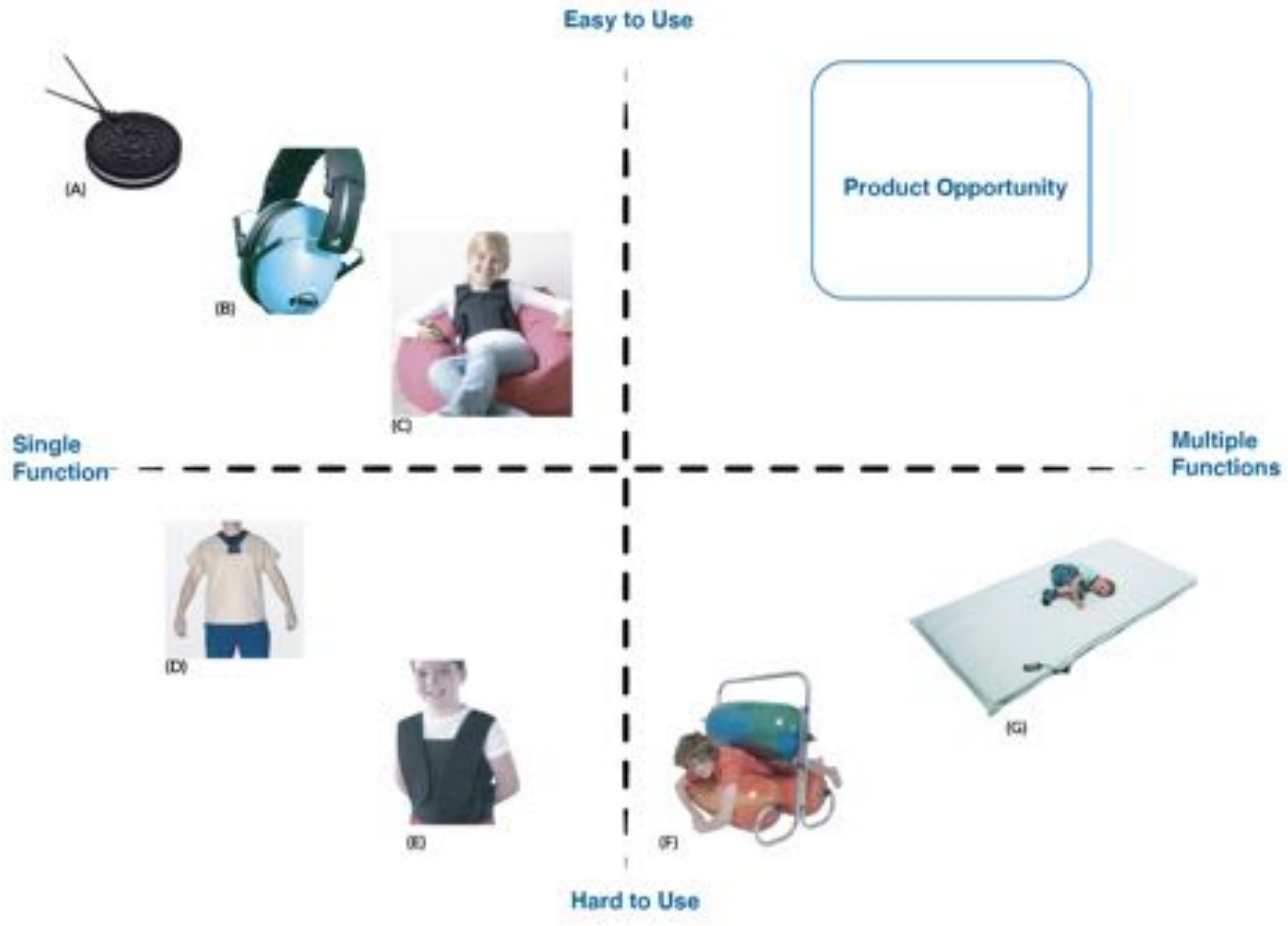
Product benchmarking for this product involved looking at a wide range of different sensory equipment. Many different types of products were examined, all had specific functions to solve specific sensory issues. The collection of data will better determine what features are truly most important to the user. The following list features the benefits and features of each product.

Table 2 - Product Benchmarking

	Wearables **Chewlery** • Expensive and easily lost or broken • Not made for "adult teeth" • Hard to keep clean • Childish • But is better for oral health then chewing on random objects
	**Weighted Vest** • Can only be used for 20 mins • Places pressure onto the spine • Bulky
	**Rip Proof Clothing** • Unfashionable and unflattering (isolating) • Thick seams can cause tactile sensory distress • Doesn't solve the problem, user will likely turn to ripping something else.
	**Deep Pressure squeeze vest** • Similar to the weighted vest but doesn't put the pressure on the spine as it uses air pressure • Can only wear the pressure for 20 mins • Requires decent hand motor skills to pump the vest
	**Noice cancelling headphones** • Good for auditory filtering • bulky • can make user seem antisocial
	Large Equipment • **Vibrating mat** • **Squeeze machine** • Large and not portable • Only helps while in or on it • Very expensive
	

From this chart a x-y graph was created in order to determine product opportunities in the current market.

Table 3 - x-y graph



2.2.2 Benchmarking – Functionality of Existing Products

To determine the functionality of existing products a comparison of features between two of the products with the most promising technology was conducted. The study consists of the Deep Pressure Squeeze Vest and the Vibration Pad.

Table 4 - Comparison of features

Deep pressure Squeeze Vest	Vibration Pad
 Figure 8 - Squeeze Vest (https://specialneedstoys.com/can/proprioception/squease-vests.html	 Figure 9 - Vibration Pad https://specialneedstoys.com/can/vibrating-floor-pad.html
• Minimal effort to put on • Provides almost instant proprioceptive relief • Slim enough to fit under baggy clothing • Can be worn all day and inflated for up to 30 mins at a time	• Multiple speeds and combinations • Instant proprioceptive relief • Features targeted and full body vibration • Easy to clean • Controlled with handheld remote

2.2.3 Benchmarking – Aesthetics and Semantic Profile of Existing Products

The current aesthetic profile of existing sensory products has two sides, the first being bright, colourful, often coming across as juvenile, (see Figure 10 for an example) and the other being discreet or built into 'normal' clothing. Often sensory therapy and related tasks are done in infanthood. These practices carry through the later years as well but are most often though about in the early stages. This causes a rift between the aesthetics of current products and the older users. Many parents and guardians have stated that finding "discreet" or "normal" looking products often is difficult and they must resort to

Figure 10- Chewlery (https://specialneedstoys.com/can/tactile/chewing/pirate-coin-chew-necklace.html)

creating it themselves. However, there are a few products that have taken the challenge of designing for young adults into mind. The product to best demonstrate this is the Deep Pressure Squeeze vest seen in Figure 11 . It is designed to fit underneath existing clothing, can be worn all day, and has a pump that can fit inside a pocket. The design is unobtrusive to the wearer, and it rarely ever seen by others. However, it is made with a more restrictive material that can impede the users' daily actions, resulting in this not being a viable all day option.

Figure 11 - Squeeze Vest (https://funandfunction.com/squease-inflatable-compression-vest.html)

2.2.4 Benchmarking – Materials and Manufacturing of Existing Products

The material for the design needs to allow stretch and act as a second skin the wearer. By comparing many different types of "stretchy" fabrics, a spandex fibre blend was determined as the fabric of choice. This decision was made by comparing existing products and the materials used within the special functions.

Figure 12- Compression Undershirt (https://smartknit.com/kids-seamless-compresso-t-3-pack-1/)

First was a compression undershirt, see Figure 12, these are tight fitting tops made from a blend of 97.3%polyester (PET) and 2.7% Lycra (elastane). This shirt is light and breathable, and the spandex fibres keep the shirt from becoming saggy or losing shape. Next, most weighted vests were mainly made from cotton, polyester, or a blend of both (See Figure 13). The weighted bags within the vest are made from cotton with steel pellets enclosed within. Next, Squeeze vests are made from mostly nylon and feature a thermoplastic polyurethane coating that keeps the vest airtight as it inflates (see Figure 14). Lastly, the weighted compression vest is made from 100% Neoprene with 100% polyester mesh sides with interior pockets for the weights, made from cotton fabric with steel pellets (see Figure 15).

There are different processes that are used by different manufacturers to produce elastane fibres. These processes are called solution wet spinning, solution dry spinning, melt extrusion, and reaction spinning (Romanowski, 2008). Dry spinning involves dissolving a polymer into a evaporable solution and is used for 95% of all elastane production (Sobuj, 2017). The dry spinning process results in an elastane yard that can then be weaved into a sheet of fabric.

Figure 14 – Weighted Vest (https://funandfunction.com/stretch-denim-weighted-vest.html)

Figure 13- Squeeze Vest (https://ww.rompa.com/squease-vest.html)

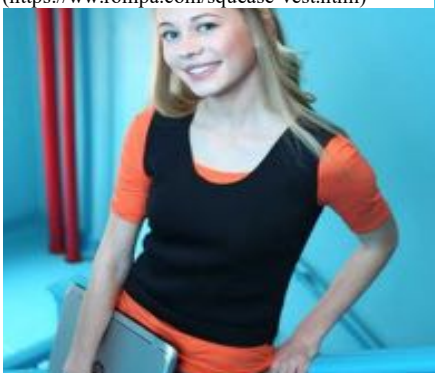


Figure 15- Weighted Compression https://www.sensorykidstore.com/sensory-clothing-fun-function-tween-teen-black-wei.html

2.2.5 Benchmarking – Sustainability of Existing Products

Most compression wear is made from materials such as nylon, silicon, and cotton. Fibres like cotton or polyester are mixed with nylon or spandex fibres to give a softer and more luxurious feel (Aufmann, 2020).

Spandex is a synthetic fabric made of a blend of 85% polyurethane (PU) and polyethylene glycol. Just like any plastic, spandex has its pros and cons, spandex's biggest flaw comes with it the non-biodegradability of the material. However, the Higg Index which measures the environmental ratings of apparel life cycles, rated the environmental impact of spandex or elastane, like that of polyester. This is because of the synthetic nature of spandex and the chemicals that are used during production, there is a lot of chemicals used in the production, however it pales in comparison to plastics such as PVC. But the synthetic nature of spandex can also be an advantage when compared to nylon which produces nitrous oxide which is 300x more potent than C02(Elastane vs spandex: Suitable for a sustainable stretch?2022).

Next, a study was done to get insights on the environmental impact of textiles such as polyester (PET), nylon, cotton, and elastane. The study concluded that polyester had the least impact on the environment, followed by elastane and nylon. Cotton had the highest environmental burden in the study (van der Velden et al., 2013).

One large environmental impact of textiles, specifically ones made from synthetic materials, is the issue of microplastics. Washing synthetic clothing may generate as many as 700,000 plastic fibers that are then released into the environment and waterways. Out of all the microplastics found in waterways it is estimated that more than one third originated from washing synthetic clothing. The European Commission noted that microfibres from clothing can be just as damaging as microbeads to marine life, if not more so ((Chua, 2020).

CHAPTER 3 : Analysis

3.1 Analysis - Needs

3.1.1 Needs/Benefits Not Met by Current Products

Currently there is a lack of fast acting, easy to use, and discreet sensory products. The current market designs these products for young children with little opportunity for the product to grow with the child. This causes an upset in the teenage years as all the products become infantile to their peer's leading to embarrassment and social isolation. By utilizing information compiled in Chapter 2, a table of needs and improvements was created.

Table 5 - Needs vs Improvement

	Need	Improvement
1.	Efficiency	• Should be fast acting • Ability for continuous use
2.	Comfort/Ergonomics	• Should be able to be worn all day • All elements should be able to be reached or accessed easily • Easy to put on and take off • Comfortable to wear under clothing
3.	Style	• Unobtrusive design styling • More 'mature' appearance

3.1.2 Latent Needs

By looking at the needs vs improvements chart and comparing it alongside Maslow's hierarchy of human needs another chart was devised. This chart links the needs with corresponding fundamental human rights and the relationship with benefit.

Table 6 – Needs vs Benefits

	Product Need	Corresponding fundamental human need	Relationship with Benefit
1.	Efficiency	Gratification (Sensory), Long Term Security, Self-Actualization	Strong
2.	Comfort/Ergonomics	Control over tasks, Safety	Strong
3.	Style	Social Belonging, fear of abandonment, Fear of the Enemy, Esteem	Strong

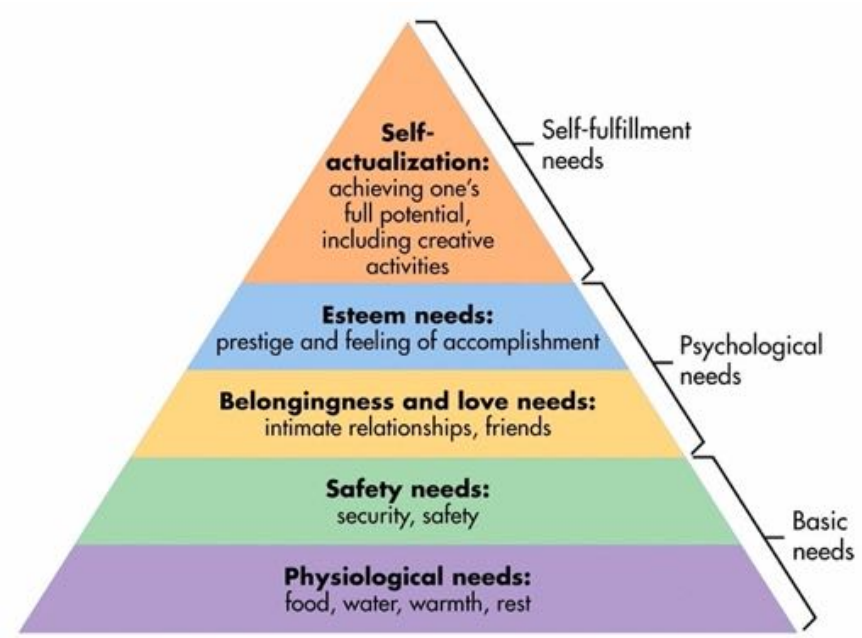


Figure 16 - Maslow's Hierarchy of Needs
https://www.simplypsychology.org/maslow.html

Efficiency

Efficiency is the top priority for the design. The product needs to be efficient; this mostly means it needs to be fast acting and easy to use. This need corresponds with the user's basic need for Sensory Pleasure / Gratification, as well as the users long term security, and self-actualization. for the first need to be met the product must provide instant or almost instant sensory relief. once that need is met it allows for the user to focus on their education in class and not be afraid of new experiences, which covers the long-term security and the self-actualization needs.

Comfort

Next, is comfort and ergonomics, this is the need for the product to be easy to use as well as comfortable and safe to wear and use. The corresponding human needs are control over environment (tasks) and safety. The user wants a safe experience, improvement of mental and physical wellbeing. Sensory processing difficulties can impact both mental and physical health. The ability to have control over environment allows the user to control the stimulation quickly and conveniently, this in turn has a positive effect on mental health.

Style

Lastly, the user needs a more stylish product. This need is connected to the need for Social Belonging, Esteem, and Self Actualization. By improving the style and aesthetics the fear of abandonment and fear of the enemy is removed as the user no longer feels threatened by rejection from peers due to infantile design. This removal of fear opens the possibilities for extrinsic and intrinsic experiential endeavors such as participating and focusing on new experiences.

3.1.3 Categorization of Needs

After determining the Latent Needs, a list of need statements was created to better understand the needs of the user and better categorize them.

Needs Statements

- The user needs to get sensory relief because without it they feel anxiety
- The user needs discrete solutions because they want to fit in with peers
- The user needs quick relief because they want to feel better immediately
- The user needs to be able to participate in new events without distress because that brings them joy
- The user needs ways to curb compulsive behaviours because these can lead to issues with social belonging

Table 7 - Categorization of Needs

Immediate needs	Latent Needs	Wants/Wishes
• Comfort • Safety • Ability to activate sensory stimulation • Ability to block excess stimulation	• Self-Actualization (ability to experience new things) • Ability to interact with peers • Ability to focus and learn	• For the product to be discreet or fashionable • To enjoy daily activities • To build meaningful relationships

3.2 Analysis – Usability

The usability of this product must allow the user to use it for long periods of time, rather than taking it on and off regularly. This is so the user doesn't have to stumble looking for the device when they need it. Having something with a very accessible and quick acting will ensure proper use of it as well as effective use.

3.2.1 Journey Mapping

The main objective of this study was to follow the daily life of a young adult with Down syndrome. In doing so, obtain a better understanding of what triggers sensory issues, as well as how they are currently dealt with, without any assistive devices. In the end there was a much stronger understanding of daily routines as well as what senses cause the most distress or are triggered the most.

Method

After obtaining permission from the individual and their guardian the user observation could begin. The guardian requested that photos not be released but they agreed to sketches of the photos being released. The user observation took place at home going through normal activities the participant decided to do, as well as going out to a restaurant at the end. Observer spent time with the family through the day but occasionally faded to the background to conduct the observation discreetly.

Table 8 - Journey Map

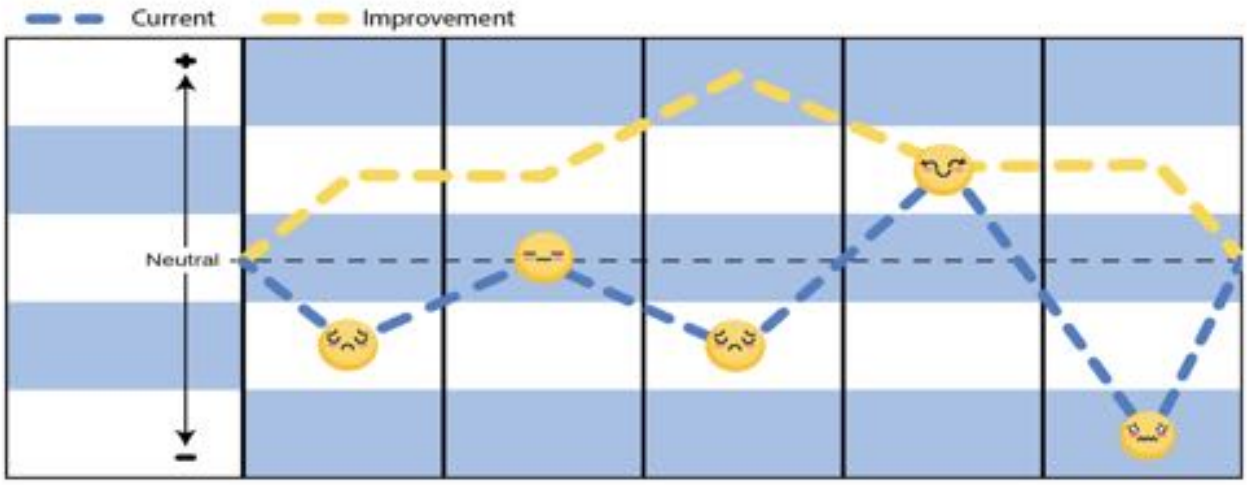
Activity	Picture	Description
Preparing Food		Wanted to help prepare dessert for the family. Enjoys helping. Doesn't love the loud sounds but they are tolerable

Sitting and interacting with family		Doesn't follow along with all the conversations, instead likes to focus on his iPad. When he was brought into conversation, he often used hand gestures mimicking sign language when trying to explain a point.
Watching tv		User finds it hard to sit still and pay attention to the show he put on. He ends up doing various random floor activities such as rolling on his back.
Dance Fit Class		He is signed up for Dance fit class over Zoom and had a session that day. User enjoys doing this but held himself very tight. Dance movements were very tight too, possibly due to low muscle tone.
At restaurant		He bends over towards the menu, rather than bringing the menu closer to him to read it. Reading was slow and he used his finger to keep his spot. He was also very excited to tell the waitress his order.

3.2.2 User Experience

From the Journey Map a User Experience Map was developed. This follows the journey the user takes and maps the user's experience, while also listing the problems and thinking about solutions. The blue line represents the current experience while the yellow line represents the goal or improved experience.

Table 9 - User Experience Map



User Goals	Baking	Communicating	Watching TV	Exercise	Eating out
Problems/ Challenges	Following directions is hard. Loud sounds are irritating. Gripping smaller utensils is hard.	Doesn't always want to talk. Uses hand signals to try and get point across	Enjoys watching show but can never sit still. Often rips clothing, rolls, or uses exercise bands.	Enjoys this type of workout as it seems like a game rather than actually exercise but gets tired very fast	Likes going out but is often frustrated not being able to order and gets stressed by lots of people and loud sounds
Ideas/Take-aways	Auditory seems to be most triggered along with comprehension issues	Mood censors can help others determine whens not a great time to chat	These activity's are proprioception stimming methods	Exercise disguised as games are best	Problems with almost all of the senses. Under clothing solutions could be viable

3.3 Analysis – Human Factors

This study of ergonomics looked to test the overall usability and functionality of the design concept. The concept being a wearable sensory stimulation device for children with Down syndrome, ages 13 to 19. The goal was to create an ergonomic 1:1 scale buck that would be tried on and its features tested to determine any issues that would cause distress later.

Most of the Anthropometric data referenced in this report is from, *The Measure of Man and Woman* (Tilley, 2002). The measurements from the 50th percentile 13-year-old youth were utilized. In comparison to their counterparts with regular development, people with Down syndrome have a higher rate of obesity; about 70% of individuals with Down syndrome are overweight or obese (Shields et al., 2015). Often this can be caused by hypotonia, weak core strength, and lower cardiovascular fitness. However, these differences are seen more with increased age, and younger children with Down syndrome can be relatively similar in size and BMI as their neurotypical counterparts. Studies have also concluded that in children with Down syndrome, body size and fitness appear to be inversely associated. Some other common physical characteristics of Down syndrome is often short limbs and fingers, as well as a larger waist circumference, or belly, often caused from thyroid issues. This can lead to much different distribution of body mass to height with age than with a neurotypical child (Zemel et al., 2015). Therefore, measurements of height and weight were also taken from the CDC's growth charts for children with Down syndrome to be used alongside the measurements from Measure of Man and Woman.

Individuals with Down syndrome also often exhibit similar facial features, such as almond eyes caused by epicanthal fold, which is when the upper lid covers a portion of the inner corner of the eye. Often, they have a shorter neck, small ears, and flattened nasal bridge as seen in Figure 17.

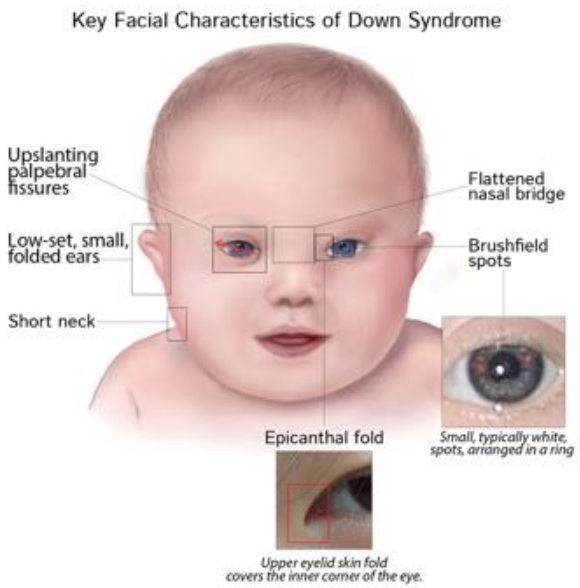


Figure 17- Down syndrome facial Characteristics (https://www.drawittoknowit.com/course/pathology/glossary/developmental-process/down-syndrome)

3.3.1 Product Schematic – Configuration Diagram

Measurements of height and weight were also taken from the CDC's growth charts for children with Down syndrome (Zemel et al., 2015) to be used alongside the measurements from Measure of Man and Woman.

This study of ergonomics looked to test the overall usability and functionality of the design concept. The concept being a wearable sensory stimulation device for children with Down syndrome, ages 13 to 19. The goal was to create an ergonomic 1:1 scale buck that would be tried on and its features tested to determine any issues that would cause distress later.

At age 13 both male and female ergonomic measurements are nearly identical, so for this study a 50^{th} percentile male youth, age 13, was examined. A male was picked to be the study as research states there is a birth ratio of 1.15 to 1, male to female, for children with Down syndrome. Due to the measurements being interchangeable for the genders this seemed to be the best choice to model the buck to. The reason 50^{th} percentile was utilized was as there is a lack of in-depth measurements for 5^{th} and 95^{th} percentile 13-year-old, and even less dimensions for those percentiles with Down syndrome. This would be a size medium shirt and it would be sold in a range of sizes from XS to XL. However, the 13-year-old schematic will be the schematic utilized in the 1:1 scale model later.

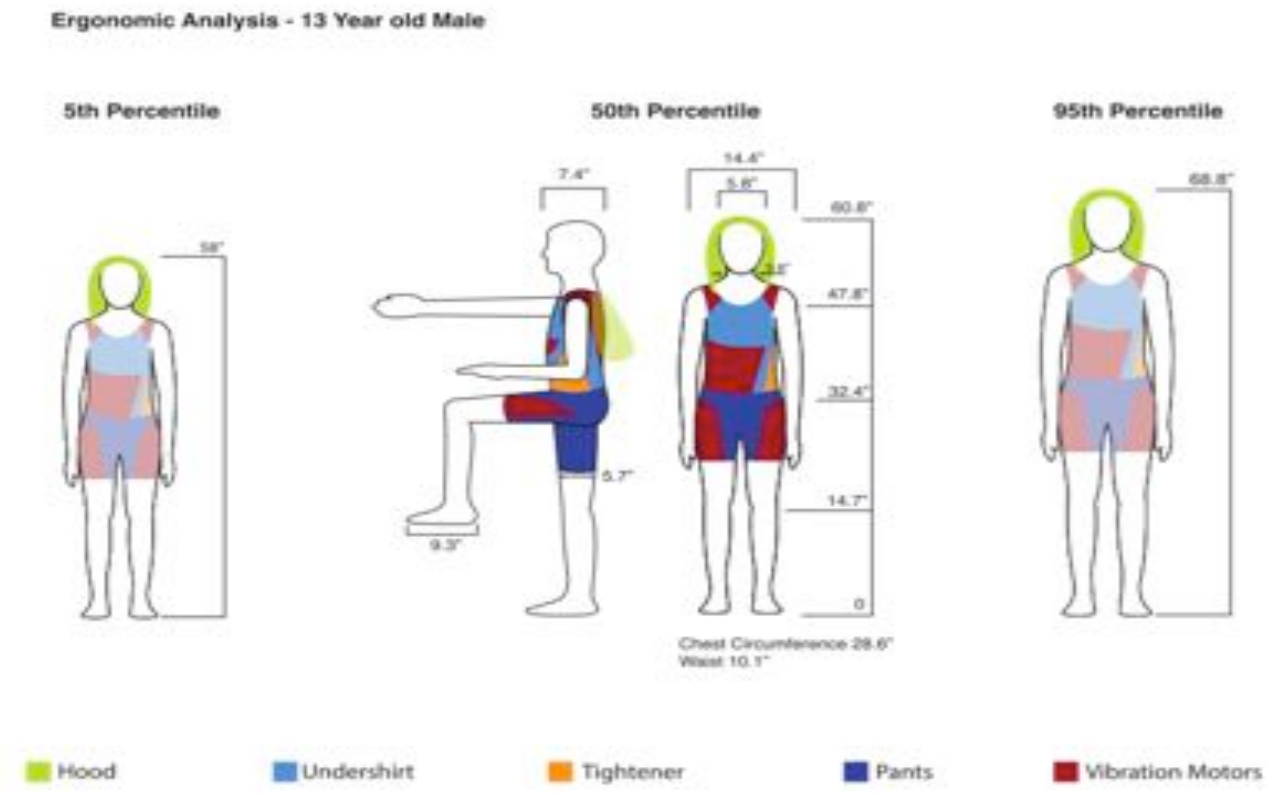


Figure 18 - Product Schematic

3.3.2 Ergonomic – 1:1 Human Scale Study

To get a proper reference of the design's ergonomics a 1:1 scale model was created. This would be later used to do an in-depth Human Scale Study.

Method

To build the buck, measurements were taken of the torso length, chest circumference and neck width to develop the pattern for the tank top. The measurements taken were of a 50th percentile 13-year-old boy. A basic paper patten of an undershirt was then drawn out and used to transfer the pattern to the fabric where it was then cut out and stitched together. Once done, a triangle was cut out of the bottom right side of the shirt to attach the underwire that make the tightener mechanism. A patch was then added inside to close the hole. The string was then threaded though the holes to complete the

tightener that allows the user to tighten the clothing. Inside the top, paper was attached to areas where the vibration motors would be stationed to see if the placement would cause any discomfort. A hood was also created that uses Velcro to attach to the back of the top.

Results

The shirt was given to the participant who had no issues donning it. Even though this participant does not have Down syndrome they were able to state that it went on just as easily as any other shirt which led to the conclusion that it would be just as easy as any other shirt for the target user to put on as well.

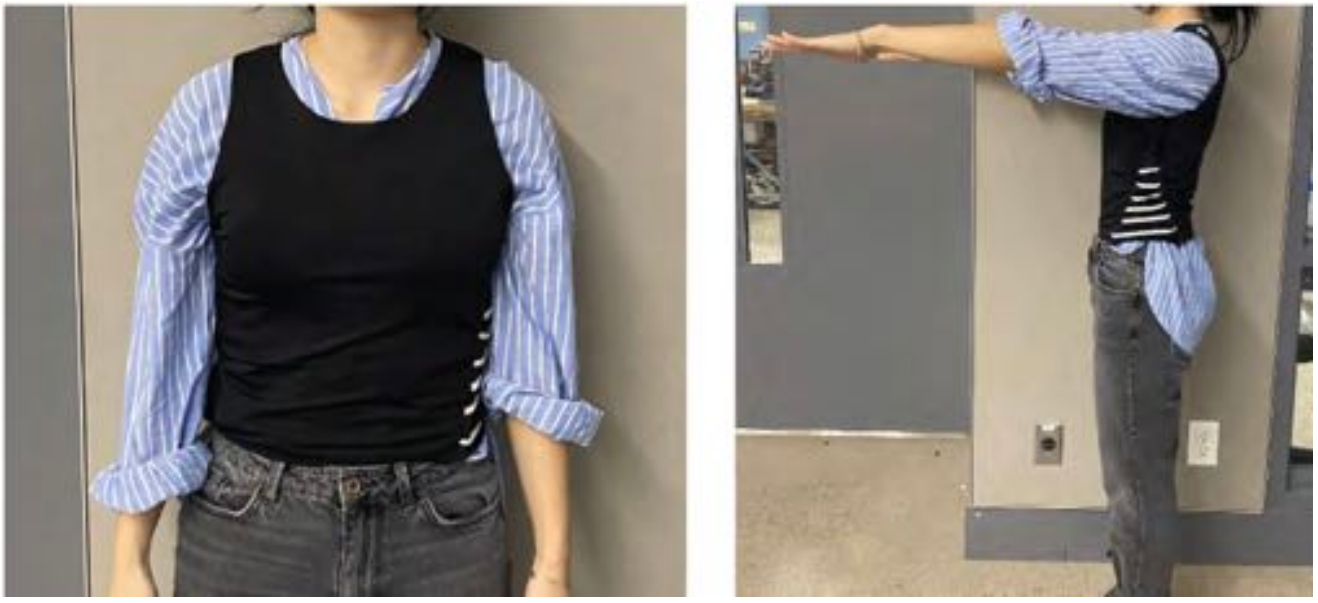


Figure 19 – Human Scale Study

The next thing observed was the reach to the tightener drawstring. At first the user attempted to reach over with the hand on the opposite side (right) to pull the drawstring, this caused the shirt to be become twisted around the torso and the user had to pull the shirt back into place. Next, they tried with pulling with the left hand and pulling outwards, this posed a great insight into how this mechanism will work. The drawstring should be pulled away from the body not towards to keep the

shirt in place. The next issue was when the drawstring was pulled there was no place to contain the extra string, this is a key area that needed to be worked on more.

Figure 20 – Human Scale Study

Next the target user was asked about the placement of the paper inside to determine if there is any discomfort or anything that makes it hard to move. The participant expressed no major discomfort but stated when sitting down the top of the ‘vibration pad’ dug into their skin slightly, this led to the conclusion that instead of using a pad of vibrations to instead use small vibrational motors, roughly smaller than a penny, that can be embedded into the fabric. This would allow full range of movement without any edges digging into skin.

Lastly, the participant attached the hood. They had trouble aligning the Velcro tabs at the neck of the shirt sparking the realization that magnets might work better. They also had trouble fitting the hood over their hair suggesting the sizing of the hood may be too small.

Figure 21 - Human Scale Study

Analysis

While building the pattern for the buck, 50th percentile 13-year-old male dimensions were utilized. The most critical measurements used in creating the top were the chest circumference, waist to shoulder length, and neck width. The chest circumference of the 50th percentile 13-year-old was determined to be 28.6”. This measurement would determine the width of the fabric pattern, to determine the correct number this measurement was divided into 4 and the result was 7.15”. The length from waist to shoulder for a 50th percentile 13-year- old was then determined to be 18.75”. Lastly, was the neck measurements, the neck width was 4.6” but to determine the head hole of the top the neck measurement was divided by 2 then 1 inch was added, leaving it to be 3.3”, this was done according to a tutorial on how to plot out and create custom clothing patterns. Next, 1 more inch was added to

determine the strap thickness and a curve was drawn to connect the strap to the body. The pattern is shown in Figure 22.

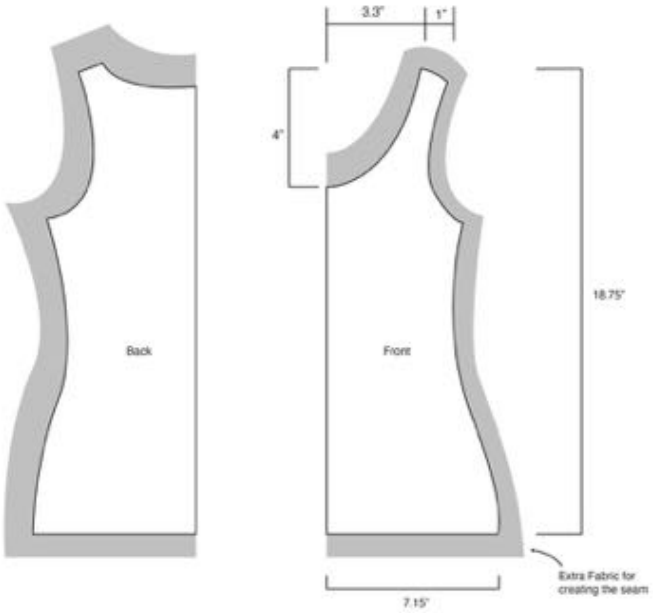


Figure 22 – Pattern

Limitations and Conclusion

Due to the pandemic, there was limitations on the gathering of results with an actual 50th percentile 13-year-old, the measurements of the design were plotted correctly to fit that percentile, but the participant was a 5th percentile woman. The 5th percentile woman was the closest match to the target subject that was required for this study that was available to consult with.

3.4 Aesthetics & Semantic Profile

The Aesthetics of this design is inspired by athletic clothing such as Adidas and Nike. The goal is to create something that doesn't draw attention. The styling should be simple yet beautiful, this product isn't designed to be seen often by others but should still be an enjoyable piece that empowers the user wearing it. This product sits beneath the clothing as an undershirt so the design must not utilize bright colours as those are easily seen through clothing. It is also to be worn frequently so the colour scheme should consider what colour will look least dirty with multiple uses. The design will also incorporate curves in the functional components as well as just the aesthetic components to make the design softer and less intimidating. The concept also pulls inspiration from clothing articles such as leather jackets. The leather jackets are designed to be worn in a confident fashion which is something that this design is attempting to imitate. Changing the idea of sensory stimulation clothing from something that is seen as juvenile to something that allows the user to feel empowered in their skin without feelings of fear and overwhelming distress. This leads to the empowerment of the wearer both mentally and physically through the slick, yet comforting, design schematic.

Figure 23 -

Semantic Profile

The design easily conveys the functions of the concept along with directing the users to locations of the controls and how to operate the mechanisms. This is done by using sweeping curved forms that direct the users' eyes to the mechanism controls on the front left side of the shirt. Colour

also influences the semantic profile as the use of accent colours also draws users to the correct location of controls without having to search. The shirt is designed to evoke a sense of comfort and safety while also empowering the user to be confident in new and often triggering situations. Next, the control mechanisms feature a small yet discreet symbol of the action they control. For example, the tightener features two arrows pointing towards each other, describing that this controls the tightener. Also, the form is highly driven by human factors as this is a skin-tight undershirt that will tighten and vibrate depending on the user's needs. Both of those functions stimulate the proprioceptive sense, calming and centring the user.

Colour Selection

Different colours were compared in the conceptualization of this design, leading colours being white, grey, black, and light blue. However, through research, it was determined that a dark grey would be best suited for this design. The colour choice for the fabric is charcoal as this is a good neutral colour that won't cause any distractions through the overshirt. The design however is not completely black, there will be accents of blue and yellow to give the design more life and to create a more enjoyable experience with the user. these accents will be focused mainly on the mechanism triggers. This will draw the attention of the primary, secondary, and tertiary users to mechanism locations and controls without additional thought.

Texture

Another vital part of this design is the material textures. The concept should feel like a second skin with no itchy tags or bulging seams, as these are triggers for many children with sensory processing

issues. The shirt itself should be made from an athletic material that fits tight to the body without discomfort and digging into the wearer's skin.

3.5 Sustainability – Safety, Health, and Environment

Materials

There are new advances in Eco-spandex on the market today, two of which are LYCRA T400 Eco Made fibres and ROICA Eco-Smart. The LYCRA T400 fibre (Figure 24) is made with 65% recycled and plant-based material. It mainly used recycled PET and dextrose derived from corn. LYCRA fibres have also been awarded C2C Gold Level Material Health Certificates.

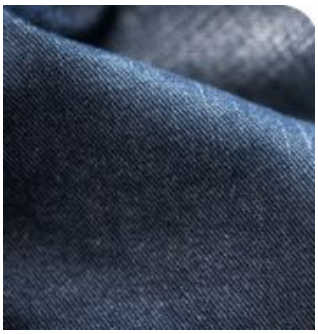


Figure 24 - LYCRA T400 (https://www.lycra.com/en/business/search-technologies/lycra-t400-ecomade-fiber)

ROICA Eco Fabrics was the world's first certified elastane by the global recycled Standards (GRS) and is made from inhouse waste. This material contains 58% of pre-consumer recycled contents and forecasts an almost 50% decrease in $C0^2$ emissions as shown in Figure 25. (Kasei , *The modern wardrobe roica*)

Figure 25 - GWP ratio (https://www.asahi-kasei.co.jp/fibers/en/roica/specialities/index.html)

Manufacturing

Many manufacturers are taking steps to reduce waste and reduce the amount of new raw material being extracted, the biggest step of which being their spandex recycling systems. The

company Spanflex reports to manufacture 4,200 tonnes of recycled elastane fibre per year. The following image (Figure 26) depicts the process of recycling spandex.

Figure 26 - Elastane Recycling
(https://www.spanflex.com.tw/english/fabrics/detail.php?dpid=17)

Next, on the issue of microplastic, some manufactures are working on new ways of weaving or knitting the garment that reduces the number of fibres that are released. Spanflex designed a neoprene-like 3D garment that utilizes a fluffy knitted connecting layer. This results in a fabric with the same firm characteristics of neoprene but with improves breathability as well. Figure 27 features a cross section diagram of how this fabric connects.

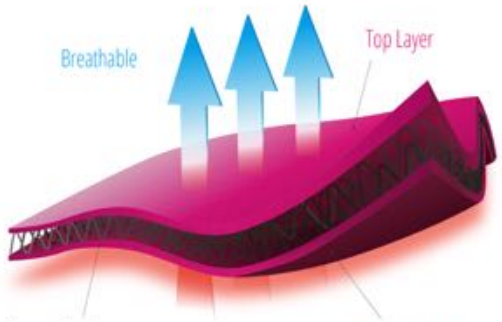
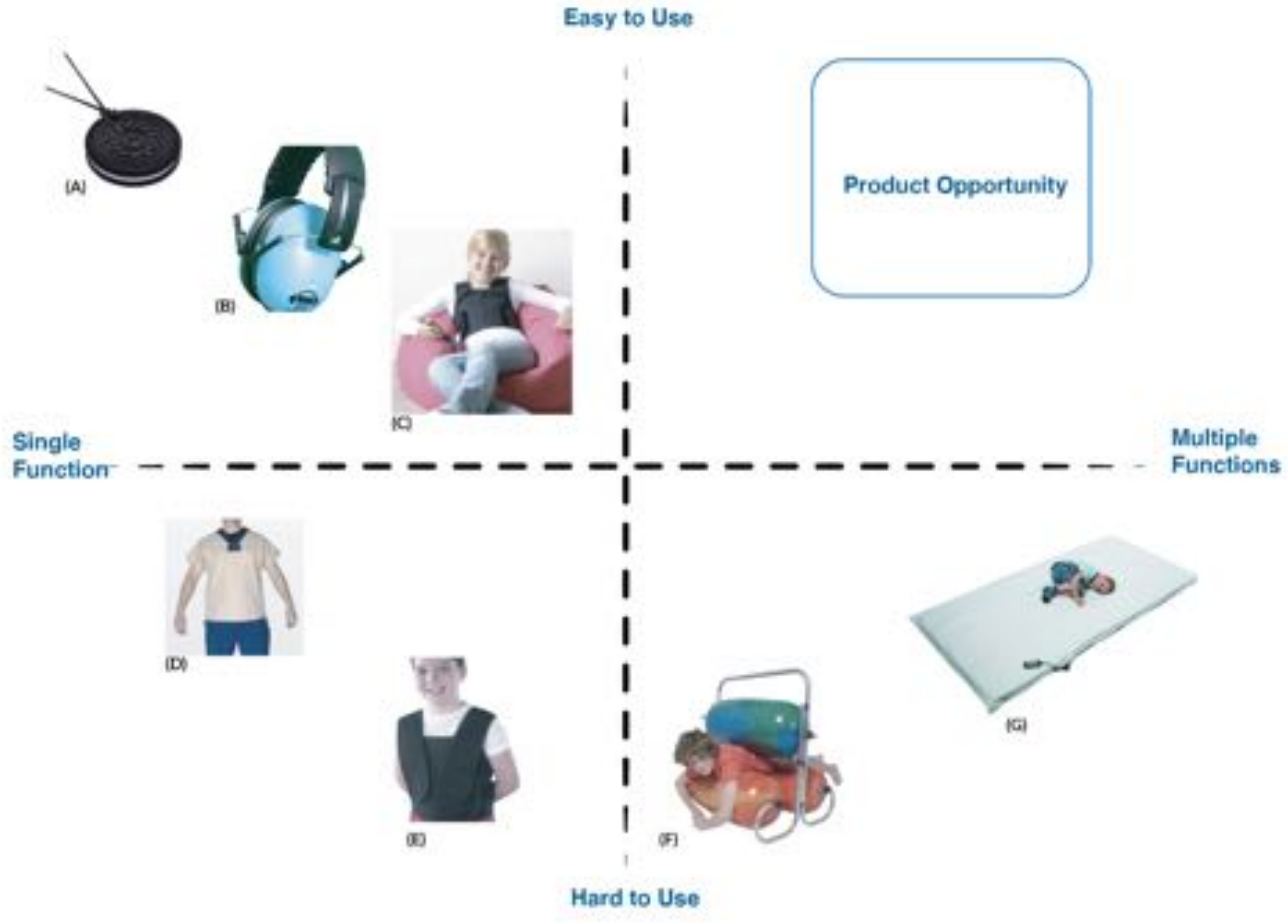


Figure 27 - Connecting Layer
(https://www.spanflex.com.tw/english/fabrics/detail.php?dpid=5)

3.6 Innovation Opportunity

By analysing existing products and using a innovation opportunity graph it is clear that the product should be easy to use and should have more than one function. Interesting products that are the closest to the product opportunity are (c) which is the squeeze vest, and (g) the vibration mat. These both are highly functional in their respective uses, but both have room for improvement, leading to the product opportunity.

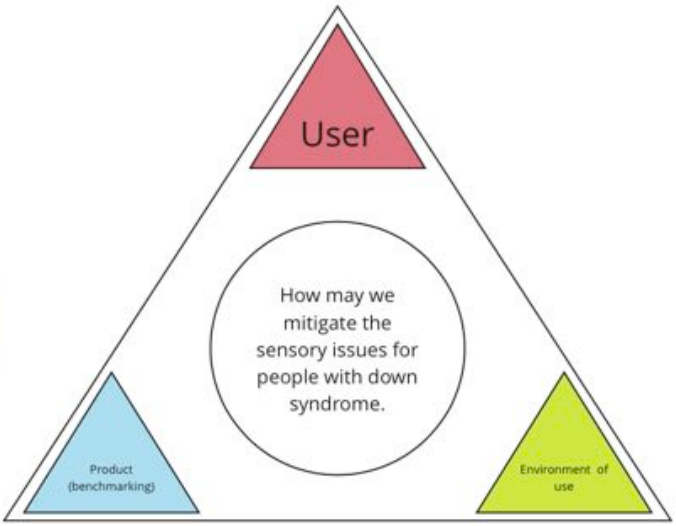
Table 10 - Innovation Opportunity



3.6.1 Needs Analysis Diagram

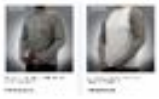
To determine needs compared to current product as well as environment they are used in a triangulation of needs was developed. Using sticky notes with corresponding colours to the triangle each point was scoped out.

Table 11 - Triangulation of Needs



These points were then expanded upon to better understand the struggles of each group in each environment or situation. Points are expanded upon below.

Table 12 - Needs Analysis

User		Product	Environment
Primary Children ages 13-18 with Down syndrome	       	Wearables **Chewlery** • Expensive and easily lost or broken • Not made for "adult teeth" • Hard to keep clean • Childish • But is better for oral health then chewing on random objects **Weighted Vest** • Can only be used for 20 mins • Places pressure onto the spine • Bulky **Rip Proof Clothing** • Unfashionable and unflattering (isolating) • Thick seams can cause tactile sensory distress • Doesn't solve the problem, user will likely turn to ripping something else. **Deep Pressure squeeze vest** • Similar to the weighted vest but doesn't put the pressure on the spine as it uses air pressure • Can only wear the pressure for 20 mins • Requires decent hand motor skills to pump the vest **Noice cancelling headphones** • Good for auditory filtering • bulky • can make user seem antisocial Large Equipment • **Vibrating mat** • **Squeeze machine** • Large and not portable • Only helps while in or on it • Very expensive **Heavy therapy rope** • Good for muscle feedback and exercise • Heavy and rope texture can be unpleasant • Expensive • Not portable	Elementary school • Frustration due to communication problems with teachers or other class mates • Trouble fitting in High school • Frustration due to communication problems with teachers or other class mates • Trouble fitting in • Longer class times and less breaks • Commute between classes • being placed in a "special classroom" (isolation) At home • Low energy • Sensory seeking behaviour can be seen as just being grumpy • In Public (parks, malls...) • Loud sounds may trigger overloads • Often tired from walking very quickly due to hypotonia (low muscle mass) • No safe places to recenter themselves if needing sensory stimulation or are having a sensory overload
Secondary Parents and family members of child	 	Wearable **360 roller ball massage mitt** • Can be used to calm child down • Hard to use in public • Can't use while driving Chew Bead Necklaces • worn by secondary user and used by primary • Designed for baby's to use • Can be heavy and embarrassing to wear in public	At home • Issues getting child to focus on their work • Sensory seeking behavior might cause child to rip clothing or other items. Or chew on household things • Might have a hard time getting child to calm down and follow instructions • Dealing with a lack of motivation from child In public • Afraid others are looking down on their child • Wants child to fit in and have friends • Doesn't want them to be excluded • Sensory overload may lead to child throwing tantrum in public
Tertiary Teachers and Special education workers and PSWs	 	Equipment **Wobble chair** • Easy to instal and keeps student hopefully seated • Rocking helps reducing anxiety and stimulating muscles • But could cause distraction Wearable **Bite proof clothing** • Expensive • Can protect user from sensory seeking behaviour (eg biting) • Only comes in 1 style • Reviews state fabric texture repels students seeking sensory stimulation	In class • Hard to pay attention to student and give them the attention they need • Hard to deal with student outbursts • Hard to get child to focus on lessons • Hard to deal with disruptions to the class • Can be bit or hit if child is seeking stimulation

Studies have shown that the most problematic sensory issues for individuals with Down syndrome are low energy/weak, under responsive/seeks sensation, and auditory filtering (Will et al., 2019). These issues are proven to be main contributors to maladaptive behaviour that is seen as unhealthy by others.

As shown in the triangulation this maladaptive behaviour hurts all three users; causing emotional and physical distress to the primary user, stress and worries to the secondary users, and frustration and stress to tertiary users.

The behaviours are largely dependent on environment of use, for example on a school bus there can be extreme auditory filtering issues which can lead to stress and frustration. In class sensation seeking behaviour, often expressed by running, jumping, and other physical activities can be seen by others as purposely disruptive behaviour. On the other hand, being under responsive to stimuli would show as not participating in discussions or activity and can be seen as being self-absorbed and having trouble concentrating.

There are many benchmarked products to help with sensation seeking behaviours such as Chewlery, weighted vests, and tear proof clothing. these products are marketed towards the primary users, but they miss the mark for age. for example, Chewlery is designed with bright colours and in shapes like Oreos and Legos, obviously designed for use by children. On the other hand, there is the tear proof clothing which is designed to be completely rip proof but there is a lack of style in the designs, often resembling medical uniforms. Lastly weighted blankets are proven to be helpful to give feedback the Proprioceptive sense, but these jackets can only be worn for 15 mins and are big, bulky, and repeated use can cause stress on the spine.

3.6.2 Desirability, Feasibility, & Viability

Using Needs Analysis Diagram, a desirability, feasibility, and Viability

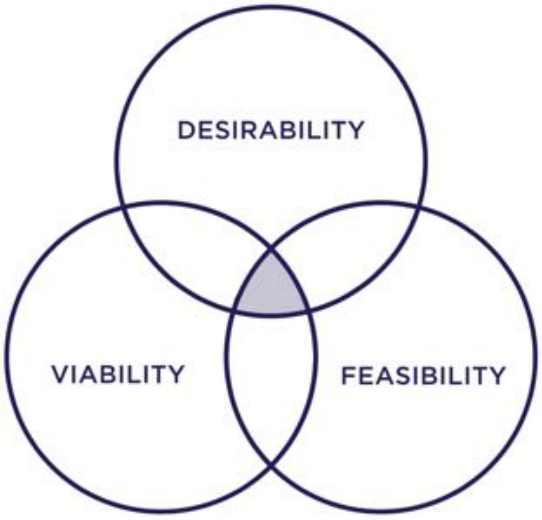


Figure 28 - Needs Analysis Diagram
(https://www.ideou.com/pages/design-thinking)

Desirability

Sensory processing difficulties can arise at any moment of any day. It can often be hard to keep a sensory product on hand 24/7 as most are either large and bulky or they are small and forgotten or lost. Another problem is that there is a stigma associated with some "special needs" products, other children may make fun of the user for using them. This can cause emotion and physical strain to the child. Not many products are designed to be discreet but also provide the support the child requires.

Viability

It can often be hard to keep a sensory product on hand 24/7 as most are either large and bulky or they are small and forgotten or lost. Another problem is wear time, products such as weighted vests can only be utilized for a short amount of time or they may cause issues to the child's developing spine. Meaning these products must be put on and taken off multiple times. Which can become irritating and time consuming causing the user to become frustrated with the device and not wear it as

often. A solution would be to design a product that can be worn all day and extra stimuli can be activated easily whenever the child requires. Additionally, this product is designed for children with Down syndrome, but the product can be utilized for other children who are neurodiverse or struggling with sensory processing difficulties.

Feasibility

The technology employed in existing product solutions is either very basic or generic, not designed to properly address the demands of the consumer. The consumer will have a more tailored product made specifically for this scenario if a unified product solution is created that uses compression methods as well as vibrotactile stimulation. Vibration is currently employed in sensory devices, but it hasn't been used in textiles, and the idea of changing body experience through vibration patterns hasn't been utilized in this fashion yet either. Use of these technology's is easily feasible in this scenario.

3.7 Summery of Chapter 3 – Defining Design Brief

Goal

A specialized sensory therapy product that provides instant sensory stimulation in any occasion for teens with Down syndrome dealing with sensory processing difficulties.

10 objectives that will guide the design of a solution for sensory processing difficulties in teens with Down syndrome:

1. More comfort and ease of use for the user
2. Easily adjustable
3. Mitigate the stresses caused from lack of sensory input

4. Mitigate maladaptive behaviours caused by lack or sensory input
5. Safe for continuous use
6. Aesthetically pleasing design
7. Integrate deep pressure and vibration to target and stimulate the muscles
8. Materials are sustainable and environmentally friendly
9. Monitor stress levels
10. Easier interaction with the product

CHAPTER 4 : Design Development

4.1 Initial Idea Generation

4.1.1 Aesthetics Approach & Semantic Profile

The sensation of personal empowerment should be one of the main emotions evoked by this product. The sensation of being at ease in one's own skin and having the freedom to live the life one desires. The designs of superhero suits were used as inspiration; many of them are skin-tight and have formidable strength-evoking designs. The styling should be simple yet elegant; this product isn't meant to be seen by people often, yet it should still be a fun piece that empowers the person wearing it.

4.1.2 Mind Mapping

Figure 29 - Mind Map

4.1.3 Ideation Sketches

The following are some preliminary sketches for the design of the wearable.

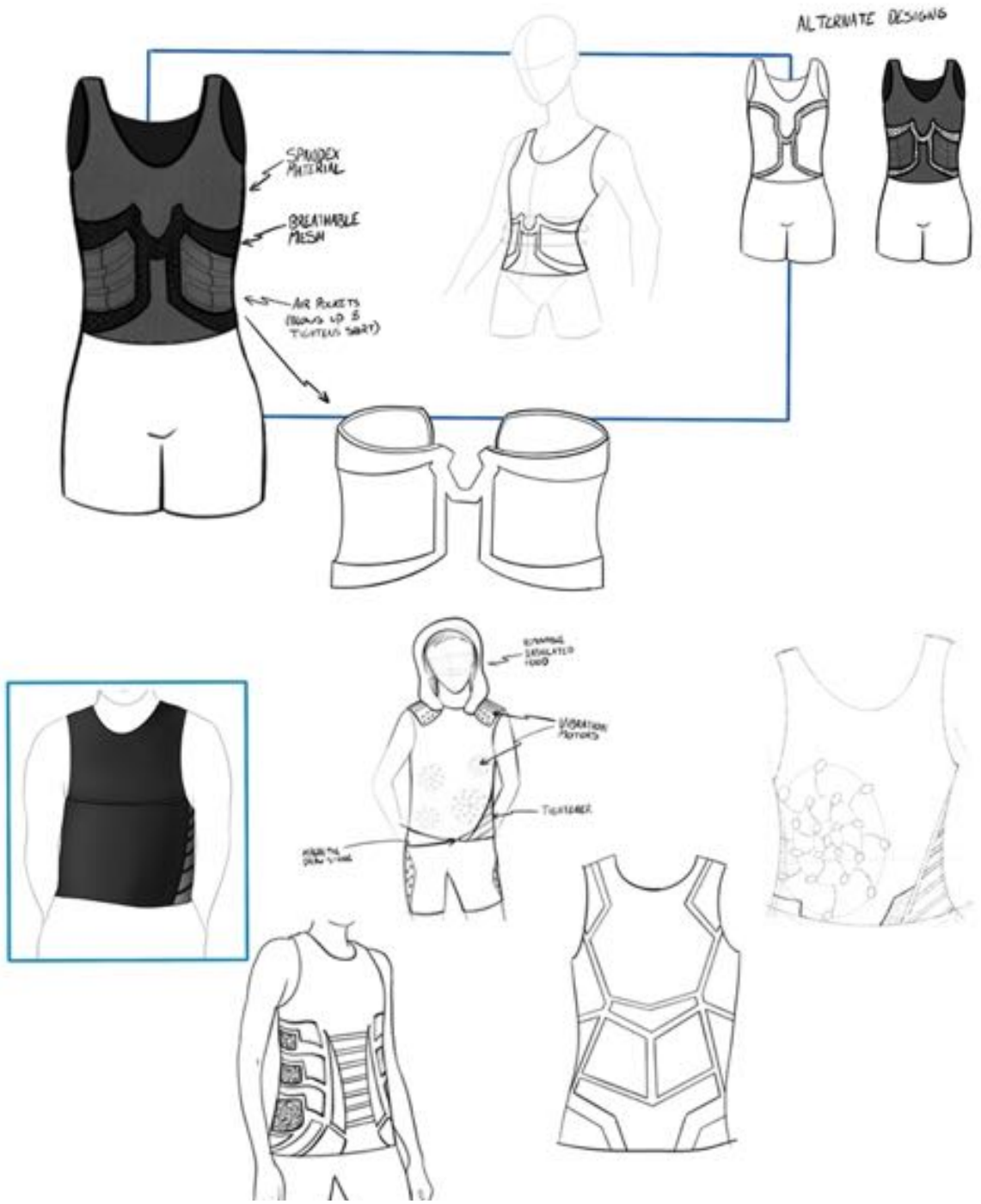


Figure 30 - Preliminary Sketches

4.2.1 Concept one

Concept one is the design for the wearable undershirt that uses lacing and underwires build into the side to tighten the shirt and squeeze the user simulating a hug. This utilizes deep touch pressure which stimulates the muscles and helps sooth users suffering from proprioceptive sensory seeking.

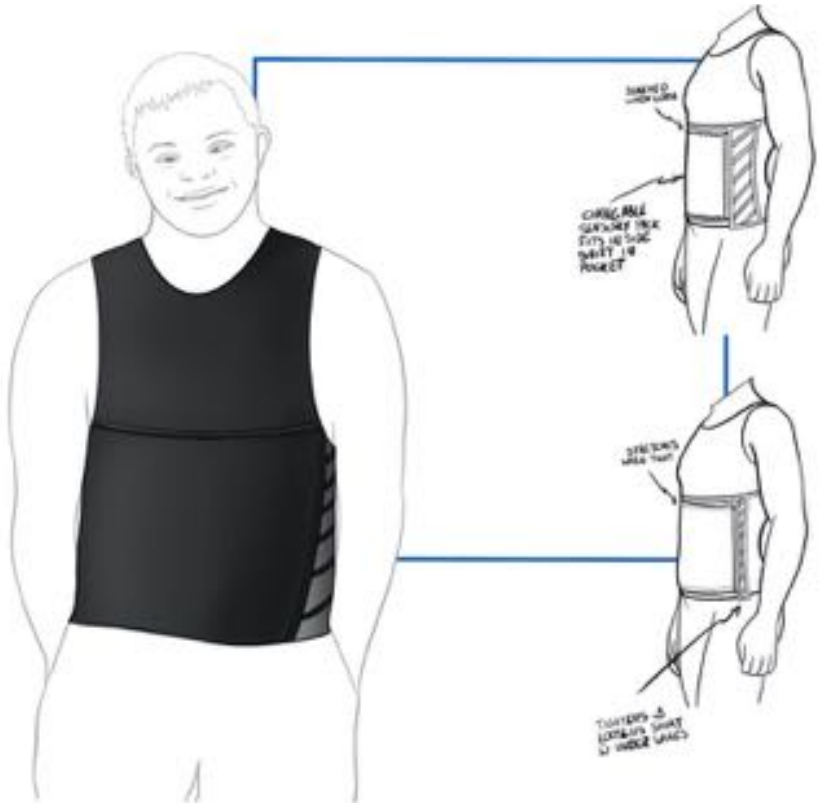


Figure 31 – Undershirt Concept

4.2.2 Concept two

Concept two is a Sensory desk that acts as a compact sensory activity centre. This is meant to be utilized in the classroom and features a removable board filled with different sensory simulation activities such as smooth and bumpy surfaces and different fidget toys. It also has a sensory overload

blockade that can be lifted to help block out external stimuli that might trigger the user.

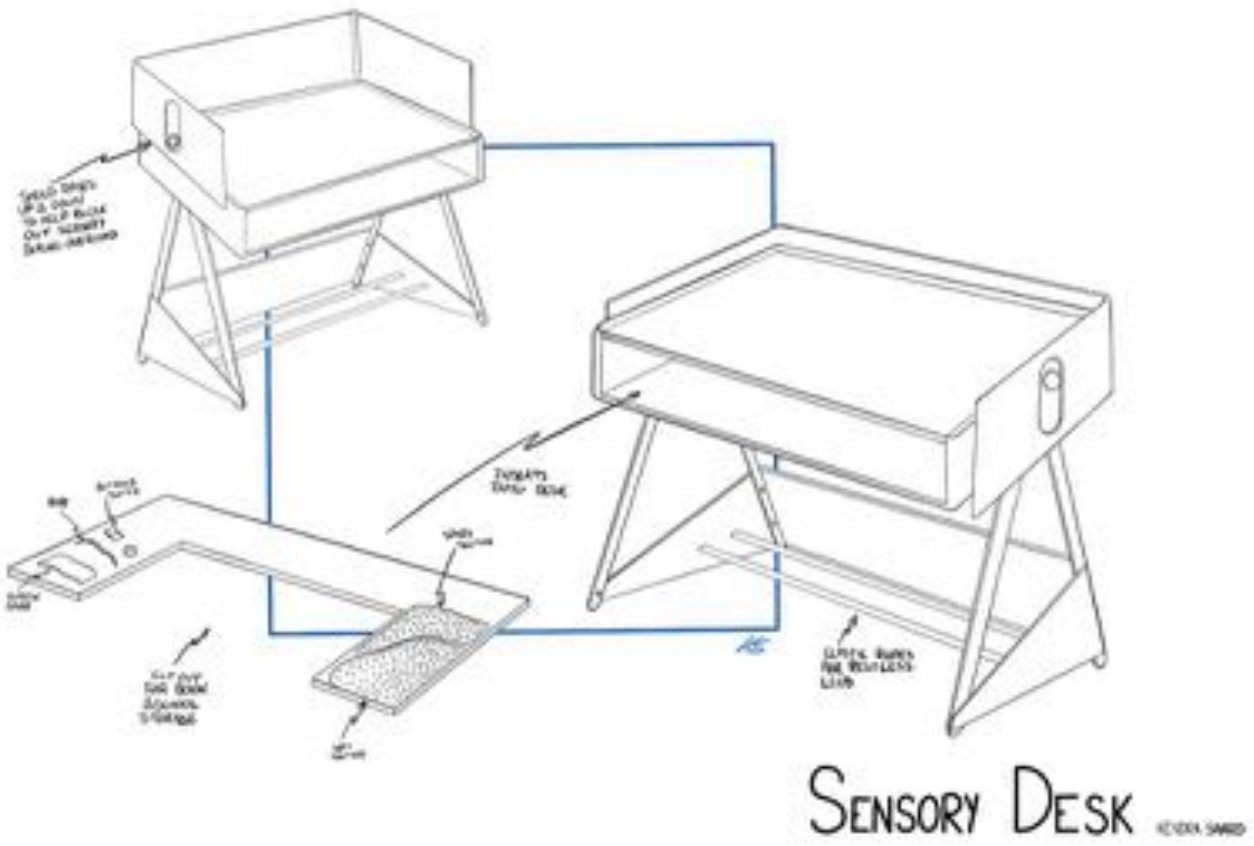


Figure 32 – Sensory Desk

4.2.3 Concept three

Concept three features an auditory sensory blocker. This concept is designed to act like noise canceling headphones without the bulk noise cancelling headphones normally feature. It connects to a smart watch that can control the use of soothing sounds that can be turned on for added comfort in difficult or overstimulating situations.

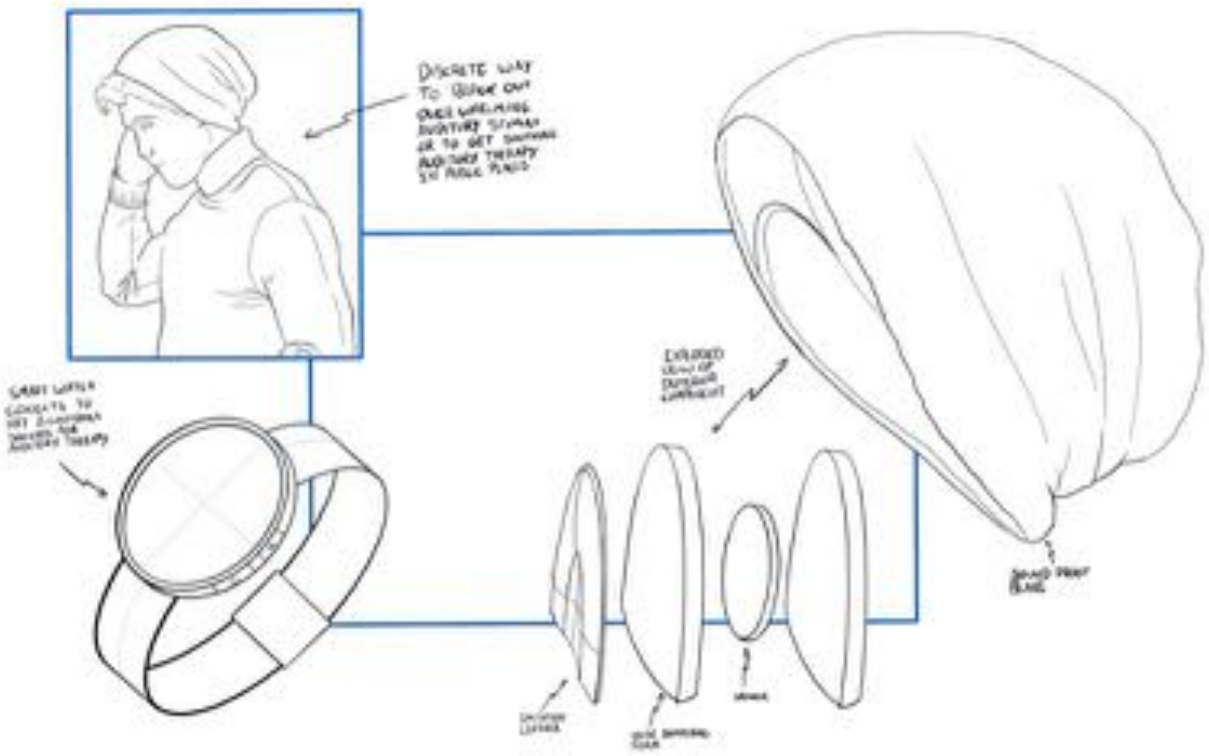


Figure 33 – Sensory Blocking Beanie

4.3 Concept Strategy

4.3.1 Concept Direction & Product Schematic One

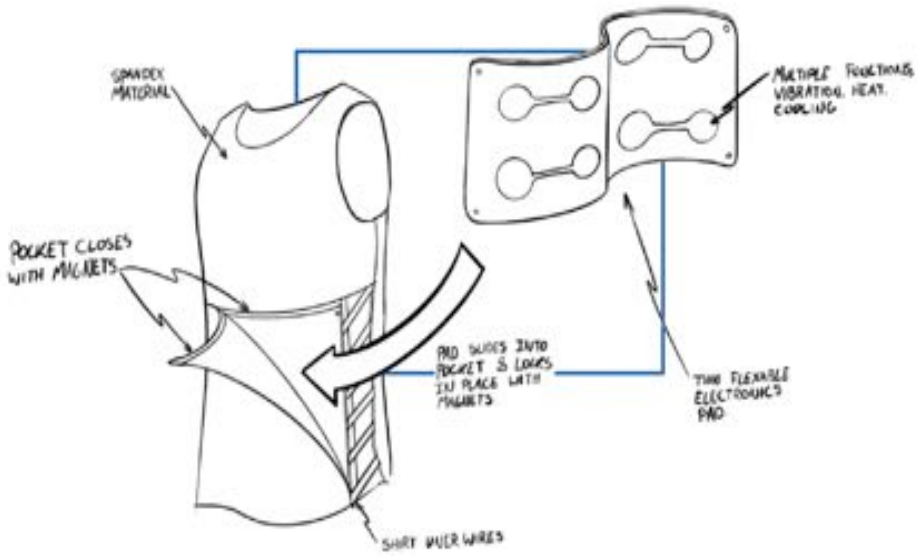


Figure 34 - Concept Direction 1

The first concept direction is a further design of the first pervious concept. It is a compression shirt that uses a flexible electronics pad that preforms multiple functions such as vibration, heating, and cooling. On the side there is a mechanism that utilizes underwiring and cords to tighten the shirt manually to get the hug type feeling from deep pressure therapy. Below is the schematic of the design showcasing percentile sizing of the first concept.

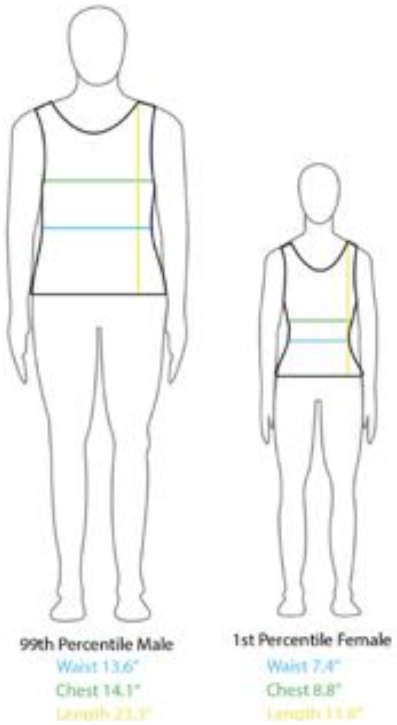


Figure 35 - Schematic 1

4.3.2 Concept Direction & Product Schematic two

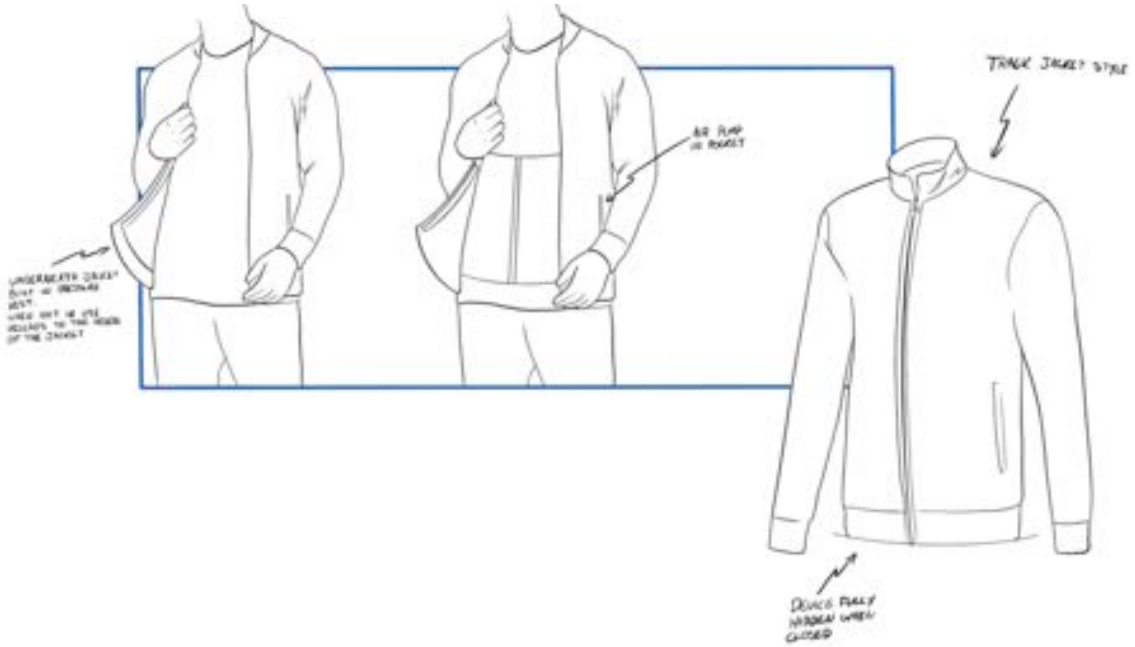


Figure 36 – Concept Direction 2

The second concept is a jacket style sensory garment. This garment uses built in air pockets that the user can pump with air to achieve deep pressure stimulation. The air panels when not in use attach within the jacket and are nearly invisible to the outside eye. Then when the user requires, they can connect the two sides and use the air pump to inflate the pockets. To the right features the schematic for the second concept.

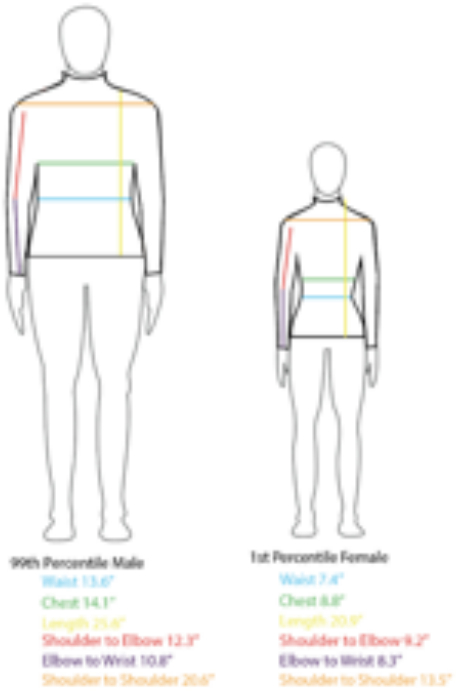


Figure 37 - Schematic 2

4.4 Concept Refinement & Validation

At this point it was determined that the first concept of the compression shirt with vibration would be the design to carry on. From here focus was put on the detailing and aesthetics of the concept as well as the placement and viability of the different technical aspects of the concept. This concept has many features, some of which were later replaced by simpler solutions. This concept uses, vibration motors, a mechanism for tightening the shirt while being worn, and heating and cooling elements, as well as the control built into the shirt.

4.4.1 Design Refinement

A lot of redesigning went into what is shown below. After developing the previous iteration of the concept, the aesthetics needed updating. Drawing inspiration from different superhero's and video game characters the new design formed.

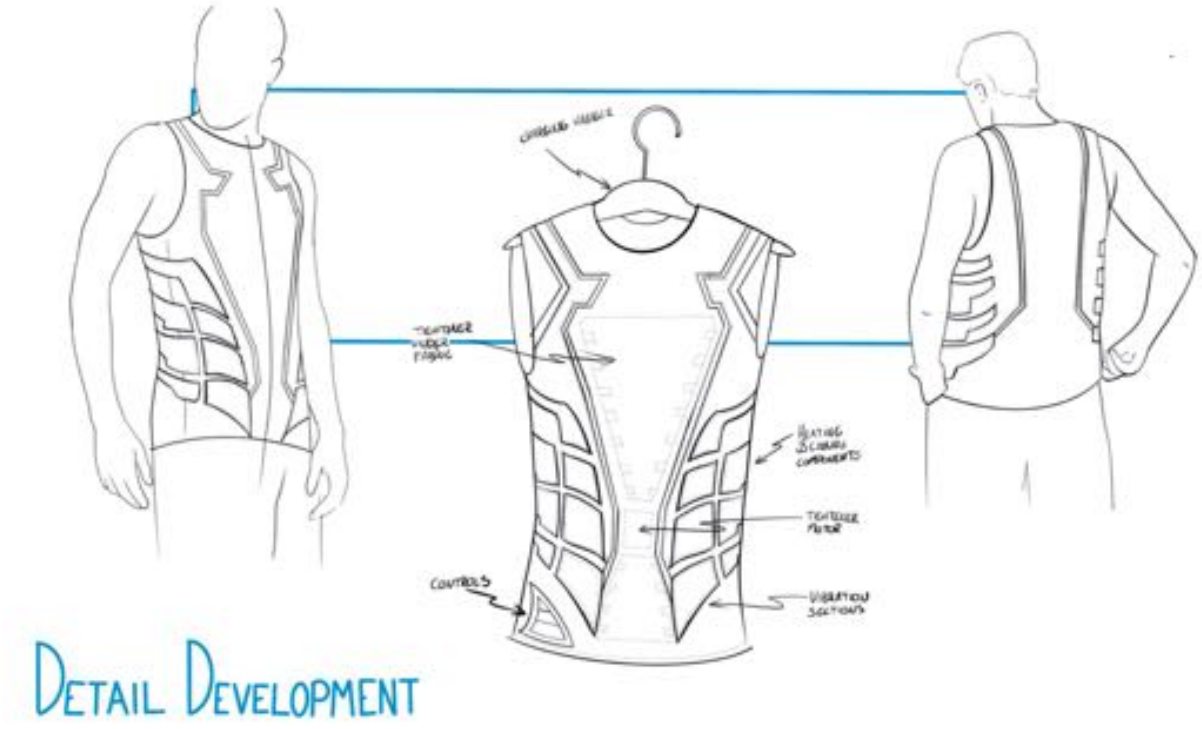


Figure 38 - Concept Refinement

4.4.2 Detail Refinement

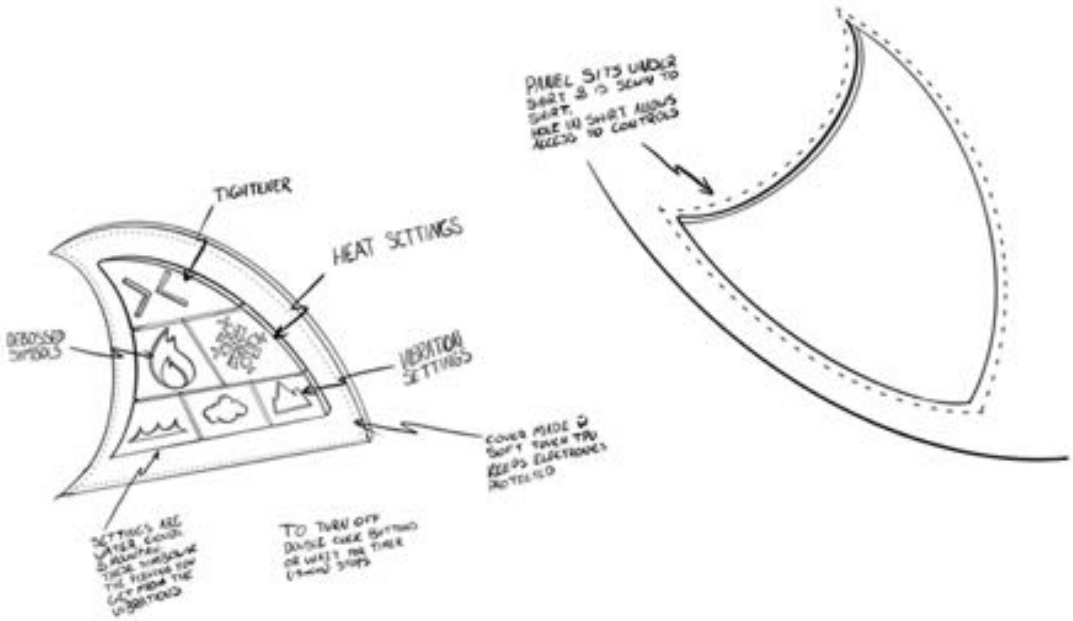


Figure 39 - Controller Concept

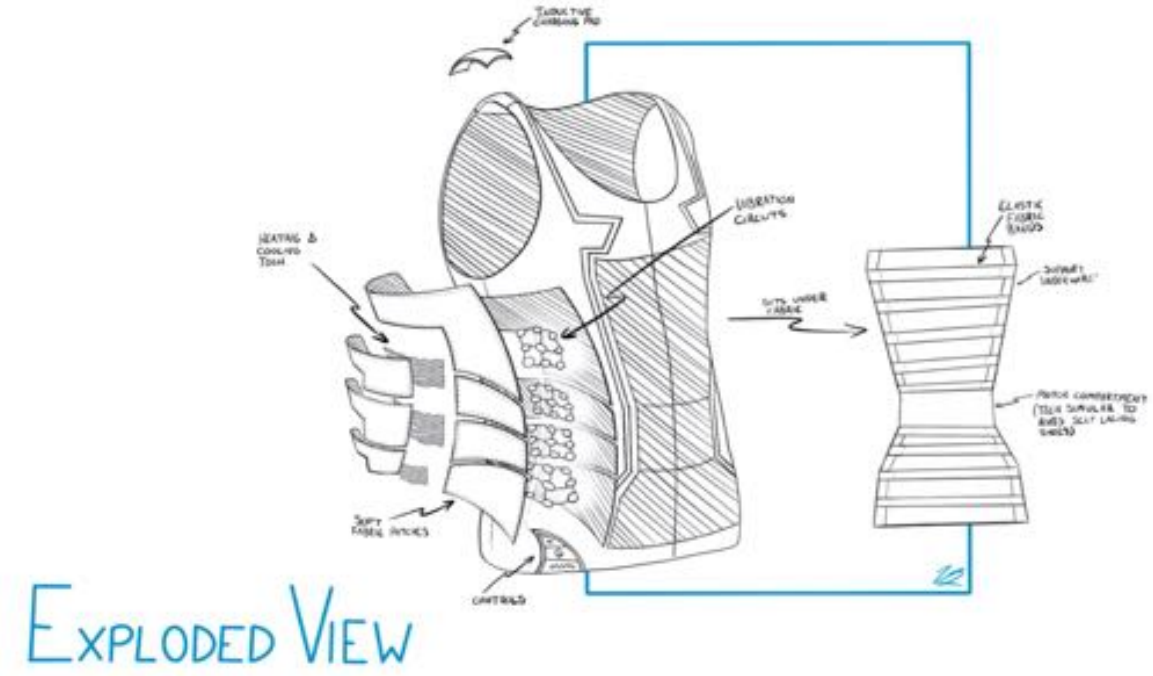


Figure 40 - Exploded View

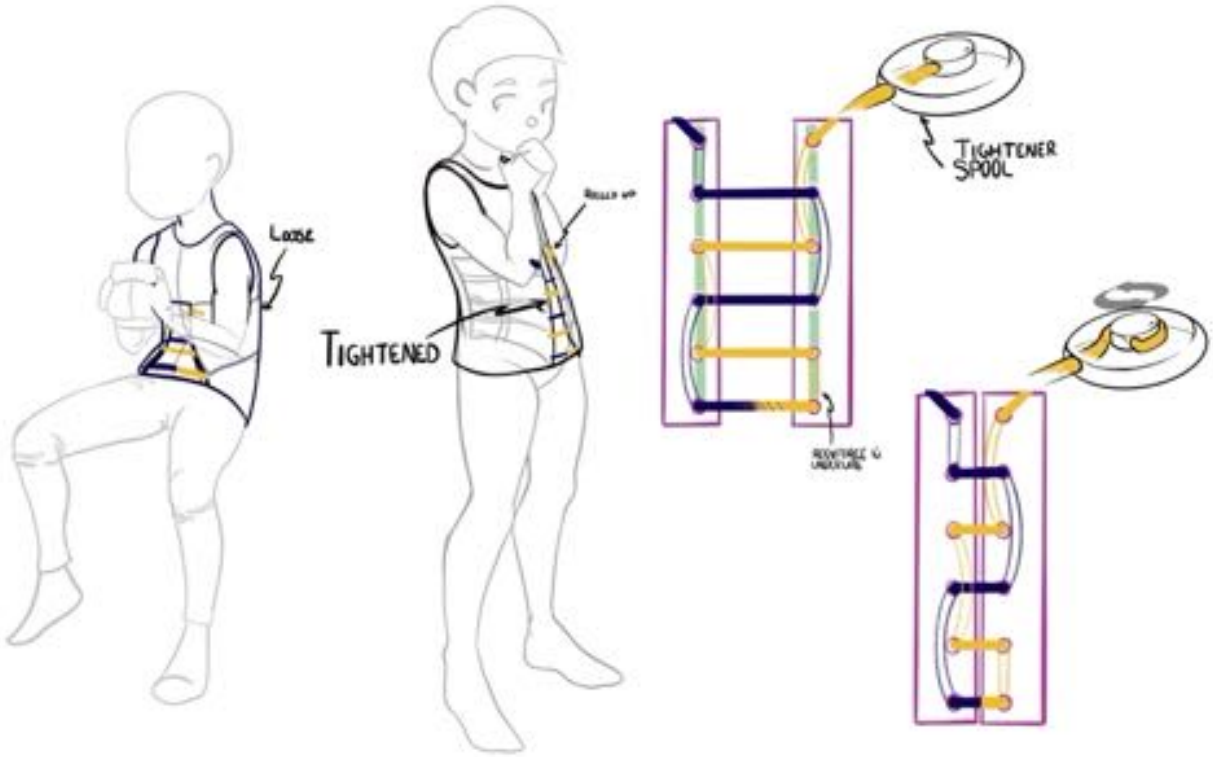


Figure 41 - Tightener Concept

Figure 42 - Rendered Concept

4.4.3 Refined Product Schematic & Key Ergonomic

A new product schematic was developed with the new developed design of the shirt and the charger hanger.

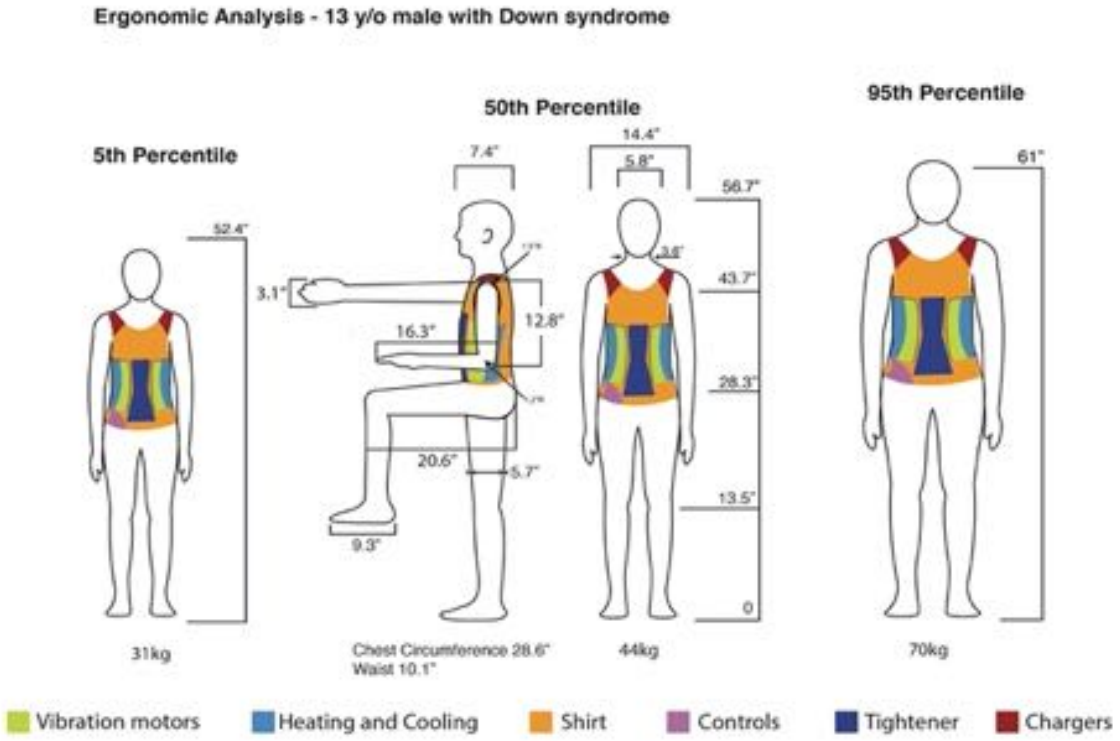


Figure 44 - Product Schematic

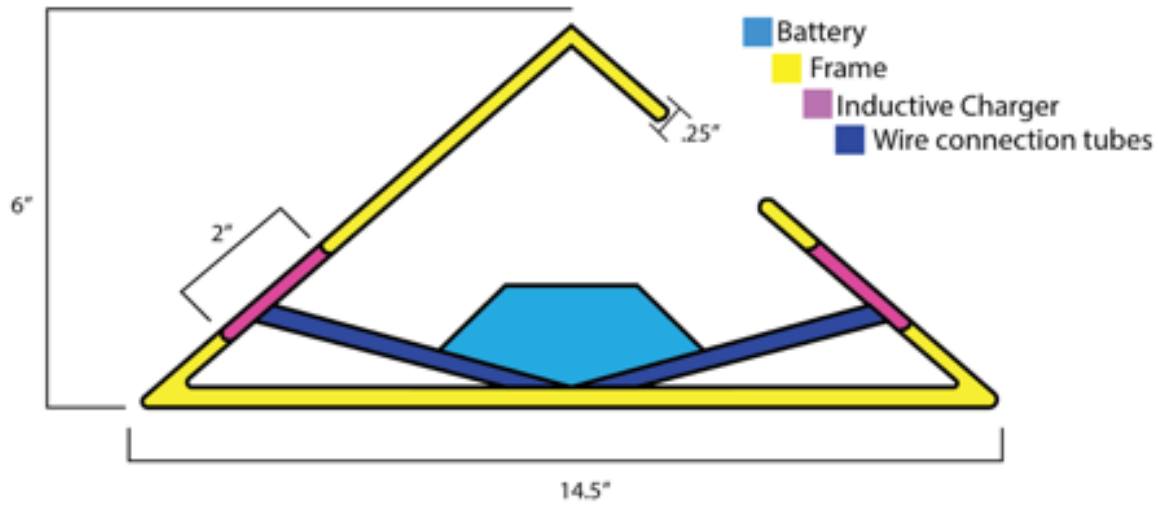


Figure 44 - Hanger Schematic

4.5 Concept Realization

This section will go over the different stages between the previous concept design and the finalized design. By utilizing a 1:1 scale physical model many changed were incorporated to change and polish the design. These changes allow the design to have more feasibility and cause less discomfort for the wearer, both very important sides of this design.

4.5.1 Physical Study Models

A 1:1 scale sketch model of the shirt, hood, controller, and charger was constructed to better understand the viability of the design, placement, and solutions to any other existing questions of the concept. The shirt was hand sewn using a simple jersey knit fabric. The hanger was constructed from cardboard. After this model was developed any flaws or inconsistencies of the design were noted and further development occurred to simplify the style. Another aspect that had to be changed was the tightening mechanism; after consulting with the research advisor, it was determined that having additional ribbing in the shirt would cause great discomfort. It was also found that by using a higher spandex content in the fabric the compression of the shirt by itself would provide enough of the deep pressure stimulation required. Another style change was the controller, the placement on the shirt made it difficult to access once regular clothing was added.

Figure 45 - Scale Model

Figure 47 - Vibration Unit

Figure 46 - Scale Model

4.6 Design Resolution

In this stage the name of the concept was finalized, and Alt was chosen. Alt symbolises the altering of the body perception by the vibration patterns used. The following sketch shows the updated design before it is taken into CAD development. The design was simplified to make it a more feasible design and certain technology such as the heating and cooling was replaced by mesh pieces to allow the torso to breath. The ribbing was removed to reduce any sensory overload and make the shirt much more comfortable. As well as an updated product schematic which shifted from a 13-year-old to a 12-year-old to fit the mannequin acquired.

Figure 48 - Final Concept Direction

Figure 49 - Finalized Remote Design

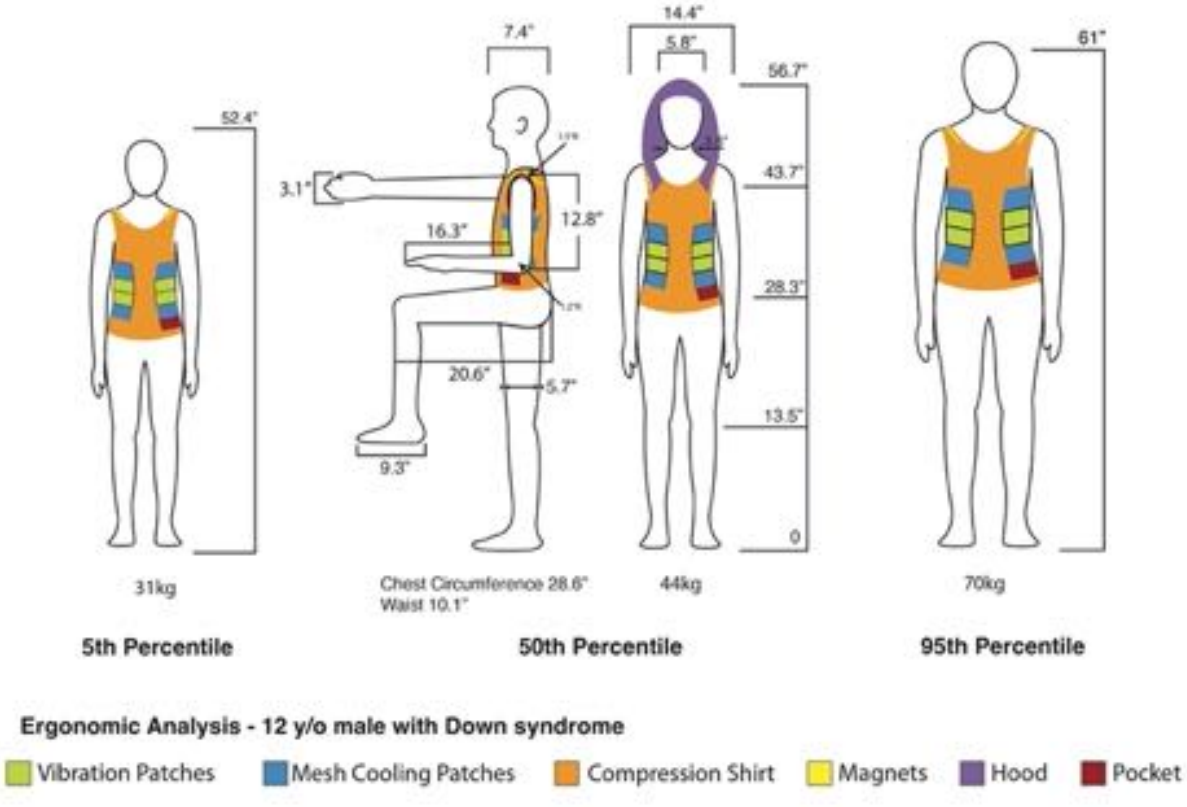


Figure 50 - Finalized Product Schematic

4.7 CAD Development

After the final design was accepted, CAD was designed to aid with completing the specifics, finalising measurements to begin sewing, and sending the remote design for 3D printing. Below features a step-by-step process of the CAD development in both the remote and the garment. The Remote was built using Soildworks and the garment was developed using Clo3D.

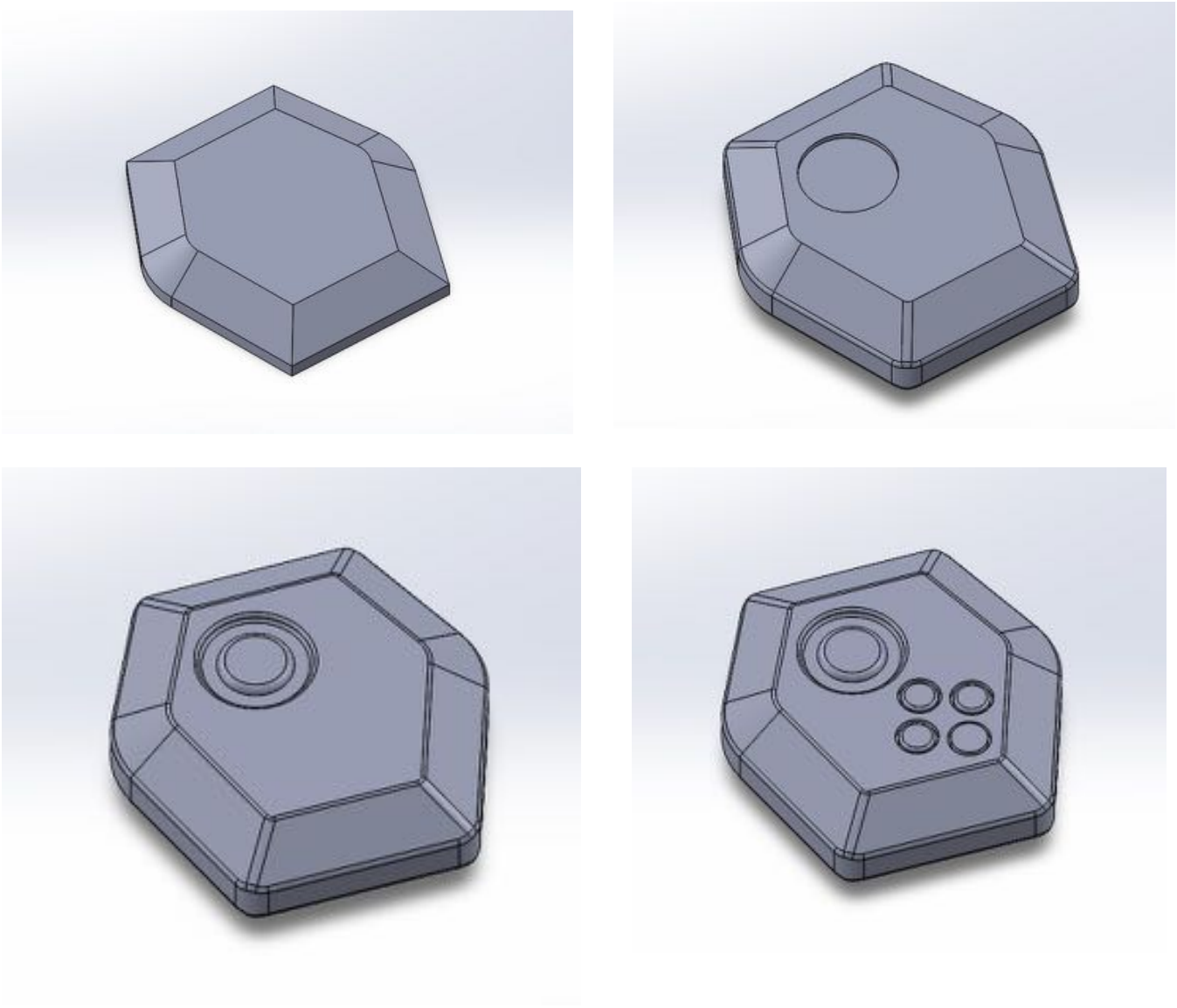


Figure 51 - CAD Development

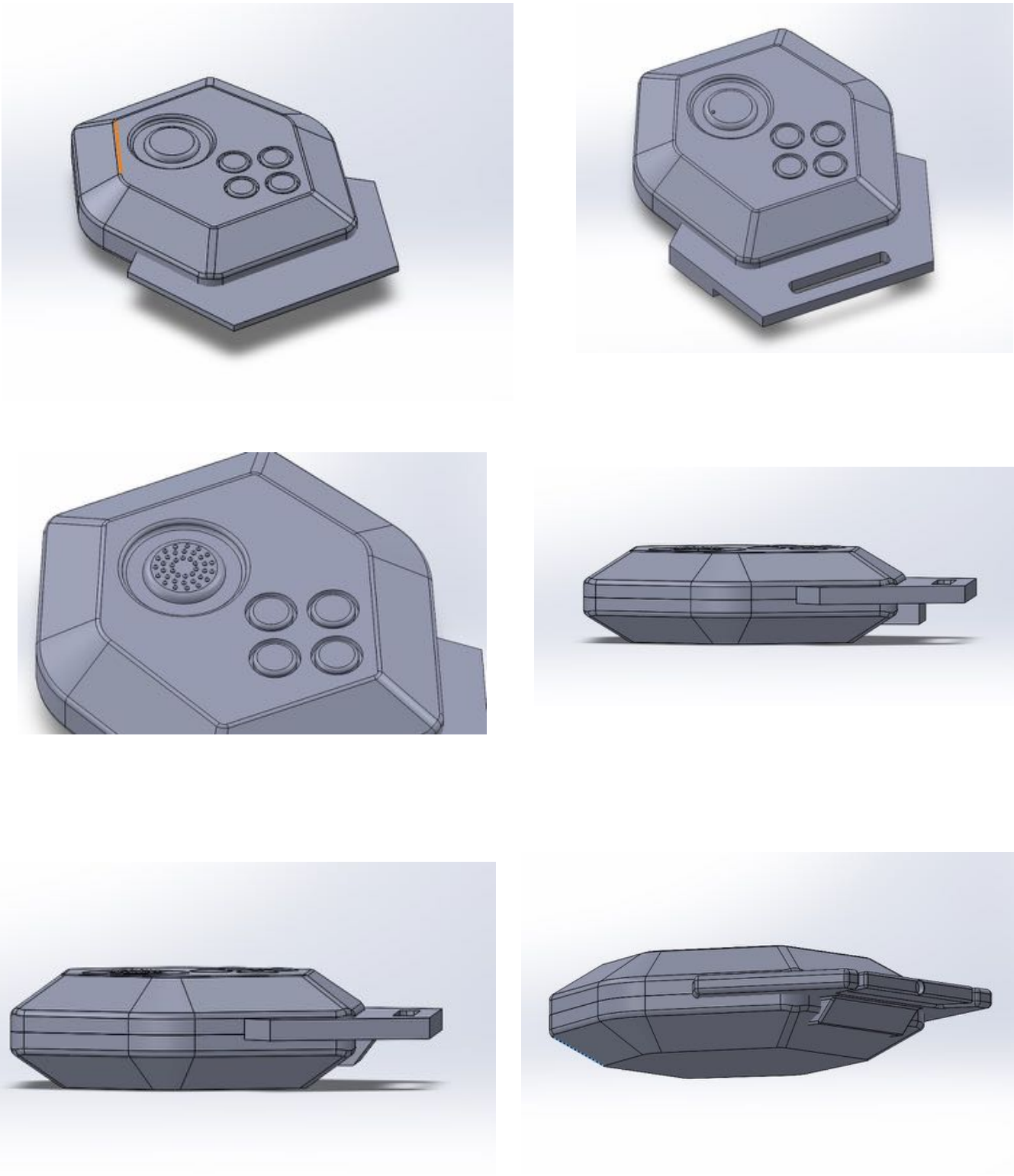


Figure 52 - CAD Development

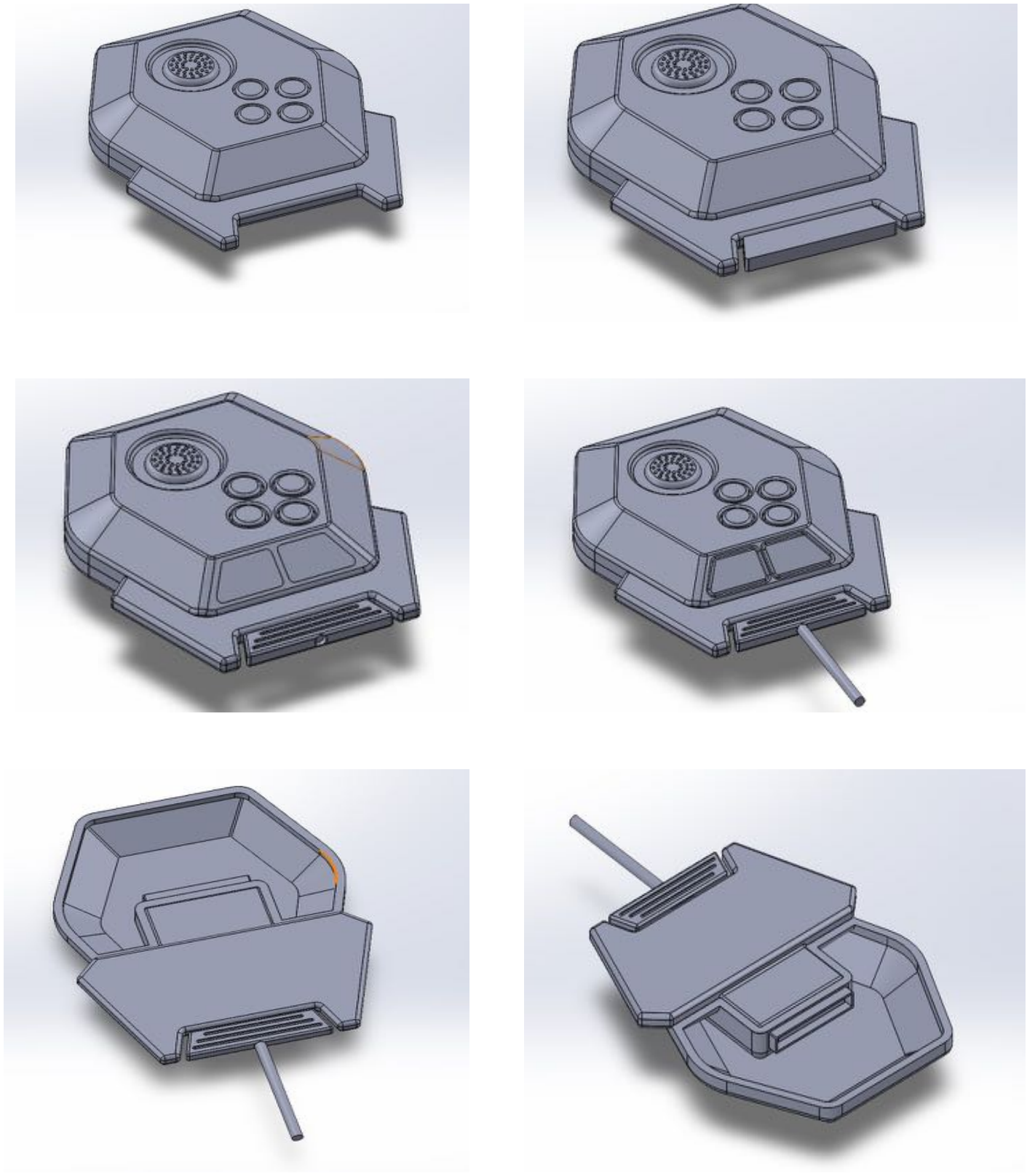


Figure 53 - CAD Development

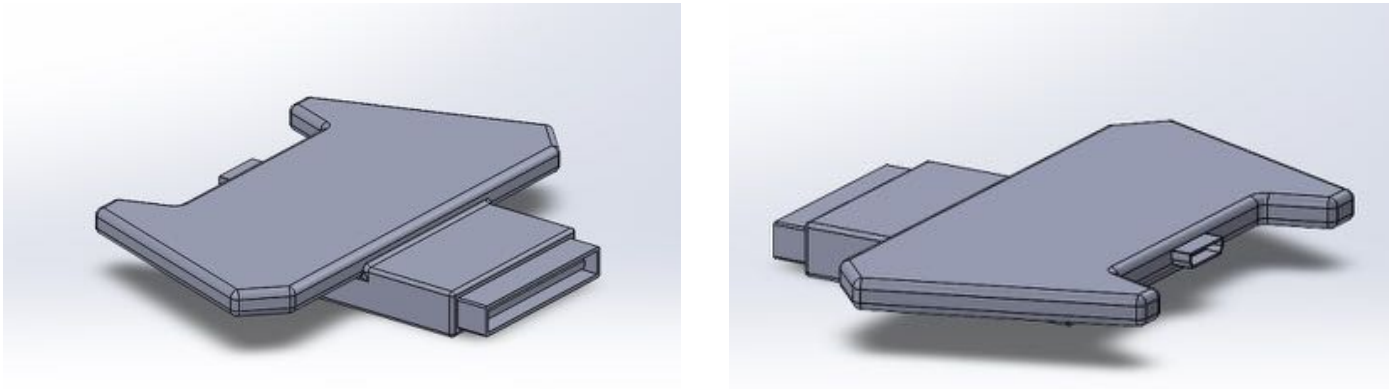


Figure 55 - CAD Development - Battery

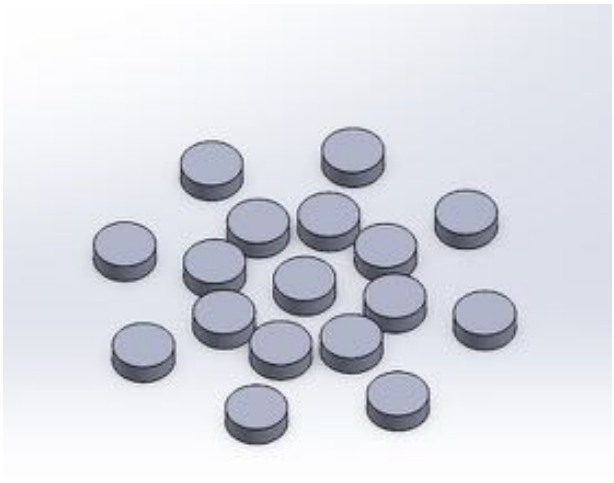


Figure 54 - CAD Development - Vibration motors

Figure 56 - CAD Development - Shirt

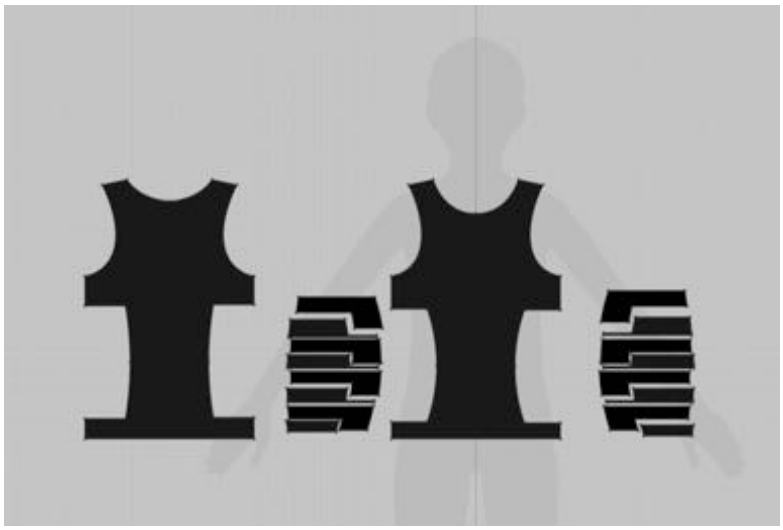


Figure 59 - CAD Development - Pattern

Figure 60 - CAD Development - Shirt 2

Figure 61 - CAD Development - Shirt 3

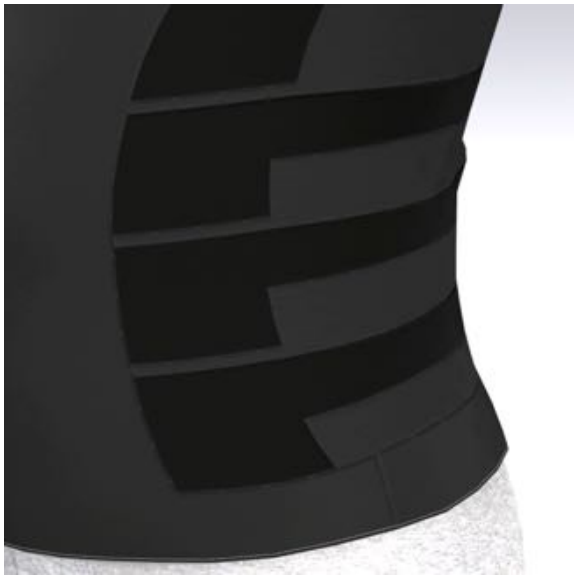


Figure 57 - CAD Development - Shirt Close Up

Figure 58 - CAD Development - Hood

4.8 Physical Model Fabrication

The physical model was built by first printing the sewing pattern out, pinning it to the fabric, then cutting the pieces out. Each part was pinned together and then sewn. The main body was sewn together first then the patches were sewn together and lastly attached to the main body. The remote was 3D printed, then sanded by hand and by Dremel. After most the imperfections were removed, the main body pieces of the remote were glued together and Bondo was applied to fill in remaining imperfections. Once it cured, it was sanded again with finer grit sandpapers to be then spray painted.

Figure 62 – Model Fabrication

Figure 63 - Model Fabrication

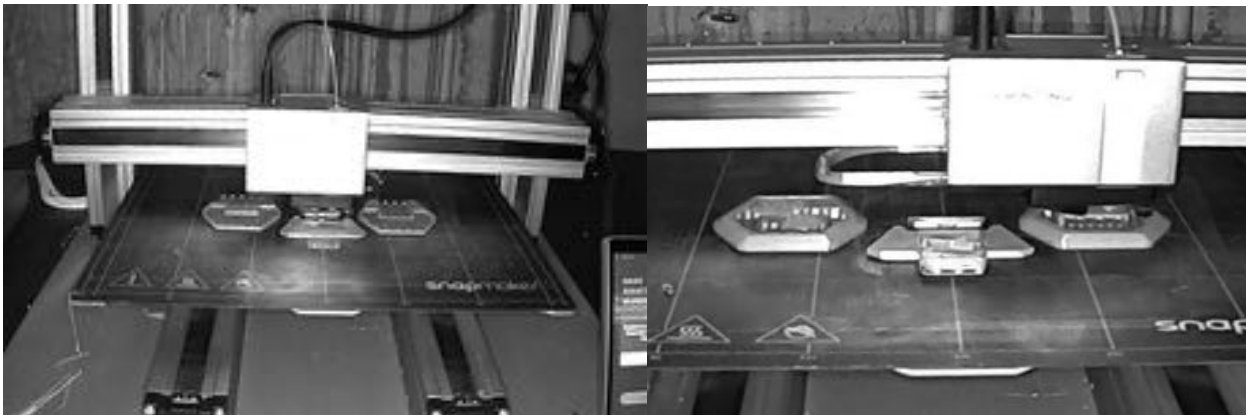


Figure 64 - 3D Printing

Figure 65 – Remote Fabrication

CHAPTER 5 : Final Design

5.1 Summery

Sensory processing difficulties impact many people, but is often overlooked, especially in individuals with Down syndrome, often chalked up to the child being bored and behaving badly. However, the sensory issues these individuals face cause physical and emotional stress and the behaviours expressed are just ways of attempting to cope. Alt is designed to provide the sensory feedback these children are craving in a discreet and healthy way. The goal is to create a solution that empowers the child and provides them the opportunity to participate in all the joyous activities that come with being a child.

5.2 Design Criteria Met

5.2.1 Full Bodied Interaction Design

Alt is designed to be bought according to the child's side; therefore, it would come in a range of sizes from youth XS to Adult XL. The wide range of sizes allows the users to obtain the correct size as the shirt should fit snug to the torso. If it's too loose the compression isn't felt and if it's too tight that will cause discomfort to the wearer. Below is an updated product schematic showing the range for 5^{th} to 95^{th} percentiles for a 12-year-old.

The remote is designed to be small but have large enough buttons and activities that the user can use it easily even with fine or gross motor difficulties. It is designed to fit within the palm and when not being used fit easily into a pocket.

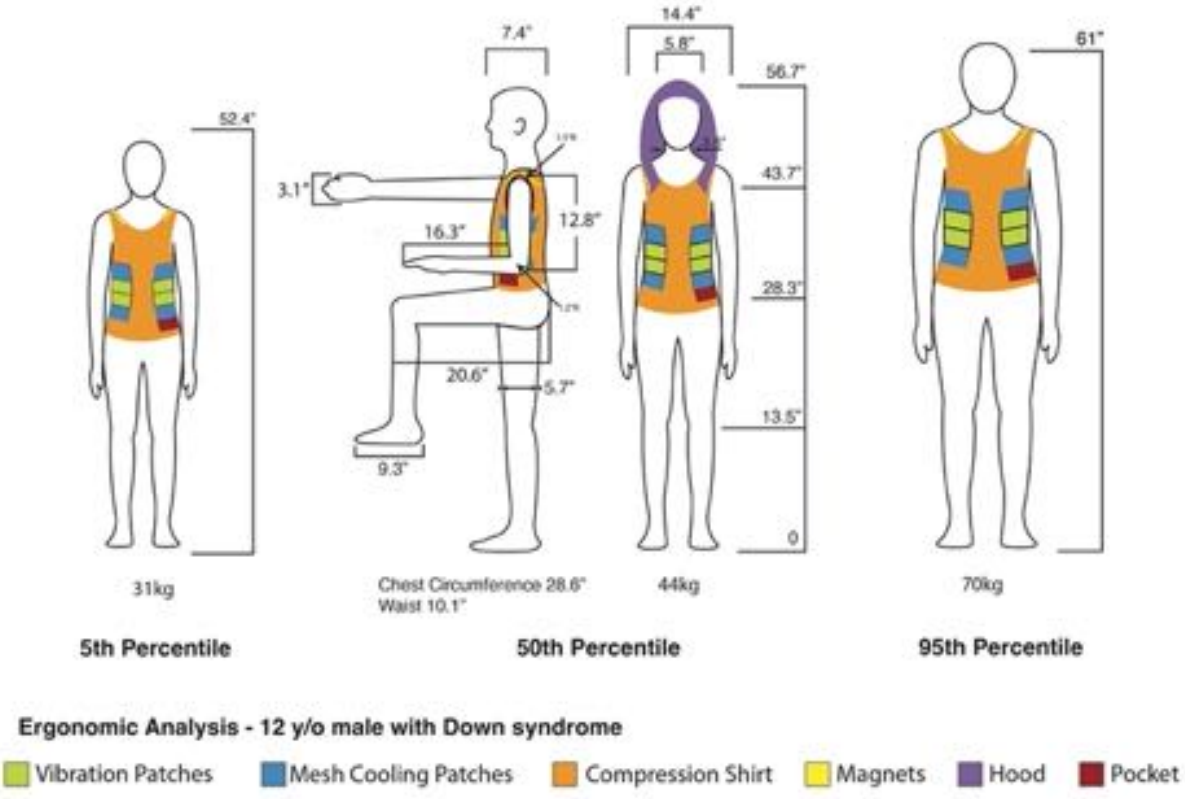


Figure 66 - Product Schematic

5.2.2 Materials, Processes, and Technology

The fabric used in the garment will be a blend of recycled PET and Lycra T400. The side mesh panels are made of a sports mesh fabric made from a recycled PET and cotton blend. And lastly the patches that cover the vibration motors are made of a cotton blend often used in children's clothing and known for its durability and softness. Alt uses a combination of compression, body perception altering vibration patterns, and fidget activities to provide the user with sensory relief. the way the vibration technology works is by using set patterns, see Figure 67 below, to alter the way the mind interprets the sensory feedback. This can change the feeling of the wearers body, making them feel heavy or light as a feather. There are 2 sets of linear resonant actuators, tiny vibration motors, that sit on each side of the torso and deliver these vibration patterns to the external oblique muscles (Thoracic portion) on the body.

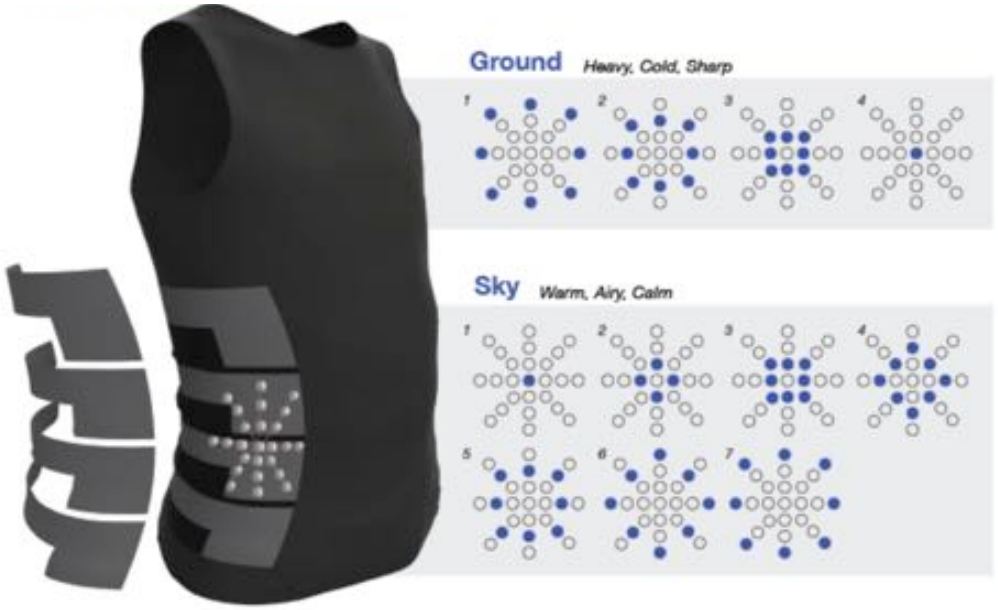


Figure 67 - Vibrotactile Patterns

5.3 Final CAD Rendering

This section presents the final rendered models, rendered in CLO3D and Keyshot.

Figure 68 - Holding Remote

Figure 69 - Sitting at Desk

Figure 70 - In Situ

Figure 71 - Garment Render

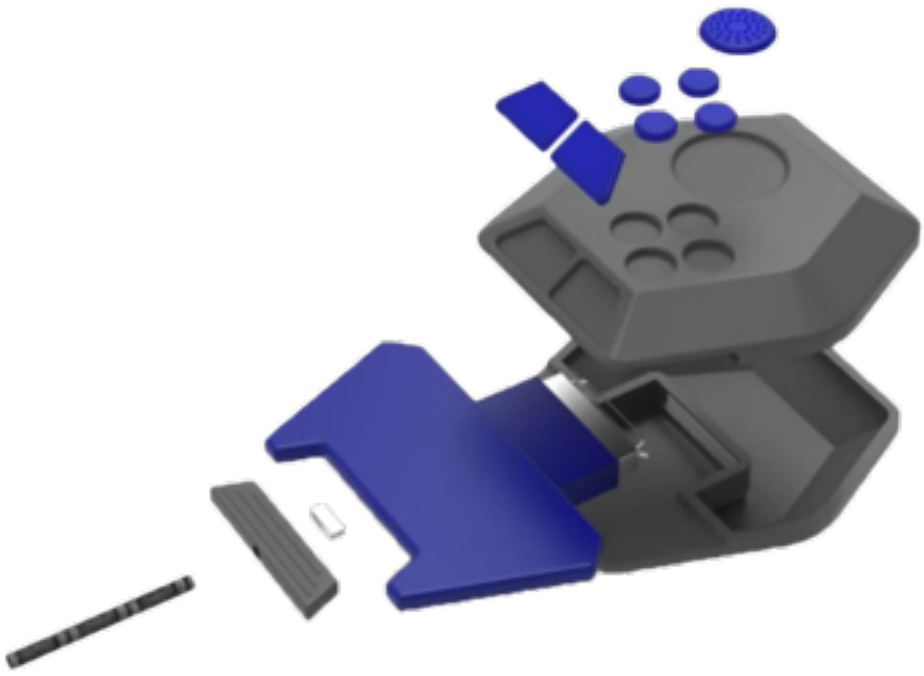


Figure 72 - Remote Exploded View

Figure 73 - Remote Render

5.4 Physical Model

Figure 74 – Physical Model

Figure 75 – Physical Model

5.5 Technical Drawings

This section compiles all the technical drawings of each aspect of the design.

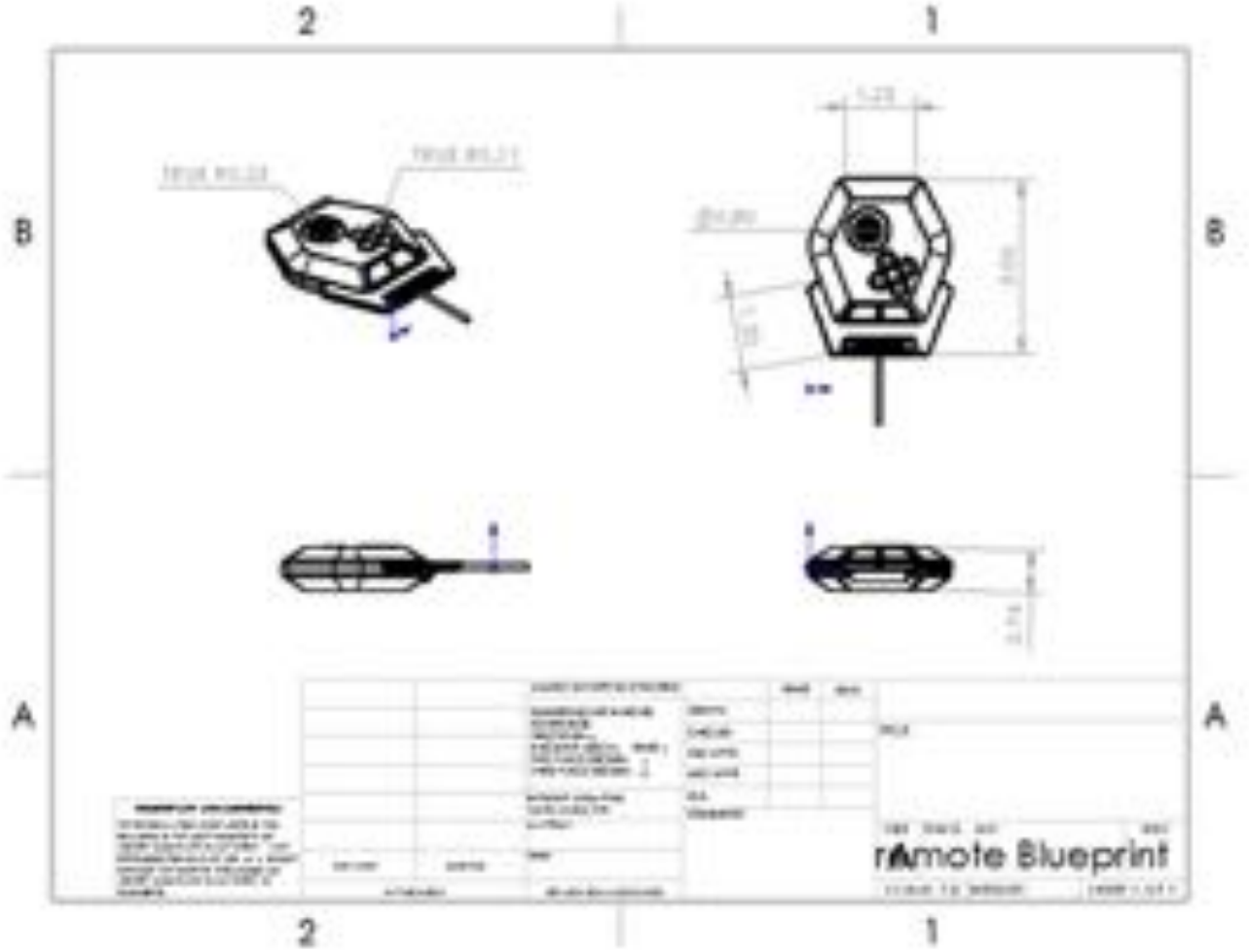


Figure 76 - Remote Tech. Drawing

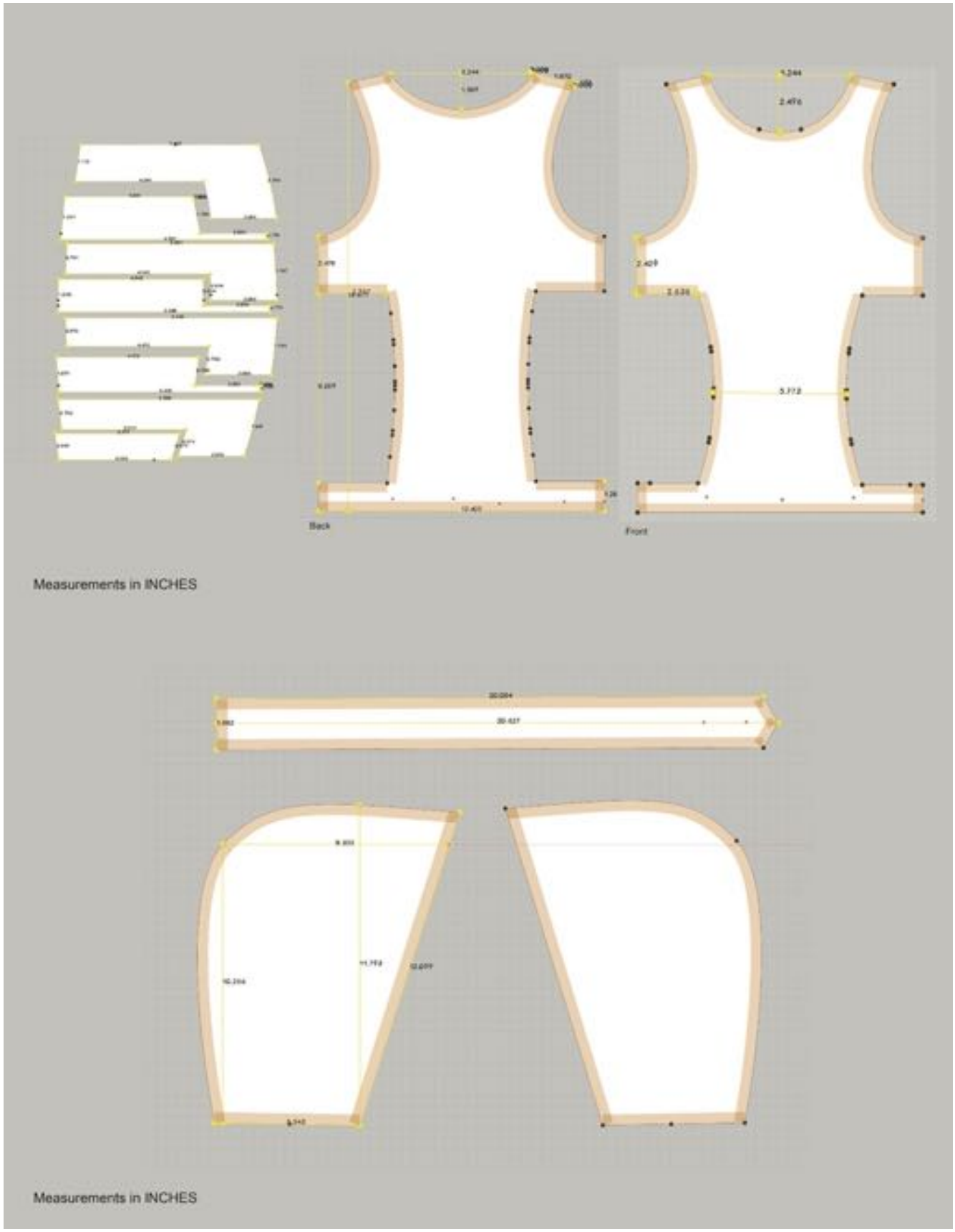


Figure 77 – Flat Pattern

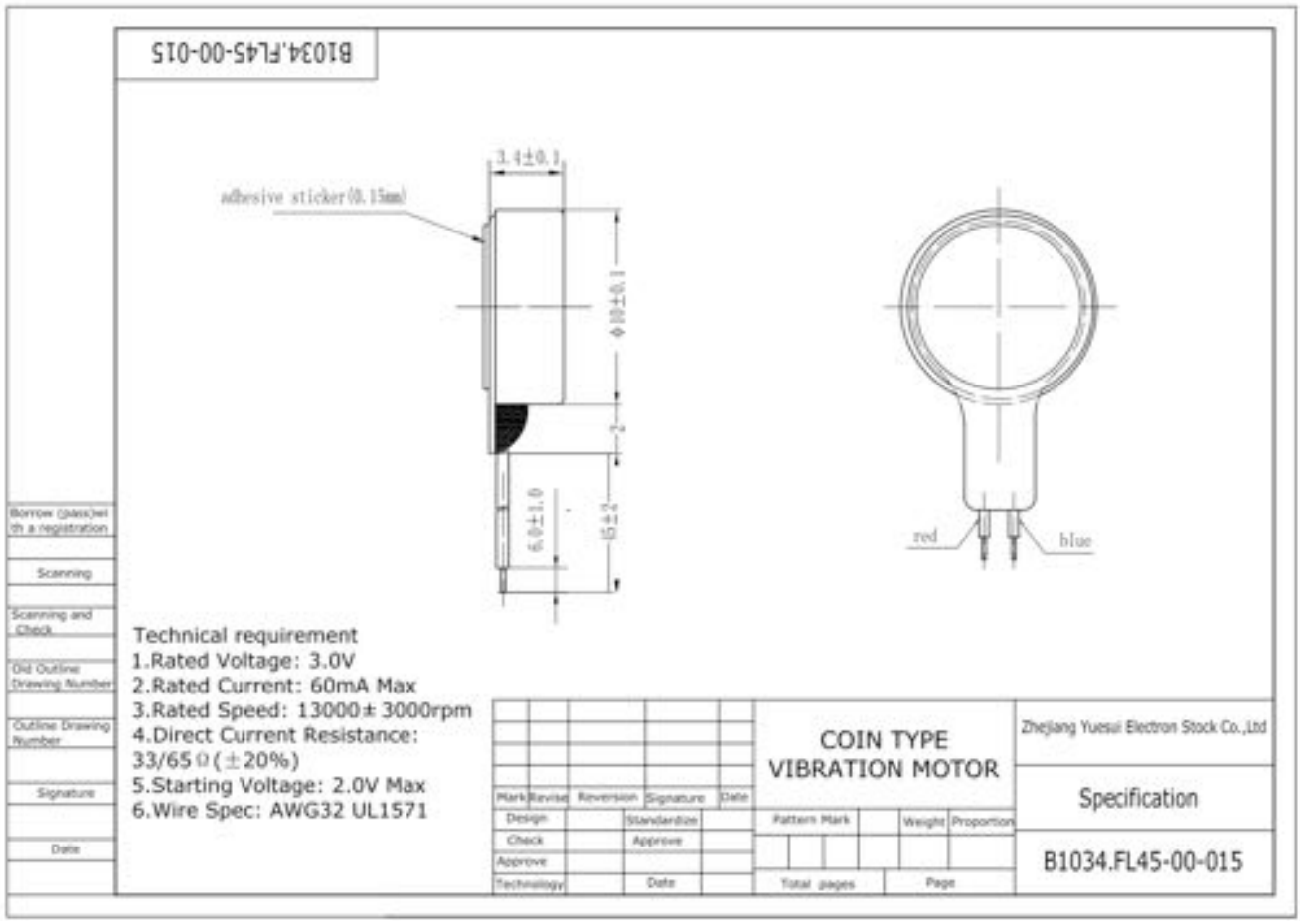


Figure 78 - Vibration Motor Tech. Drawing
(https://cdn.sparkfun.com/datasheets/Robotics/B1034.FL45-00-015.pdf)

5.6 Sustainability

The materials chosen for the garment in this report have been based on recyclable materials and green manufacturers. The fabric used in the garment will be a blend of recycled PET and Lycra T400. By using sustainable materials and manufacturers who take steps to maintain environmental sustainability; we can reduce waste as well as the amount of new raw material being extracted.

CHAPTER 6 : Conclusion

Alt is a wearable sensory stimulation device that uses multiple therapeutic sensory techniques such as compression, vibrotactile stimulation, and fidget activities to provide a comprehensive solution for children with Down syndrome. These children specifically struggle with sensory processing difficulties who are hyposensitive to stimuli, meaning they require more stimuli to obtain the feedback they require. Alt is designed to fit seamlessly under the wearers regular clothing and can be safely worn all day. With Alt the child can feel comfortable in their skin without encountering the stresses normally caused by these sensory processing difficulties.

Figure 79 - In Situ

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Appendix A – Discovery

Elizabeth A. Will, Lisa A. Daunhauer, Deborah J. Fidler, Nancy Raitano Lee, Cordelia Robinson Rosenberg & Susan L. Hepburn (2019) Sensory Processing and Maladaptive Behavior: Profiles Within the Down Syndrome Phenotype,Physical & Occupational Therapy In Pediatrics, 39:5, 461-476, DOI: 10.1080/01942638.2019.1575320

Results indicated that Low Energy/Weak, Under-responsive/Seeks Sensation, and Auditory Filtering were the areas of greatest sensory regulation difficulty, and that Self-Absorbed behavior and Disruptive/Antisocial behavior were elevated areas of maladaptive behavior. Multivariate regression analyses indicated that Under-responsive/Seeks Sensation was the only sensory regulation domain significantly associated with Self-Absorbed and Disruptive/Antisocial behavior.

Impairments in sensory processing may include over- or under-responsiveness, difficulties with stimuli discrimination, and challenges with proprioception and motor planning

From infancy, individuals with DS demonstrate greater ability (relative to their mental age) with aspects of visual-spatial processing, yet significant challenges in aspects of auditory processing and motor functioning

They also found small to moderate correlations between sensory processing domains and adaptive behavior (r = .41–.48) as well as between sensory processing and participation in school (r = .30–.38).

Disruptive/Antisocial behavior ("deliberately runs away" or "has temper tantrums"); Self-Absorbed behavior ("Aloof" or "has poor attention span").

The Disruptive/Antisocial and Self-Absorbed scales were regressed on Low Energy/Weak, Under-responsive/Seeks Sensation, and Auditory Filtering in a multivariate multiple regression (see Table 3). Collectively, **sensory processing accounted for 51% of the variance in maladaptive behavior domains**. Under-responsive/Seeks sensation was the only sensory processing predictor that significantly predicted collective outcomes in maladaptive behavior ($F(2,44) = 9.32$; $p < .001$; $\eta 2 = .30$). In addition, sensory processing collectively and significantly predicted Disruptive/Antisocial behavior ($F(3,48) = 4.60$; $p = 0.007$), and accounted for approximately 24% of the variance ($R2 = 0.24$). Sensory processing also collectively and significantly predicted Self-Absorbed behavior ($F(3,48) = 14.62$; $p = 0.001$), and accounted for approximately 49% of the variance ($R2 = 0.49$).

The current study replicates previous findings which identified Low Energy/Weak (demonstrating low strength and initiation); Under-responsive/Seeks Sensation (demonstrating low sensory responsivity and sensory seeking behaviors); and Auditory Filtering (demonstrating difficulty attending when multiple auditory stimuli are present) as the most problematic for individuals with DS (Bruni et al., 2016).

Collective results suggest a high consistency between characteristics of the DS phenotype and challenges in certain aspects of sensory processing.

Hypotonia (low muscle mass) ->
Low Energy/Weak and Under- responsive/Seeks Sensation

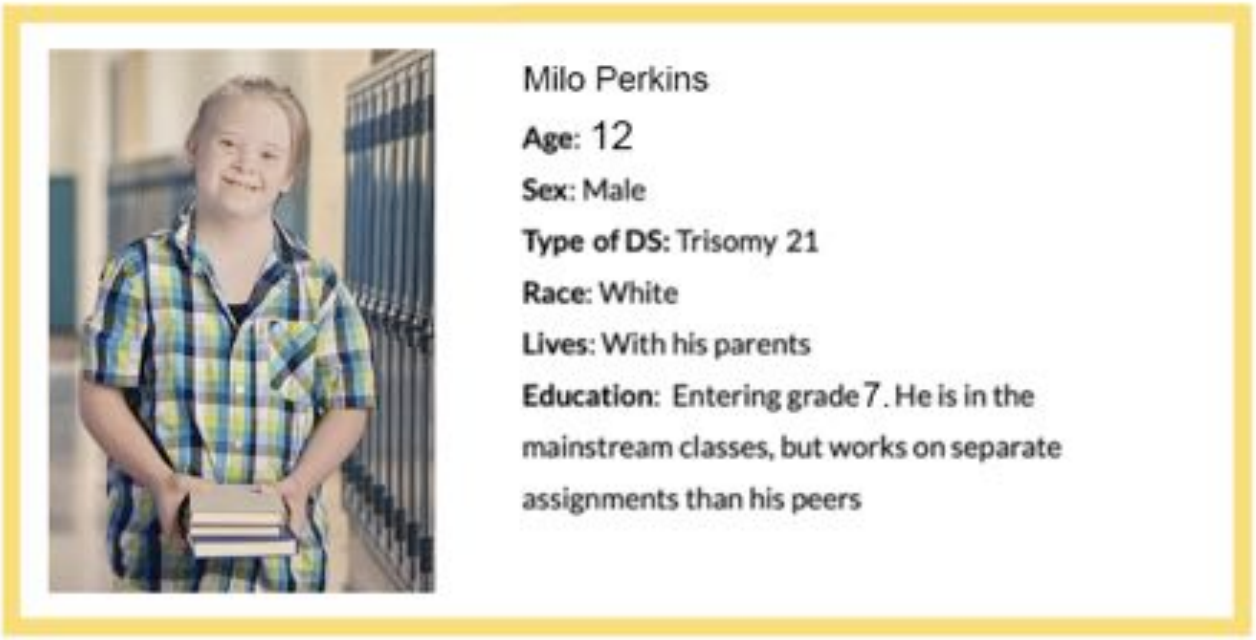
difficulties with verbal/auditory processing

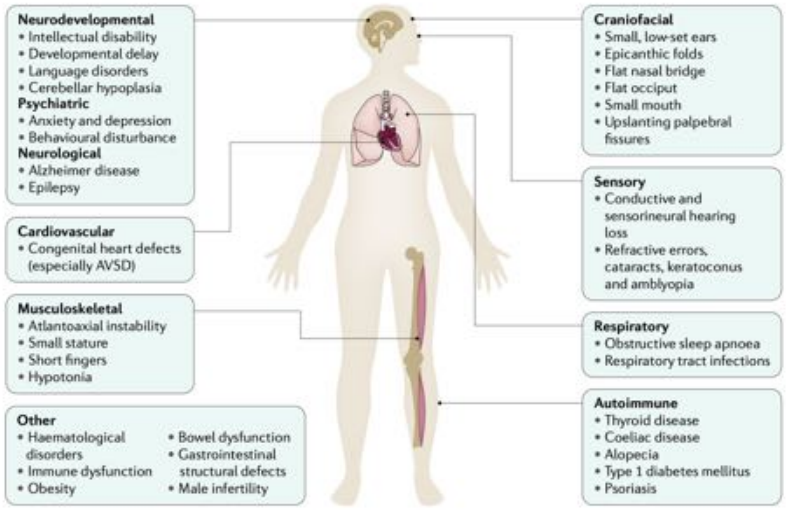
Auditory Filtering area involve being hyper- sensitive to sounds, not seeming to notice loud sounds, and having the ability to complete tasks with background noise.

Relying on informant report to assess for sensory processing challenges in a population with co-occurring intellectual disability is not without challenges. Parents may misinterpret the ability to complete tasks with background noise as relating to sensory processing difficulties when it actually relates to a primary verbal impairment.

For example, if a child is more under-responsive to stimuli and therefore participating less in the environment, an adult may perceive this as engaging in withdrawn and self-absorbed behavior. Conversely, sensation seeking behavior is hypothesized to be driven by a need for intense sensory input and sometimes looks like excessive running, jumping, swinging, and other active pursuits (Bundy et al., 2002) which in some contexts (e.g., the classroom,) can be viewed as disruptive.

Appendix B – Contextual Research (User)





Appendix C – Field Research (Product)

Wearables

Chewlery

- Expensive and easily lost or broken
- Not made for "adult teeth"
- Hard to keep clean
- Childish
- But is better for oral health then chewing on random objects

Weighted Vest

- Can only be used for 20 mins
- Places pressure onto the spine
- Bulky

Rip Proof Clothing

- Unfashionable and unflattering (isolating)
- Thick seams can cause tactile sensory distress
- Doesn't solve the problem, user will likely turn to ripping something else.

Deep Pressure squeeze vest

- Similar to the weighted vest but doesn't put the pressure on the spine as it uses air pressure
- Can only wear the pressure for 20 mins
- Requires decent hand motor skills to pump the vest

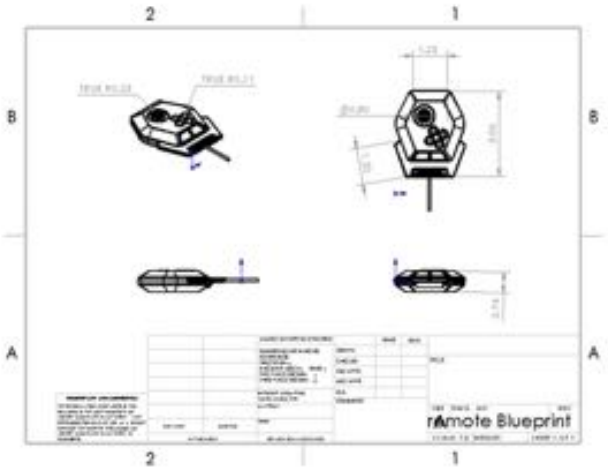
Noice cancelling headphones

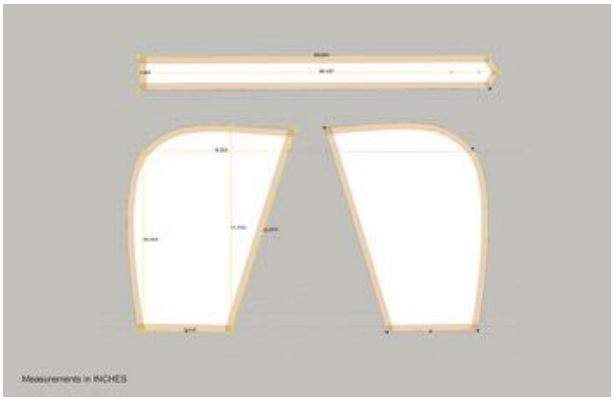
- Good for auditory filtering
- bulky
- can make user seem antisocial

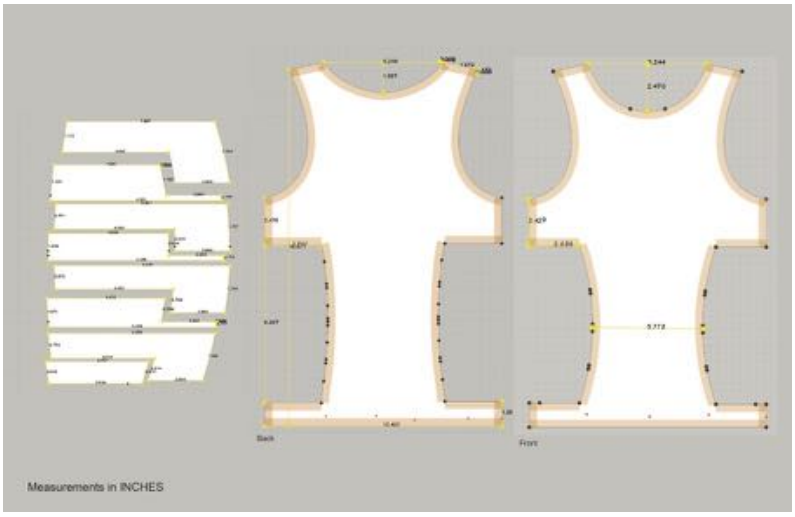
Large Equipment

- **Vibrating mat**
- **Squeeze machine**
- Large and not portable
- Only helps while in or on it
- Very expensive

Appendix G – Technical Drawings







Appendix I – Sustainability Info/Data

Spandex

One of the most stretchable fabrics available, spandex is a lightweight synthetic fabric known for its expansive and durable properties.

uses about 20% spandex in compression fabric

also known as elastane.
stretchy ness comes from long chain synthetic fibres often blended with polyester
higg index rates it having the same enviromental impact as polyester. impact coming from the use of fossil fuels and the chemicals used in production.
hard to recycle when blended with other stuff

Eco LYCRA made with a renewable source from dextrose derived from corn. also the LYCRA T400 fibre.

Sheiflex- Spanflex CF eco fabric - a blend of waste elastane and recycled polyester from plastic bottles.

Singtex - recyclable- 20% more energy efficient that conventional elastane.

Oratex eco stretch from lenzing tencel, organic cotton, recycled polyester and nylon

Nylon

Within compression gear, nylon makes up the majority of the fabric used

Jomi Compression's compression knee-highs are made up of between 70 and 82 percent nylon.

nylon, which releases nitrous oxide – ~300x more potent than CO2 at warming our planet.

SpanFlex

has half the energy consumption rating and carbon footprint as spandex

Lycra T400

Uses EcoMade technology.

65% of the fibre content is recycled and plant based material

uses dextrose derived from corn

fiber made with 65% renewable and recycled materials (Recycled PET)

LYCRA® T400® EcoMade fiber

Silicon

Silicon is a chemical element used for many different applications. In compression, it is minimally used to increase the ease of wear and the comfort of the wearer. It's primarily used for the support bands that keep compression gear from slipping at the top. Silicon dots can be found on certain models of compression stockings and socks

Appendix J – Approval Forms & Plans

IDSN 4002/4502
SENIOR LEVEL THESIS ONE AND TWO

Humber ITAL / Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2021
Catherine Chong / Sandro Zaccolo

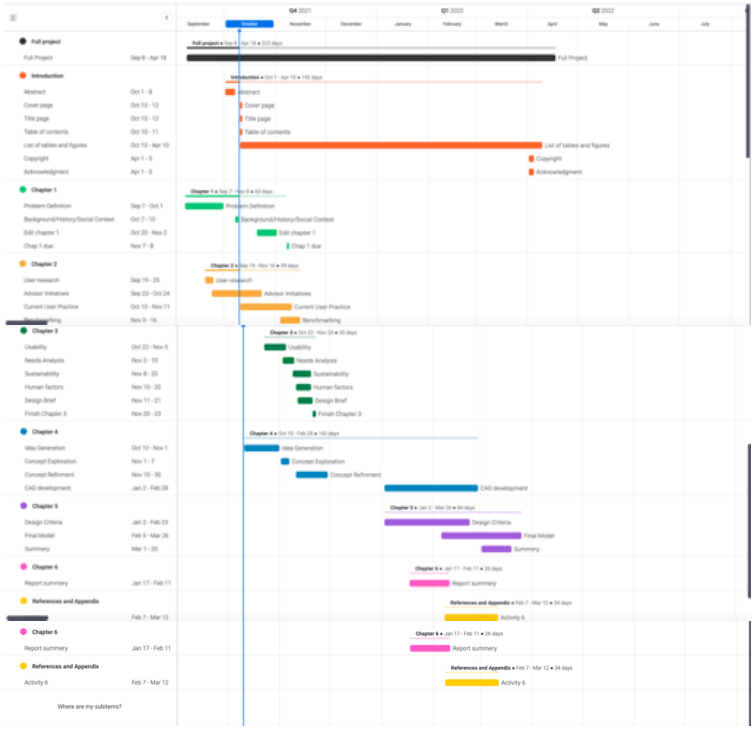
THESIS TOPIC APPROVAL:

Student Name:	Kendra Savard
Topic / Problem Definition:	**How may we mitigate the sensory issues for people with Down syndrome**

TOPIC DESCRIPTIVE SUMMARY (Preliminary Abstract)

Sensory processing difficulties impact many people, but is often overlooked, especially in individuals with Down syndrome, often chalked up to the child being bored and behaving badly. However, the sensory issues these individuals face cause physical and emotional stress and the behaviors expressed are just ways of attempting to cope. The goal of this thesis proposal is to determine ways to mitigate the sensory issues for people with Down syndrome in a way that empowers the users and improves their quality of life. One major issue with current products in the market today is the infantile design and lack of research into how older users interact with them. User research including observational studies and interviews with professionals who specialize in child development, as well as with parents of teens with Down syndrome will give insight and detail into how these issues arise and how to develop healthy ways to cope. Additionally, a one-to-one model will be developed to understand ergonomics and human scale and will be given to targeted users to test the feasibility of the solution. Results from this analysis will realize a design solution that sheds light onto the issues of this problem area and most importantly provide a stress-free experience for people with Down syndrome that helps cope with sensory processing difficulties and does not create a negative perception of the user by others.

Student Signature(s):	Instructor Signature(s):
Date: 02 / 10 / 2021	Date: 07 October 2021



IDSN 4502
SENIOR LEVEL THESIS TWO

CRITICAL MILESTONES: APPROVAL FOR CAD DEVELOPMENT & MODEL FABRICATION

Student Name:	Kendra Savard
Topic / Thesis Title:	DOWN SYNDROME SENSORY SUPPORT

THESIS PROJECT – DESIGN APPROVAL FORM

Design is reviewed and approved to proceed for the following: [X] CAD Design and Development Phase

Comment:
- Initial CAD started reasonably as of week #7/February 22nd; continue with detailing and refinement.
- Refinement and development coming along as of week #8/March 8th.
- Need to step-up and continue refinement and detailing.
- Advised completion latest by week #9 (March 17th).
- CAD completion in week #11.

Design is reviewed and approved to proceed for the following: [X] Model Fabrication Including Rapid Prototyping / 3D Printing and Model Building Phase

Comment:
- Cannot approve of model fabrication until CAD development at 90% completion of all components > advised completion latest by week #9 (March 17th).
- Once CAD is completed, can move forward to model fabrication from week #10 onward.
- Model fabrication in progress.

Instructor Signature(s):

Date: 29th March, 2022

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

This document certifies that

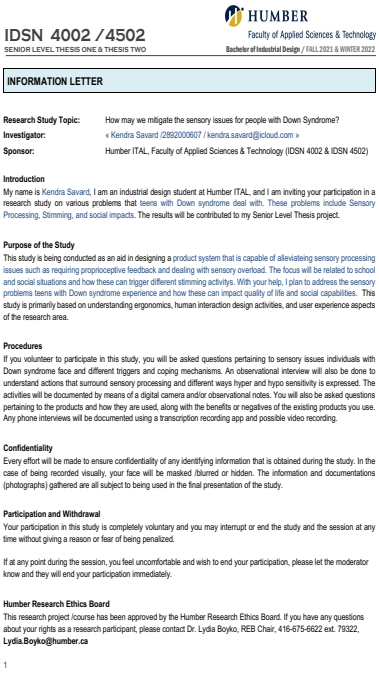
Kendra Savard

has completed the Tri-Council Policy Statement:
Ethical Conduct for Research Involving Humans
Course on Research Ethics (TCPS 2: CORE)

n01297629

Date of Issue: **22 September, 2021**

Appendix K – Advisor Meetings and Agreement Forms



IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2021 & WINTER 2022

INFORMATION LETTER

Research Study Topic: How may we mitigate the sensory issues for people with Down Syndrome?
Investigator: « Kendra Savard /2892000607 / kendra.savard@icloud.com »
Sponsor: Humber ITAL, Faculty of Applied Sciences & Technology (IDSN 4002 & IDSN 4502)

Introduction
My name is Kendra Savard, I am an industrial design student at Humber ITAL, and I am inviting your participation in a research study on various problems that teens with Down syndrome deal with. These problems include Sensory Processing, Stimming, and social impacts. The results will be contributed to my Senior Level Thesis project.

Purpose of the Study
This study is being conducted as an aid in designing a product system that is capable of alleviateing sensory processing issues such as requiring proprioceptive feedback and dealing with sensory overload. The focus will be related to school and social situations and how these can trigger different stimming activitys. With your help, I plan to address the sensory problems teens with Down syndrome experience and how these can impact quality of life and social capabilities. This study is primarily based on understanding ergonomics, human interaction design activities, and user experience aspects of the research area.

Procedures
If you volunteer to participate in this study, you will be asked questions pertaining to sensory issues individuals with Down syndrome face and different triggers and coping mechanisms. An observational interview will also be done to understand actions that surround sensory processing and different ways hyper and hypo sensitivity is expressed. The activities will be documented by means of a digital camera and/or observational notes. You will also be asked questions pertaining to the products and how they are used, along with the benefits or negatives of the existing products you use. Any phone interviews will be documented using a transcription recording app and possible video recording.

Confidentiality
Every effort will be made to ensure confidentiality of any identifying information that is obtained during the study. In the case of being recorded visually, your face will be masked /blurred or hidden. The information and documentations (photographs) gathered are all subject to being used in the final presentation of the study.

Participation and Withdrawal
Your participation in this study is completely voluntary and you may interrupt or end the study and the session at any time without giving a reason or fear of being penalized.

If at any point during the session, you feel uncomfortable and wish to end your participation, please let the moderator know and they will end your participation immediately.

Humber Research Ethics Board
This research project /course has been approved by the Humber Research Ethics Board. If you have any questions about your rights as a research participant, please contact Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca**

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IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2021 & WINTER 2022

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: How may we mitigate the sensory issues for people with Down Syndrome?
Investigator: « Kendra Savard /2892000607 / kendra.savard@icloud.com »
Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, Jennifer Savard (First Name/Last Name), have carefully read the Information Letter for the project How may we mitigate the sensory issues for people with Down Syndrome? , led by Kendra Savard. A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact Kendra Savard at any time during the project.

I understand that my participation is voluntary and give my consent freely in voice recording, photography and/or videotaping; with the proviso that my identity will be blurred in reports and publications.

Consent for Publication: Add a (X) mark in one of the columns for each activity

ACTIVITY		YES	NO
Publication	I give consent for publication in the Humber Library Digital Repository which is an open access portal available to the public	☒	☐
Review	I give consent for review by the Professor	☒	☐

Privacy
All data gathered is stored anonymously and kept confidential. Only the principle investigator /researcher, « insert student Name here » and Prof. Catherine Chong or Prof. Sandro Zaccolo may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant (subject) and data would be aggregated.

I also understand that I may decline or withdraw from participation at any time, without negative consequences.

I understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca** or « insert student Name /Phone Number /Email Address ».

Verification of having read the Informed Consent Form:

☒ I have read the Informed Consent Form.

My signature below verifies that I have read this document and give consent to the use of the data from questionnaires and interviews in research report, publications (if any) and presentations with the proviso that my identity will not be disclosed. I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Jennifer Savard		2021-10-17
Participant's Name	Participant's Signature	Date

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IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2021 & WINTER 2022

INFORMATION LETTER

Conditions of Participation
- ✓ I understand that I am free to withdraw from the study at any time without any consequences.
- ✓ I understand that my participation in this study is confidential. (i.e. the researcher will know but will not disclose my identity)
- ✓ My identity will be masked.
- ✓ I understand that the data from this study may be published.

☒ **I have read the information presented above and I understand this agreement. I voluntarily agree to take part in this study.**

Jennifer Savard		2021-10-17
Participant's Name	Participant's Signature	Date

Project Information
Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: 289 200 0607
Email: Kendra.savard@icloud.com

My supervisors are:
Prof. Catherine Chong, **catherine.chong@humber.ca**
Prof. Sandro Zaccolo, **sandro.zaccolo@humber.ca**

Full Transcription

Kendra Savard 0:01
Okay, so I just want to quickly go over and clarify some details of this interview before we begin. Firstly, you are invited to be a research participant, and the nature of this interview is to find insights into the sensory processing difficulties teens with Down syndrome face. I want to make sure that you are aware that this interview is voluntary, and you can stop at any time, and there's no penalty for withdrawal from the interview. You will remain anonymous and confidential, and at no time will your identity be revealed. I am recording this conversation for transcription and any digital recording will be destroyed. At the conclusion of the thesis project. Do you agree to your voice and image being recorded during the call and consent to participate in the study.

Interviewee 1:03
Yes.

Kendra Savard 1:04
All right, perfect. Thank you. And thank you for giving me your time. So first off, could you tell me a little bit about your background in intellectual and developmental development

Interviewee 1:23
Well, I have my bachelor of applied science with honors in child development. I have worked for the region of durham for almost 25 years working with children at risk for development, be it psychosocial, emotional, or biological risk.

Kendra Savard 1:45
All right, that's perfect. And so, as I mentioned before, I'm trying to get an insight into sensory issues that teens, specifically ages 13 to 18 with Down syndrome face. So I was just wondering if, like, what are some daily things that can be hard for teens with Down syndrome to do,

Interviewee 2:18
eating, dressing, socializing. Okay. Um, what sort of things are you looking for.

Kendra Savard 2:35
Well I'm looking to just get an insight into basically just what sort of things that they do during the day like going to the classroom like what sort of issues do they have there.

Interviewee 3:00
in a classroom, there's all sorts of issues. It could be noise related, it might be having to sit within a chair for too long. They might need help with getting dressed or any of that kind of stuff.

Kendra Savard 3:17
All right, yeah that's that's good to know.. Do you any additional insights?

Interviewee 3:35
Well there's lots of different things but like that's very open ended question. With feeding, they might not be able to accommodate textures, they may not be able to chew properly they might gag.

Kendra Savard 3:50
Okay, yeah thats great to know. So, the next question I want to ask deals more with sensory, and I just want to know what sort of things can trigger sensory overload.

Kendra Savard 10:27
Okay, yeah that's that's really good insight into that. Another question. So, this one, I'm not sure if he'll be able to answer it or if it has one answer, but I just want to know when your professional opinion, is there one sense that causes the most distress in these individuals, such as like the auditory or the proprioceptive?

Interviewee 11:02
Ah, I don't, I don't think that there is I think that it depends on each individual child basis, similar to everything also I think some, some children are more sensitive with their ears so hearing loud sounds might be really disturbing to them, or other children might want it louder if, if they've got say if they've got a hearing deficit or children with better mouse control and better oral motor might be fine with the chewing of textures like chocolate chip ice cream for kids that don't have as great of sort of tactile and or motor might struggle with those textures, I think it's very independent to the child.

Kendra Savard 11:48
Okay, yeah, that's, that's really good to know because I was definitely wondering that while I was doing my research. It seemed that a lot of the ones that really popped out where the pro perceptive and the auditory. I'm just because of like hypotonia, and existing ear issues.

Interviewee 12:13
I was gonna say I think if you if we're if we classify it. I think most children would have with some struggles with the proprioception and with some auditory just because you station tubes are so small. They typically a lot of children with Down Syndrome have typically a buildup of earwax and respiratory issues sort of that are sometimes clogging there, and also the hypotonia, okay. But, but again it's everyone is so different, as with any disability. Yeah, some, some don't but I think if you're looking for some similarities, I would say that those would be the probably the more, the more popular. Yeah prominence a good word, yep.

Kendra Savard 13:05
Okay yeah that's really good to know and I'm not trying to group everybody in the same category I'm just trying to kind of get a feel. So, really great to know that. Um, so, are there products out there that you recommend that for teens, specifically with Down syndrome to cope with sensory processing difficulties, and if so what are your opinions on these products.

Interviewee 13:39
There's more sensory products available for the younger children. There is. There is stuff available for the older kids but it typically it looks very infantile or, or it's not necessarily safe for them. Older kids, we have to look more at things like, Say fitness bands or, you know, clothing that not Nestle-rippable so sort of like the Under Armour type Gore Tex not Gore Tex lycra type clothing that sort of fits with their sensory issue but also doesn't make them stand out differently. The, the, the supplies out there for teenage kids is much definitely much lower than it is for infants and babies.
Kendra Savard 14:34
Yeah. And that is what I'm trying to get an insight into and see if I can come up, or find better ways to help with that issue.

Interviewee 15:04
Yeah. And a lot of them are like so, say, say someone needs something to chew on to work on sort of calming themselves a lot of times you're using jewelry or truly chewing, chewing beads or stuff like that, well most teenagers don't do that so it definitely sets them out, you know, being able to have something that would be appropriate for a teenager would be great, that would be accepted by say other peers, so that that you know they are already that the teenagers already don't feel like they fit in and this just makes it worse.

Kendra Savard 16:21
Okay, yeah, exactly. That's what I was thinking, and I just have one last question. It's a little less about processing, but a little bit more about high school. I just wanted to get your opinion about the special classrooms and special buses, and how that might affect the well being of these children.

Interviewee 16:55
Well, that's a tough one, too. I think that a lot of kids now we'll go into the small class placements because it does offer more one on one and, and maybe more opportunities for that child to find their own find their own place where they're a little more accepted. It does decrease obviously on sort of integration which was you know what we were trying to move away from having segregated classes, years ago. I do find the small classes of those, they are quite often necessary I do find that it that it does segregate the, the, the children and it does. I think it, it causes for less acceptance from us I hate the word typical but from typical children, as opposed to the children that have special needs it does definitely cause a divide when the when the classes are separate, children that do go mainstream, they might feel part of the class but then again when they're in the mainstream classes they're typically doing work that is not what the rest of class is doing so then they often feel a little more centered out to it that's a, that's a really hard question actually.

Interviewee 4:10
What sort of things could trigger well that depends on, I guess if you're hypo or hyper sensitive so if you're hypo sensitive like loud sounds can be triggering clothing country can trigger. Too many people around things that are happening too quickly.

Interviewee 5:58
If you're looking at what causes over overstimulation it could be as simple as having on a pair of pants that is too tight for a child and every time they move, it's, it's causing pressure on their stomach. It could be that they're in a classroom, and there's too much background noise, for them to concentrate, it could be that they're at home or in the car, and there's just so many different sounds or, or sensations that they're trying to incorporate like a restaurant post. Okay, not being able to filter out the outside sound or the outside stimuli that's coming at them,

Kendra Savard 6:46
and that would be auditory processing correct.

Interviewee 6:51
auditory, visual.

Kendra Savard 6:53
Oh yes. Okay thats great. I just wanted to know. In regards to the last question, what sort of actions or behaviors are often exhibited when there is a sensory overload.

Interviewee 7:18
So a lot of times you get sort of behaviors, lack of impulse control, aggression, sort of acting out quite wildly yelling, running, you know, not following sort of not following sort of their routines.

Kendra Savard 8:12
Okay, yeah, that makes sense.

Interviewee 8:13
Right, if they're overstimulated by means everything's kind of firing and they don't know what to do unless they're given something to use that extra stimuli, like the extra sensory needs, then they're just like a, like a firecracker.

Kendra Savard 8:29
Okay, yeah that's a good analogy. So now I just want to ask you a couple questions on the opposite side of the sensory spectrum. What really causes a child with Down syndrome to seek out sensation?

Interviewee 8:54
So it could be lack of movement. If they're very sedentary, if they're not having a lot of activity in their daily diet. If they're not given enough to stimulate, so say that they are placed in front of a TV, as opposed to actually out and moving and doing a lot of their activities. Is that what you're what you're meaning.

Kendra Savard 9:21
Yeah that's exactly what I was meaning, so say for example a child, ripping their clothing while watching the TV, it's not just a boredom thing it's like, caused by the proprioception sense.

Interviewee 9:47
It has to do with their sense, their sense reason sort of their sensory diet and there's something missing. So is it is it in that case, are they looking to, you know, do they have some extra energy that they don't know what to do with, or are they needing extra energy and that's why they're ripping the clothes because when the ripping the clothes are actually using a little bit of force, is it, you know, are they what are they looking for why are they doing that. Why are we seeing them rip their clothes. Why are we seeing them chewing. Why are we seeing kids you know, just sitting there and rocking instead of actually moving.

Kendra Savard 18:17
Yeah. And that's a good insight on it seeing both sides, um, I was just thinking if there was like a product that was discreet and allowed or helped those children cope with the sensory issues. If they would want to go back into mainstream but hearing both sides of the story

Interviewee 19:00
It's a hard one when you're talking about Down syndrome or any sort of cognitive delays when you're looking at say someone with ADHD, which is obviously a diagnosis. Typically, children with ADHD can function quite well within a mainstream class as long as they have extra supports put in place that identify their need someone with Down syndrome, they can you know they can maintain themselves in a mainstream class but typically, they're not still doing the same work and that's where the key comes into effect and also there's not time for, sort of, in the high school setting, there's not time for sort of meeting that individual's needs. So if that child say has Down Syndrome and they need, you know they're getting really upset in the classroom unless they have somebody there with them in order to take them out and maybe walk around the school, you know, do some push ups against the wall or what have you. They're not necessarily able to sort of manage within, within the mainstream I don't know if that makes sense or not, I'm not sure if I

Kendra Savard 20:07
guess. Yeah, it definitely does. Um, I'm definitely gonna have to do some more thinking. You brought up some great points I didn't even really think about.

Interviewee 20:19
It's hard. It's hard for someone with Down syndrome, to be in a mainstream class. These days I find I think that if, if a family advocate strongly enough that a hybrid model is great in the sense that if a child with Down syndrome can, you know, participate in say gym classes with typical children or they could participate in say, cooking classes, or I know a lot of the art classes, all that kind of stuff, some of the ones that are a little bit less academic based if they can participate in those classes with typical children, then you do get some of keeping sort of the acceptance and, you know, the, the bond between a child that has special needs and somebody that has the typical needs right. I think that that's great, I don't know that that always happens, but I often think that's a good sort of way to kind of meet the needs and with both.

Kendra Savard 21:19
Yeah, yeah that's it does seem like the best of both worlds, if it can be done

Interviewee 21:27
Yeah, yep. And some kids with Down Syndrome have a lot more medical needs and others, other children are functioning quite well and then they can going mainstream, it totally again depends on, like any disability, it depends on what that child as we're entering the school system width, and what the parents, schools are is obviously one of the big keys. If parents, schools are academic then a lot of times if you stay in a small class placement. You can sort of get the ratios with the educational assistance in a small class placements remain low versus if you're in the mainstream, very rare anymore, do you get 100% of an ass time, so your child is left functioning on their own in some of those mainstream classes now we're functioning on our own. And as you have Down syndrome that can cause overstimulation or under stimulation because you're, you're, sometimes not able to tune in, there's a lot of things going on the classes, classes are about 30 some odd students in one room. And if you don't have an EA there to sort of modulate you and modulate the work you're doing, that can cause issues.

Kendra Savard 22:58
That's some really good insights on that, um, yeah, that's actually really helpful. Um, well, I, that is the end of my questions. I just want to ask you if you have any additional thoughts or anything you would like to add.

Interviewee 23:14
Um, I don't right now, are you going to be asking people that have children with Down Syndrome and sort of of that age range

Kendra Savard 23:33
I do plan to I have a contact, and that I do plan to reach out to

Interviewee 23:42
and even might be a little bit older but have gone through gone through the high school can also probably tell you because then it's sort of, that would give you an idea of sort of what they felt like they could have used to have made high school more successful.

Kendra Savard 24:02
Yeah. Yeah, definitely. I do definitely plan to interview more people. And I just want to make sure with you if I need any more questions, or if I have any more questions if you will be open for additional interviews. Oh, thank you, that's, that's really great. Um, and I would just like to thank you again for taking your time and helping me out with this, your insights were very appreciated.
Interviewee 24:40
No problem, feel free to reach out for other information.

Kendra Savard 24:46
Yes, thank you so much. All right. All right. Have a great night.

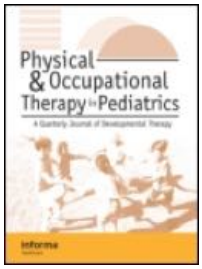
Interviewee 24:54
You too.

Appendix M- Topic Specific Data

Deep touch pressure also results in increased endorphin levels and releases the "happy hormones" serotonin and dopamine. Serotonin is a neurotransmitter that helps to regulate some brain functions and help with mood regulation. It is also known to stimulate parts of the brain that are responsible for sleep and the production of melatonin. Dopamine is a "happy hormone" that controls the reward or pleasure center of the brain. While it regulates our emotional responses and is in action when we set or achieve goals, an excess of dopamine is also linked to risk taking and addiction.

https://www.adaptandlearn.com/post/how-do-weighted-vests-benefit-children

The use of weighted or compression clothing is a form of sensory integration therapy. It is meant to provide deep pressure in order to calm the central nervous system. This type of sensory input is referred to as "proprioceptive input." Think about when you have a new baby. You swaddle her tightly in blankets and snuggle her firmly to your body in order to calm her down when she is upset. It also helps her to relax and fall asleep. This form of proprioceptive input is working off of this same concept. Some people prefer to use weight such as weighted vests or weighted blankets. Others prefer to use compression garments such as UnderArmour or special medical compression garments.
https://www.childrenstherapyteam.com/index.php/2014/09/22/weighted-vests-proprioceptive-inpu/



Physical & Occupational Therapy In Pediatrics

ISSN: 0194-2638 (Print) 1541-3144 (Online) Journal homepage: https://www.tandfonline.com/loi/ipop20

Reported Sensory Processing of Children with Down Syndrome

Maryanne Bruni, Debra Cameron, Shelly Dua & Sarah Noy

To cite this article: Maryanne Bruni, Debra Cameron, Shelly Dua & Sarah Noy (2010) Reported Sensory Processing of Children with Down Syndrome, Physical & Occupational Therapy In Pediatrics, 30:4, 280-293, DOI: 10.3109/01942638.2010.486962

To link to this article: https://doi.org/10.3109/01942638.2010.486962

Published online: 24 Aug 2010.

BALANCE PROBLEMS IN DOWN SYNDROME CHILDREN: VARIOUS SENSORY ELEMENTS AND CONTRIBUTION TO MIDDLE EAR PROBLEMS

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Abstract

Background: Down syndrome (DS) is one of the commonest causes of developmental delay in children, with equilibrium problems being an integral part of the syndrome. This leads to further impairment of cognitive and concentration abilities.

Material and methods: In our study, 30 DS children were categorized into 3 groups: bilateral normal middle ear pressure, bilateral abnormal middle ear pressure, and unilateral abnormal middle ear pressure. Sensory components of balance (somatosensory, visual, and vestibular) were assessed using computerized dynamic posturography.

Results: Results showed a statistically significant decrease in composite score, visual ratio, and vestibular ratio among DS children compared to normal children. No significant differences in sensory parameters between the various DS groups (with various tympanogram types) were encountered.

Conclusions: This might lead one to suspect central and proprioceptive causes behind balance problems in DS, but further extended studies are needed to confirm this. Bedside screening tests for visual and vestibular functioning of balance are recommended, e.g. past pointing and Fukuda for early detection and intervention.

Keywords: Down Syndrome • ear middle • postural balance

PROBLEMAS DE EQUILIBRIO EN LOS NIÑOS CON EL SÍNDROME DE DOWN: SUS DISTINTOS COMPONENTES SENSORIALES Y LA RELACIÓN CON LAS ALTERACIONES EN EL OÍDO MEDIO

Resumen

Introducción: El Síndrome de Down (Down syndrome, DS) es una de las causas más frecuentes del retraso del desarrollo de los niños con problemas de equilibrio, que, al mismo tiempo, es una parte integral de DS. Esto, a su vez, conduce a mayores dificultades en la adquisición de habilidades cognitivas y en la concentración.

Materiales y métodos: En nuestro estudio, 30 niños con el Síndrome de Down han sido divididos en 3 grupos: primer grupo con una presión bilateral normal en el oído medio, segundo grupo con la presión bilateral incorrecta en el oído medio, y un tercer grupo, con la presión unilateralmente incorrecta en el oído medio. Los componentes sensoriales del equilibrio (somatosensoriales, visuales y vestibulares) han sido evaluados mediante la posturografía computerizada dinámica.

Resultados: Los resultados demuestran una disminución estadísticamente significativa en el resultado total, del índice visual y vestibular, entre los niños con el Síndrome de Down, en comparación con los niños sanos. No se han observado diferencias significativas en los parámetros entre los tres grupos de personas con el DS (con distintos tipos de timpanogramas).

Conclusiones: Los resultados obtenidos indican que los trastornos centrales o kinestésicos pueden ser responsables de los problemas de equilibrio en el caso del síndrome de Down. Sin embargo, para confirmar este hallazgo, se necesitaría más investigación en profundidad. Para una detección e intervención tempranas, se recomiendan las pruebas de cribado de las funciones visuales y vestibulares de equilibrio, tales como, por ejemplo, past pointing y Fukuda.

Palabras clave: el Síndrome de Down (DS) • oído medio • balance corporal

frontiers in Robotics and AI

Front Robot AI. 2020; 7: 7.
Published online 2020 Feb 18. doi: 10.3389/frobt.2020.00007
PMCID: PMC7805743
PMID: 33501176

Altering One's Body-Perception Through E-Textiles and Haptic Metaphors

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Associated Data

Supplementary Materials

Data Availability Statement

Abstract

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Technologies change rapidly our perception of reality, moving from augmented to virtual to magical. While e-textiles are a key component in exergame or space suits, the transformative potential of the internal side of garments to create embodied experiences still remains largely unexplored. This paper is the result from an art-science collaborative project that combines recent neuroscience findings, body-centered design principles and 2D vibrotactile array-based fabrics to alter one's body perception. We describe an iterative design process intertwined with two user studies on the effects on body-perceptions and emotional responses of various vibration patterns within textile that were designed as spatial haptic metaphors. Our results show potential in considering materials (e.g., rocks) as sensations to design for body perceptions (e.g., being heavy, strong) and emotional responses. We discuss these results in terms of sensory effects on body perception and synergetic impact to research

Physical & Occupational Therapy In Pediatrics

ISSN: 0194-2638 (Print) 1541-3144 (Online) Journal homepage: https://www.tandfonline.com/loi/ipop20

Sensory Processing and Maladaptive Behavior: Profiles Within the Down Syndrome Phenotype

Elizabeth A. Will, Lisa A. Daunhauer, Deborah J. Fidler, Nancy Raitano Lee, Cordelia Robinson Rosenberg & Susan L. Hepburn

To cite this article: Elizabeth A. Will, Lisa A. Daunhauer, Deborah J. Fidler, Nancy Raitano Lee, Cordelia Robinson Rosenberg & Susan L. Hepburn (2019) Sensory Processing and Maladaptive Behavior: Profiles Within the Down Syndrome Phenotype, Physical & Occupational Therapy In Pediatrics, 39:5, 461-476, DOI: 10.1080/01942638.2019.1575320

To link to this article: https://doi.org/10.1080/01942638.2019.1575320

BALANCE PROBLEMS IN DOWN SYNDROME CHILDREN: VARIOUS SENSORY ELEMENTS AND CONTRIBUTION TO MIDDLE EAR PROBLEMS

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Abstract

Background: Down syndrome (DS) is one of the commonest causes of developmental delay in children, with equilibrium problems being an integral part of the syndrome. This leads to further impairment of cognitive and concentration abilities.

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