Low-Profile Dynamic Wrist Orthosis Device For Pediatric Patients With Wrist Motor Impairment

(Technical Report)

A Contemplative Space that Prioritizes Student-Identified Flourishing at UVA

(STS Research Paper)

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Sophia A. Martinese

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Technical Project Team Members

Kelsey Hannifin, Madisan Yates

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Signature:  Date 11/8/2019

Sophia A. Martinese

Approved:  Date 12/5/2019

William Guilford, Department of Biomedical Engineering

Approved _____ Date _____

Sean Ferguson, Department of Engineering and Society

Prospectus

Introduction

For my team's capstone project, we will be re-designing a low profile dynamic wrist orthosis for children and teens aged 5-17. Children affected by motor impairments caused by cerebral palsy or muscular dystrophy, or acquired through injury such as stroke, can have weak wrist extensor muscles. There are several current methods of occupational therapy and physical therapy on the market which are used by professionals to work with patients suffering from weak extensor muscles. Primarily, weak wrist extensors in children under 18 years of age are treated with occupational therapy that is tailored to their specific degree of weakness and other surrounding conditions. As described by Chaillo et al. (2019) , a capstone team from the previous year produced a final prototype as a potential aid for these patients.The recognized design constraints were and still remain crucial for progression of the wrist splint: allowing dynamic movement and variable tension, durable, low-profile, supporting proper wrist and thumb positions, and customizable per each patient. The current team determined that there are shortcomings within the existing orthosis and will be creating a new design, while also carrying out the IRB approved clinical trial which was initiated by the previous team.

For my STS thesis, I started first with an observed problem. Why are so many UVA students, and college students in general, struggling with mental & physical health issues? What is the common link between the problem and the solution? Through research, I discovered the missing piece to the puzzle and incredible solutions that already have scientific backing. The answer is contemplation paired with destigmatization. Contemplation is the "enhancement of self-regulation as the ability to notice and effectively manage thoughts, emotional responses, and behavior." (Dorjee, 2016) Contemplation is incredibly useful for improving mental and physical health, and can also contribute to improvement in other areas of personal development. (Bruce, et. al, 2018) It has been scientifically proven that mental health, and even more so the negative stigma surrounding mental health issues, causes increased depression and poor performance in academic settings. (Holland, 2016) Removal of negative stigma surrounding mental and physical health via education, which influences culture change, significantly impacts how students are able to perform better academically and also perceive themselves in a better position in comparison to their peers who are not educated on such topics (DeRosier, et. al, 2013) Integration of contemplative practices and improving student mental health go hand-in-hand, and by increasing knowledge and practice of both in the university setting has the capacity to greatly improve student quality of life and success.

Dynamic Wrist Orthosis for Affected Children and Teens

Some children are affected with varying levels of motor impairment, which makes controlling limbs difficult or even impossible. Such disabilities and disorders include cerebral palsy, muscular dystrophy, and stroke aftermath. According to the Centers for Disease Control and Prevention (2018), acquired or congenital cerebral palsy is the most prevalent pediatric motor disability and can vary in its effects. Wrist extensor muscles of children with motor impairments can often be weak. In addition, their flexor muscles may experience a higher degree of muscle tone, which also positions the wrist downward in the relaxed state. This increases the difficulty encountered when gripping and lifting objects, which are facets within daily tasks of life, including eating, writing, and playing. Last year's capstone team designed a low profile dynamic wrist orthosis, shown in Figure 1, and gained IRB approval for a clinical trial. The

goal of this year's work is to use last year's wrist orthosis as a baseline to improve the device, alongside carrying out the clinical trial our predecessors began.

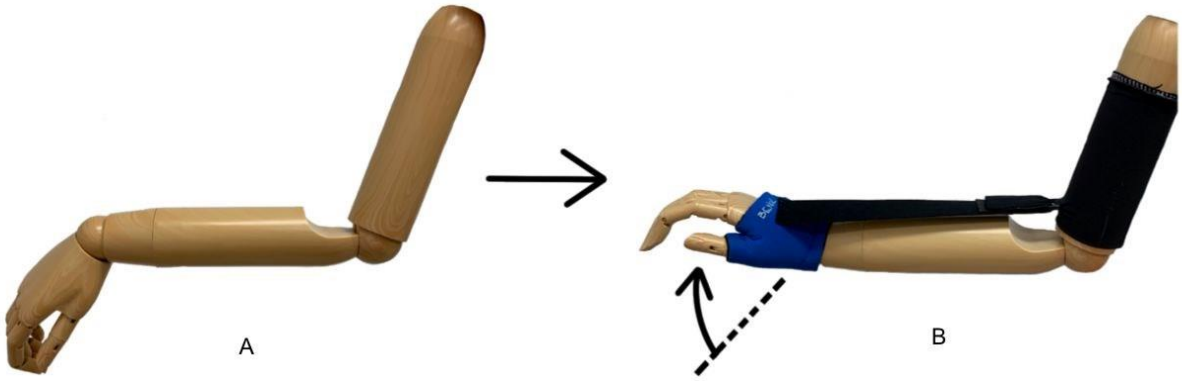

Figure 1: Existing Design for Low-Profile Dynamic Wrist Orthosis: Image A represents a wrist with weak extensor muscles not wearing an orthotic device. Image B represents the same wrist wearing the existing low-profile dynamic wrist orthosis. The bottom arrow on Image B demonstrates the orthosis pulling the wrist up to the 20° neutral position.

Our first goal with this project is to ideate design improvements upon the previous baseline design. We will use a sequence of engineering analysis techniques to improve upon the previous design. We will develop crucial criteria covered in previous design baseline which must be included in a new design. Some of which will certainly include: raising wrist to neutral 20° position, preserving a degree of natural movement in the wrist (dynamic), and low profile nature of the device. Upon establishing the critical design components, we will list several methods of accomplishing each criterion, known as a functional decomposition. We will then iterate through different combinations of these methods creating draft designs until we have a result of 5-7 potential designs. Some aims of the improved design may include: optimal hand/thumb support, dynamic movement ability, ideal material for skin protection, grip capacity, more low profile nature, and longevity of material strength so the angle of suspension is not altered with wear. We will compare each of these designs to the baseline design using a Pugh chart analysis. This will determine our top 1-2 alternate design(s) from theoretical criteria satisfaction.

Secondly, we will prototype and test top alternate designs determined from ideation engineering analysis. We will order appropriate materials to construct prototypes for new designs and test the theoretical improvement. We construct the prototypes for the new designs on a synthetic hand model. We will use an Instron machine for mechanical testing to determine yield strength of the components of the devices which will bear the most torque over time to assess at what point they change from elastic deformation to plastic deformation and compare those results to the baseline design's results. We will assess the low profile nature of the designs by attempting to put on the device with different items of clothing, such as long sleeves, and also perhaps incorporate behavioral assessments by wearing the devices in public to determine which draw public attention. Any other criteria which we identified in the PUGH analysis will also be tested. The testing will inform adaptations to the improved designs and repeated iterations of this process will result in a final version of a device most improved from the baseline.

Finally, we aim to carry out clinical trials for last year's design as outlined in approved IRB protocol. To supplement our engineering analysis and data, we will begin the proposed clinical trial,

which involves 10 recruited subjects in a 5-17 year age range. Listening to the patient perspectives about the device will assist in evaluating the aesthetic for the children, as well as other improvements such as size adjustment capacity and comfortability.

By using our engineering design analysis, prototyping and testing, and supplementing those results with qualitative patient response to the baseline device during clinical trials, we expect to accumulate results which ultimately improve upon the function and aesthetic of the baseline design. We believe the resulting improved device will benefit many pediatric patients with use of their hand/wrist in everyday motions and tasks.

A Student Contemplative Space that Prioritizes Mental and Physical Health

Contemplation is currently an elusive subject that is referenced frequently, but rarely defined and capitalized upon. Professors and students alike talk about contemplation without integrating its practices into the classroom setting, and thus, nobody benefits from its principles. As a latent impact, student populations do not benefit from these scientifically-supported practices and their academic experiences are left worse off, whether they knew it or not. The term contemplation is notoriously hard to define because it is personal in its nature, and therefore has different meanings for different contexts. The one which applies directly to my purposes is: "enhancement of self-regulation as the ability to notice and effectively manage thoughts, emotional responses, and behavior." (Dorjee, 2016)

This leads to the purpose of the project, through which I intend to study what it means for students to 'flourish' – what are the factors that students actually identify as helping improve their quality of life at UVA, and how does that differ from the faculty, staff and Board of Visitor perspective? There are many student spaces that have been built on grounds and are currently utilized by students for academic and personal purposes. Despite a lot of fancy new spaces with new technology imbedded into them, it is clear that students still don't feel that they are flourishing, specifically with identifications of serious mental and physical health concerns that end up impacting their academics, their social life, and overall livelihood. This is evident from several articles published over the last few years in student publications, from social media posts, from student-given Ted talks at UVA, and from my own surveying and experience both through this class and as a Resident Advisor.

It is clear that the individuals responsible for designing and promoting these student spaces (faculty, staff and Board of Visitors), as benevolent as their efforts may be, are not in touch with the student perspective and as a result, whatever spaces they design are not helping improve the student flourishing experience at UVA.

I will use the following specific research questions to guide my investigation of the correlation of student's learning space with their mental and physical health at UVA:

1. What do students identify as the main criteria for them to flourish? What part does mental and physical health play in that?
2. What student spaces are used most frequently on grounds?
3. What is the correlation between students choosing to use those spaces and students feeling an improvement in their mental and physical health?
4. What do students identify as the biggest point of improvement needed in spaces on grounds?
5. What is the faculty & staff perspective on all of the above points?

6. What are the discrepancies between the student perspective and the faculty/staff perspective?
7. How can the practices of contemplation help improve these issues?

The following sources represent a literature review which addresses many of these questions.

Contemplation is incredibly useful for improving mental and physical health, and can also contribute to improvement in other areas of personal development. (Bruce, et. al, 2018) There is currently a lack of understanding and integration of contemplative practices in learning spaces at UVA, and due to the many experimentally proven benefits of these practices, inclusive of benefits to mental and physical health, this is a considerable area of necessary improvement. Additionally, the widespread mental & physical health stigma that negatively affects students at UVA is an important hurdle to jump before contemplation can have lasting impact on student lifestyles. This need has been indicated by several anonymous student testimonies in Housing and Residence Life leadership, as well as by UVA President Jim Ryan, who aims to eliminate honors housing because of this stigmatization having catastrophic impact on students. The students there struggle with various mental health issues but are forced into close quarters with others who are unable to discuss such issues due to the negative stigma and mental health issues being perceived as 'weakness' - and thus, students spiral down and many end up tanking in academics and personally due to this negative feedback loop.

It has been scientifically proven that mental health, and even more so the negative stigma surrounding mental health issues, causes increased depression and poor performance in academic settings. (Holland, 2016) Self esteem is another component negatively affected by negative mental and physical health and the stigma surrounding those topics, which often leads to students either performing poorly in academic settings because they don't believe they are smart enough, or withdrawing from clubs and other social settings, which ends up being detrimental to overall success as well. (Millard & Wessely, 2014) This evidence clearly points towards the first item of business being to eliminate such stigma from the community and culture. Removal of stigma and education on counseling resources, as well as ease of access to those counseling resources with limited barriers (financial, racial, geographical, etc), is critical for student mental health (Holland, 2016; Shankar & Park, 2016)

But how is this accomplished? What are the specific, tangible mechanisms by which such a widespread concept as a "stigma" can be removed? An assessment of multiple studies shows that removal of negative stigma surrounding mental and physical health via education, which influences culture change, significantly impacts how students are able to perform better academically and also perceive themselves in a better position in comparison to their peers who are not educated on such topics (DeRosier, et. al, 2013) Teaching students how to be resilient by professionals in mental & physical health, and through example, and providing them spaces to do that, improves their mental health (DeRosier, et. al, 2013; Holland, 2016; Millard & Wessely, 2014; Shankar & Park, 2016) In other words, the first step towards removing the stigma and thus increasing thrivingness among students, is learning about and discussing the topic of mental health more often, and becoming so familiar with the subject that it becomes part of how you view the world. Interestingly enough, this draws a parallel to the very practice of contemplation, which involves being present and knowledgeable about issues or just facets of who you are which you would normally overlook. (Bruce, et. al, 2018)

The next step following improving education to remove and/or reduce stigma surrounding mental and physical health issues, would be to proactively improve upon mental and physical health by providing environments for students to work and socialize which are conducive to healthy practices. Environments

which remove stress and allow students to work and think productively and in a relaxed manner can be very effective in improving student wellbeing (mentally) as well as has been shown to improve academic performance (Shankar & Park, 2016) Some of the physical modifications to a space which have been scientifically proven to have a positive effect on mental and physical health, as well as contemplation, are as follows: pleasant aromas such as lilac or peppermint based aromas, natural light and limited amount of blue light from screens, instrumental or lyric-less music with steady bass tones and limited percussion, sound proof walls to limit excess stimuli, high ceilings, calming low-wavelength colors such as restful green and calming blue to improve efficiency and focus without being stress-inducing, and access to the outdoors for fresh oxygen and vitamin D. (Bruce, et. al, 2018; Shankar & Park, 2016) Additionally, Tai chi is a really useful technique to improve focus, discipline, and mental health via the endorphins released. (Wang, et. al, 2004)

STS Framework & Research Method

The essential STS framework which will be used to analyze these research questions is the idea of interpretation flexibility. This concept helps lay the ground for dissecting the relationship between what the students view as their flourishing in mental and physical health, as well as overall, compared to the faculty & staff perspective. For example, when I examine what cues lead faculty & staff members to believe that students are or are not flourishing, what are the differences in their interpretations of these cues versus the actual signals students are trying to send. I believe that using this central framework, it will help uncover the necessary tools that Dr. Germano and his team will need to access the student point of view and be able to pitch to the Board of Visitors why certain aspects of the space need to be created for the students.

As a method of collecting data, I will primarily use qualitative and quantitative student and staff surveys, and I will use the method of selective/purposive sampling to acquire an equal number of student representatives from a few key demographics: year (1^{st}, 2^{nd}, etc), school (College of Arts & Sciences, Engineering, etc), race, sexuality and gender. I will use this method of sampling to ensure the amplified voice of minority students or students who are often lost in many university-wide decisions, despite their perspectives weighing majorly on the future of our university and our nation. I will compile qualitative data to put students in different relative categories, and I will compile quantitative data by asking certain questions which can be identified by the subject on a point scale. My hope is to uncover a common trend among the voices of students otherwise unrepresented that will positively influence the design and ultimate use of the space being created by Dr. Germano.

Ultimately, there are a wealth of parallels to improvement in mental & physical health and contemplation practices, both in the methods they are achieved and in the results they yield. These two issues go hand-in-hand and are both necessary for ultimate success in an academic space, which is why UVA has an imperative to explore implementation of the aforementioned methods in order to improve quality of life for students at this university.

Bibliography

Bruce, M., Skrine Jeffers, K., King Robinson, J., & Norris, K. (2018). Contemplative Practices: A Strategy to Improve Health and Reduce Disparities. *International Journal of Environmental Research and Public Health*, *15*(10), 2253. https://doi.org/10.3390/ijerph15102253

Centers for Disease Control and Prevention. (2018, March 9). Prevalence and characteristics. In Data and statistics for cerebral palsy. Retrieved from https://www.cdc.gov/ncbddd/cp/data.html

Chaillo, M. D., Frank, K. F., & Newman, R.M. (2019). Low-profile dynamic wrist splint for pediatric patients with motor impairment (Unpublished undergraduate thesis). University of Virginia, Charlottesville, VA.

DeRosier, M. E., Frank, E., Schwartz, V., & Leary, K. A. (2013). The Potential Role of Resilience Education for Preventing Mental Health Problems for College Students. *Psychiatric Annals*, *43*(12), 538–544. https://doi.org/10.3928/00485713-20131206-05

Dorjee, D. (2016). Defining Contemplative Science: The Metacognitive Self-Regulatory Capacity of the Mind, Context of Meditation Practice and Modes of Existential Awareness. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.01788

Holland, D. (2016). COLLEGE STUDENT STRESS AND MENTAL HEALTH: EXAMINATION OF STIGMATIC VIEWS ON MENTAL HEALTH COUNSELING. *Michigan Sociological Review, 30*, 16-43. Retrieved from http://www.jstor.org/stable/43940346

Millard, C., & Wessely, S. (2014). Parity of esteem between mental and physical health. *BMJ: British Medical Journal, 349*. Retrieved from https://www.jstor.org/stable/26518633

Shankar, N. L., & Park, C. L. (2016). Effects of stress on students' physical and mental health and academic success. *International Journal of School & Educational Psychology*, *4*(1), 5–9. https://doi.org/10.1080/21683603.2016.1130532

Wang, Y. “Tai,” Taylor, L., Pearl, M., & Chang, L.-S. (2004). Effects of Tai Chi Exercise on Physical and Mental Health of College Students. *The American Journal of Chinese Medicine*, *32*(03), 453–459. https://doi.org/10.1142/S0192415X04002107