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Letter from the Editor

The pleasure of presenting the newest issue of *Perpetua* to you, the students, faculty, researchers, and associates of the University of Alabama in Huntsville, and welcoming any reader outside of the UAH system to our undergraduate research family, is a distinction that has only become more honorable in succession. As I dictate this letter, I reflect not just upon last semester's issue, but upon the entire history of the publication.

Since the Fall of 2016, *Perpetua* has been tasked with creating the best possible representation of undergraduate research at UAH not only through the commitment and efficiency of our staff, but also due to the consistent excellency of the undergraduate research community: the students who perform the research and the faculty and staff who provide them with resources and continued support, to whom we remain in a perpetual state of indebtedness. Two and a half years of service would not have been possible without the participation of these intelligent, creative, and talented individuals.

As I reflect, gradually my thoughts invert, from nostalgia for the past to optimism for the future. As a graduating senior, this fifth issue of *Perpetua* will be my final one, but the future remains bright. Brighter, perhaps, than it ever has before. Within the pages and behind the scenes, *Perpetua* remains populated by a group of students whose aspirations are nothing short of monumental. Loud, impassioned voices are the ones which dictate the ongoing path of history. The undergraduate researchers of UAH are these voices and *Perpetua* is their platform, unified in the purpose of serving as beacons of reason and inspiration on the shores of academic and professional success.

Together we stand, unified in our mission, energized by our purpose, strengthened by our conviction, and impassioned by our goals. We are *Perpetua*.

Sincerely,

James Shelton
Editor-in-Chief
*Perpetua*
Special Thanks

Perpetua is a collaborative effort and publication would be impossible without the support of numerous individuals and organizations across UAH and throughout the greater Huntsville research and outreach community. We offer special thanks to all who have contributed their time, expertise, financial support, and hard work to Perpetua. A few of our biggest contributors are recognized below.

First and foremost, we would like to thank the undergraduate student researchers for entrusting us with the privilege and the responsibility of promoting their work. We thank the various faculty and staff who serve as sponsors to undergraduate research and to the Research and Creative Experience for Undergraduates for providing resources and opportunities and who likewise support and promote undergraduate research.

We thank the Student Government Association for providing invaluable organizational funding and the Office of Student Life for providing ample opportunities to promote Perpetua and its purpose. We thank the Office of Academic Affairs for enabling us to reach as many members of the UAH community as possible. We would also like to thank Dr. William Wilkerson and the UAH Honors College for their commitment to providing additional financial support to Perpetua. Next, we would like to extend our thanks to our faculty advisors: Mr. David Cook, Dr. Yu Lei, and Dr. Hamsa Mahafza, who have consistently provided exceptional insight and guidance to our editorial staff since our inception.

Finally, we thank every UAH graduate student and faculty member who served as a reviewer for one of the manuscripts featured in this issue. Without such individuals volunteering their time and expertise, Perpetua would not be able to provide our services to the UAH community.
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Puget Sound Water Resources
Evaluating Methods for Identification and Monitoring of Factors in the Puget Sound that Indicate Eutrophication and Hypoxia

Christine Evans, Emily Kinkle, Yu Han, & Helen Baldwin-Zook
Department of Atmospheric Science

Abstract – Dissolved oxygen levels have been declining in the Puget Sound since 2000 due to eutrophication, resulting in Harmful Algal Bloom (HAB) events which negatively impact water quality and wildlife in the area. Therefore, analyzing and identifying eutrophication and hypoxic events is integral to water quality control and watershed management. The project team partnered with the Pacific States Marine Fisheries Commission (PSMFC) Habitat Program to test methods for monitoring water quality using remote sensing. The team tested multiple algorithms utilizing Landsat 8 Operational Land Imager (OLI) and Sentinel-2 Multispectral Imager (MSI) data to detect turbidity and chlorophyll concentrations. Using satellite imagery along with geographic information systems techniques will assist the PSMFC Habitat Program with filling gaps, enhancing local decision-making practices, and water resource management. The Chlorophyll Concentration Map and the ACOLITE Analysis Map highlighted areas such as Skagit Bay and Tacoma Inlet as having high chlorophyll concentrations. Using Pearson’s Correlation statistical analyses, the team found there was no significant relationship between the in situ data and the evaluated algorithms from ACOLITE. This preliminary investigation suggests that further work is necessary in order to utilize satellite data processed with ACOLITE to identify HABs in the Puget Sound area.

I. Introduction

Background Information

The Puget Sound estuary, located in northwestern Washington, stretches 161 km from the Admiralty Inlet to Olympia (Figure 1). Approximately two-thirds of Washington’s population resides along the 2,143 km long coastline along with a wide variety of aquatic and terrestrial organisms. Puget Sound’s depth reaches 0.28 km at its deepest point, making it the second largest coastal plain estuary in the United States by volume. The Puget Sound is approximately 83% seawater, which travels...
to the estuary from the Pacific Ocean through the Strait of Juan de Fuca, and 17% fresh water, which primarily comes from the Skagit River, entering through the Whidbey Basin (MacCready, 2017). The estuarine circulation throughout the sound has a substantial influence on water quality, with an average residence time of the water being one month. This high residence time allows for biogeochemical processes to take place and cause severe hypoxia problems (Babson, Kawase, & MacCready, 2006).

Hypoxia, low oxygen levels, and eutrophication, an excess of nutrients which causes a dense growth of plant life, have become more prevalent in the Puget Sound since 2000, which has led to negative impacts on water quality and wildlife (Environmental Protection Agency, 2017). Harmful algal blooms (HABs) rapidly develop in response to the eutrophication of the water. When the algal blooms begin to decay, their decomposition consumes the dissolved oxygen needed by aquatic organisms to breathe. This leads to an increase in fish kill events (events involving the death of a large number of fish over a short period of time) and a decrease in healthy sessile organisms, both of which negatively impact the area’s marine economy (Sellner, Doucette, & Kirkpatrick, 2003). Certain species of HABs, such as *Pseudo-nitzschia*, produce domoic acid, which is harmful to humans if consumed through contaminated shellfish (Washington Department of Fish and Wildlife, n.d.). Agriculture is a large contributor of nutrients to water bodies. These nutrients, such as phosphorus and nitrogen, are utilized in fertilizer and enter the water through runoff (Sebastia et. al., 2012).

**Project Partners & Objectives**

The Pacific States Marine Fisheries Commission (PSMFC) aims to protect and manage fisheries in a five-state region, including the fisheries within the Puget Sound. The PSMFC’s Habitat Program has a non-voting seat with the Pacific Fishery Management Council and works to protect essential fish habitats and provide water quality management advice to communities and organizations. The Habitat Program also assists fishermen and communities with recycling fishing nets, gear, and other marine debris in order to support fish habitat conservation and restoration. They act as the grant coordinator for the Oregon Watershed Enhancement Board and serve on the boards of the Oregon Central Coast Estuarine Collaborative, Mid Coast Watersheds Council, and the Salmon Drift Creek Watersheds Council. The PSMFC Habitat Program partners with communities and organizations to maintain water quality in watersheds and estuaries along the West Coast. They also monitor eutrophication and hypoxia, and they offer advice to the Pacific Fishery Management Council on the protection of essential fish habitats. They currently use seaplanes, ferries, and moored instruments to monitor water quality in the Puget Sound (Pacific States Marine Fisheries Habitat Program, 2012).

This project aimed to identify factors indicative of HABs in the Puget Sound. The team assessed the suitability of utilizing Sentinel-2 MultiSpectral Imager (MSI) (European Space Agency, 2015) and Landsat 8 Operational Land Imager (OLI) (U.S. Geological Survey Earth Resources Observation and Science Center, 2014) data processed through ACOLITE, a program developed at the Royal Belgian Institute of Natural Sciences (n.d.), to identify areas that are historically prone to HAB development. ACOLITE is used to process images of marine and inland water from Landsat (5/7/8) and Sentinel-2 (A/B) by applying atmospheric corrections and providing outputs of different water reflectance parameters (Royal Belgian Institute of Natural Sciences, 2017a). The team used ACOLITE specifically for images captured by OLI and MSI to obtain chlorophyll concentration and turbidity. Based on studies in areas such as Paracas Bay, Peru, the team hypothesized that there would be a high correlation between chlorophyll concentration and turbidity. Based on studies in areas such as Paracas Bay, Peru, the team hypothesized that there would be a high correlation between chlorophyll concentration and turbidity. Based on studies in areas such as Paracas Bay, Peru, the team hypothesized that there would be a high correlation between chlorophyll concentration and turbidity.
II. Methodology

Data Acquisition

OLI Level-1 data were downloaded for May 2013 - October 2017, and MSI data were downloaded for May 2016 - October 2017. The images were acquired from the United States Geological Survey (USGS) EarthExplorer portal (U.S. Geological Survey Earth Resources Observation and Science Center, 2014) with restrictions applied to acquire images with less than 10% cloud cover for the study area. This yielded OLI imagery for 24 dates and MSI imagery for seven dates (Table 1). Remotely-sensed images contain a timestamp for indicating the start and stop time of each row/path area. Since chlorophyll concentration multiplication can increase or decrease quickly with changes in nutrient availability or cloud cover, the team identified remotely-sensed images with timestamps overlapping with in situ data measurements (O’Brien, 2015). Finding exact overlapping occurrences was challenging due to the differing return times of OLI and MSI and buoy data times.

<table>
<thead>
<tr>
<th></th>
<th>S2MSI</th>
<th>L8OLI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>N/A</td>
<td>07/03, 07/19, 07/26, 08/20</td>
</tr>
<tr>
<td>2014</td>
<td>N/A</td>
<td>08/07, 08/23, 09/15</td>
</tr>
<tr>
<td>2015</td>
<td>N/A</td>
<td>06/07, 06/14, 06/23, 07/09, 08/17, 09/11, 09/27, 10/04</td>
</tr>
<tr>
<td>2016</td>
<td>08/29, 09/18</td>
<td>05/31, 07/27, 08/09, 08/12, 09/13</td>
</tr>
<tr>
<td>2017</td>
<td>06/05, 08/04, 08/24, 09/13, 10/03</td>
<td>05/27, 07/05, 07/14, 10/09</td>
</tr>
</tbody>
</table>

Table 1. Dates of satellite data downloaded from USGS EarthExplorer.

The team obtained in situ data from King County’s Puget Sound Marine Mooring Home Data Download, the National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center, and the State of Washington Department of Ecology Marine Water Monitoring websites (Figure 2). Fifty-two stationary platforms within the Puget Sound provided measurements of chlorophyll concentration and turbidity levels. All 52 buoy locations measured chlorophyll concentration; however, only 15 buoy locations measured turbidity levels. The remaining 37 buoys recorded light-transmission percentage, which is not easily converted to turbidity and were not included in the data analysis. King County buoy data, specifically water depth, chlorophyll fluorescence, and turbidity, were downloaded from 6 locations within the sound from May 01, 2013 through October 31, 2017. Within NOAA’s National Data Buoy Center database, the team determined which buoys were located within our study area using their interactive mapper. The team used the Historical Data Downloader to determine which buoys within the area contained oceanographic data measurements taken during the study period; this provided 9 buoys with valuable information. Using the State of Washington Department of Ecology Marine Water Monitoring website, the team downloaded 37 buoy locations containing long-term marine water quality data.

Figure 2. Buoy locations from King County Mooring, NOAA National Data Buoy Center, and State of Washington Department of Ecology
**Data Processing**

The team processed MSI and OLI data using ACOLITE to obtain turbidity and chlorophyll concentration. Royal Belgian Institute of Natural Sciences (2017a) describes multiple algorithms for processing these data in ACOLITE. The team tested four algorithms to detect chlorophyll concentration and five algorithms to detect turbidity. The team processed the OL image using two algorithms to detect chlorophyll concentration and five algorithms to detect turbidity. The team processed the MSI data using four algorithms to detect chlorophyll concentrations and five algorithms to detect turbidity (Table 2). The team kept default settings for all processing options when running ACOLITE.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Algorithm</th>
<th>Wavelength (Band)</th>
<th>Satellite/Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorophyll</td>
<td>CHL_Oc2 (CH2)</td>
<td>483/561nm (Blue/Green)</td>
<td>Landsat 8 OLI, Sentinel-2 MSI</td>
</tr>
<tr>
<td>Chlorophyll</td>
<td>CHL_Oc3 (CH3)</td>
<td>443/483/561nm (Ultra Blue/Blue/Green)</td>
<td>Landsat 8 OLI, Sentinel-2 MSI</td>
</tr>
<tr>
<td>Chlorophyll</td>
<td>CHL_RE_GONS (GON)</td>
<td>665/705/776nm (Red/Red Edge)</td>
<td>Sentinel-2 MSI</td>
</tr>
<tr>
<td>Chlorophyll</td>
<td>CHL_RE_MOSES3B (MO)</td>
<td>665/708/753nm (Red/Red Edge)</td>
<td>Sentinel-2 MSI</td>
</tr>
<tr>
<td>Turbidity</td>
<td>T_DOGLIOTTI (T)</td>
<td>645/859 nm (Red/NIR)</td>
<td>Landsat 8 OLI, Sentinel-2 MSI</td>
</tr>
<tr>
<td>Turbidity</td>
<td>T_GARABA_645_LIN (TGAR)</td>
<td>645nm (Red)</td>
<td>Landsat 8 OLI, Sentinel-2 MSI</td>
</tr>
<tr>
<td>Turbidity</td>
<td>T_NECHAD_645 (TNEC)</td>
<td>645nm (Red)</td>
<td>Landsat 8 OLI, Sentinel-2 MSI</td>
</tr>
</tbody>
</table>

Table 2. ACOLITE Algorithms Used (Royal Belgian Institute of Natural Sciences, 2017a)

After processing the images through ACOLITE, the team projected them to North American Datum (NAD) 83 Universal Transverse Mercator (UTM) zone 10N in ArcMap 10.4.1. The team then clipped the imagery to the Puget Sound Water Basins shapefile before processing. The team used the focal statistics tool to fill any NoData pixels, pixels with missing data, within the study area for each image using a mean value calculated from a seven by seven-pixel neighborhood. Some NoData areas remained after this step as the neighborhood was composed of NoData pixels for some of the pixels. Using a larger neighborhood to calculate the pixel statistics would have fixed this, but also would have reduced the benefits of the relatively high resolution of the OLI and MSI imagery use.

Within the in situ data, the team utilized the following parameters: chlorophyll concentration, turbidity level, water depth, and time of collection. The King County chlorophyll concentration and turbidity measurements were collected every 15 minutes at a depth of three meters. NOAA’s National Data Buoy Center measurements were collected randomly throughout each month at a depth of three meters. The State of Washington Department of Ecology buoy data measurements were recorded once a month, on random days, with no time stamp, and at depths ranging from one meter to 200 meters. Rather than turbidity, these buoys measured light-transmission percentage, which is related to turbidity but not easily converted to turbidity.

While comparing in situ data recorded during the 10-minute interval of the satellite overpass would have been ideal, there were not enough matching data points to make this feasible. In order to compare the greatest number of matching in situ data points with the remotely sensed data, the team calculated the average chlorophyll concentration and turbidity levels for each date at each buoy. This introduced error, as the approximately 10-minute satellite overpass was
compared with up to a 24-hour average of in situ data. In addition, some buoy measurements were not averages because there was only one measurement for that day. However, using a daily average seems reasonable considering the lifespan of a HAB to be a couple weeks to a few months. The team obtained corresponding chlorophyll concentration and turbidity from the satellite data for each buoy location and imported the values into excel to conduct statistical analysis.

The team processed all 24 OLI images through ACOLITE using the CHL_OC2 algorithm because these outputs had the fewest NoData pixels after processing. This produced 24 ACOLITE analysis maps to provide the PSMFC with an assessment of the utility of the algorithms. The team created a time series of the OLI images from May 2013 through October 2017 to display change in chlorophyll concentration levels over time. Using the Empirical Bayesian Kriging Interpolation in ArcMap, the team created two buoy interpolation maps. This kriging method estimates the values between two known points using restricted maximum likelihood (Krivoruchko, 2015). The dates August 20, 2013 and July 09, 2015 had 10 buoy locations that provided the specified parameter measurements required in order to conduct Empirical Bayesian Kriging.

**Data Analysis**

This relationship would show that both parameters are useful for identifying HABs. Using RStudio (RStudio Team, 2015), the team compared the in situ chlorophyll concentration to the turbidity to determine their relationship. Three statistical measures within RStudio were used to compare the algorithms to one another and to the in situ data. The team used Analysis of Variance (ANOVA) to examine whether there was a significant difference between algorithms for each parameter and the Tukey’s Honest Significant Difference (HSD) test to determine which of the algorithms were significantly different from each other. The team used Pearson correlation analysis to determine which of the algorithms had the highest correlation with the in situ data to validate the chlorophyll concentration and turbidity outputs from ACOLITE. After assessing the correlation, the team tested the significance of the correlation by graphing the in situ data, chlorophyll and turbidity against the satellite data to examine the relationship between them (Figure 3a - Figure 3d).

### III. Results & Discussion

#### Table 3. Correlation coefficient between in situ chlorophyll concentration and in situ turbidity.

<table>
<thead>
<tr>
<th>Buoy location</th>
<th>Correlation Coefficient (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alki Buoy</td>
<td>-0.01</td>
</tr>
<tr>
<td>Dockton</td>
<td>0.03</td>
</tr>
<tr>
<td>Point Williams</td>
<td>0.06</td>
</tr>
<tr>
<td>Quarter Master Yacht Club Buoy</td>
<td>0.12</td>
</tr>
<tr>
<td>Quarter Master Buoy</td>
<td>0.35</td>
</tr>
<tr>
<td>Seattle Aquarium</td>
<td>0.13</td>
</tr>
<tr>
<td>Yacht Club</td>
<td>0.27</td>
</tr>
<tr>
<td>Algorithms</td>
<td>Mean difference</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>CH3-CH2</td>
<td>-0.013</td>
</tr>
<tr>
<td>GON-CH2</td>
<td>18.893</td>
</tr>
<tr>
<td>MO-CH2</td>
<td>-272.232</td>
</tr>
<tr>
<td>GON-CH3</td>
<td>18.906</td>
</tr>
<tr>
<td>MO-CH3</td>
<td>-272.219</td>
</tr>
<tr>
<td>MO-GON</td>
<td>-291.125</td>
</tr>
<tr>
<td>TGAR-T</td>
<td>0.579</td>
</tr>
<tr>
<td>TNEC-T</td>
<td>0.026</td>
</tr>
<tr>
<td>TNIR-T</td>
<td>6.771</td>
</tr>
<tr>
<td>TRED-T</td>
<td>-0.474</td>
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<tr>
<td>TNEC-TGAR</td>
<td>0.605</td>
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<td>TNIR-TGAR</td>
<td>7.350</td>
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<tr>
<td>TRED-TGAR</td>
<td>0.104</td>
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<tr>
<td>TNIR-TNEC</td>
<td>6.745</td>
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<tr>
<td>TRED-TNEC</td>
<td>-0.501</td>
</tr>
<tr>
<td>TRED-TNIR</td>
<td>-7.246</td>
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</table>

**Table 4a.** Tukey multiple comparisons of means 95% family-wise confidence level for algorithms for MSI data processed through ACOLITE. * (The mean difference is significant at the 0.05 level.)

<table>
<thead>
<tr>
<th>Algorithms</th>
<th>Mean difference</th>
<th>95% Confidence Interval</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
</tr>
<tr>
<td>CH3-CH2</td>
<td>-0.001</td>
<td>-0.27</td>
<td>0.26</td>
</tr>
<tr>
<td>TGAR-T</td>
<td>-2.556</td>
<td>-10.12</td>
<td>5.00</td>
</tr>
<tr>
<td>TNEC-T</td>
<td>-1.575</td>
<td>-9.14</td>
<td>5.99</td>
</tr>
<tr>
<td>TNIR-T</td>
<td>4.27</td>
<td>35.14</td>
<td>50.26</td>
</tr>
<tr>
<td>TRED-T</td>
<td>-1.575</td>
<td>-9.14</td>
<td>5.99</td>
</tr>
<tr>
<td>TNEC-TGAR</td>
<td>9.812</td>
<td>-6.58</td>
<td>8.52</td>
</tr>
<tr>
<td>TNIR-TGAR</td>
<td>4.526</td>
<td>37.70</td>
<td>52.82</td>
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<tr>
<td>TRED-TGAR</td>
<td>9.812</td>
<td>-6.58</td>
<td>8.54</td>
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<tr>
<td>TNIR-TNEC</td>
<td>4.428</td>
<td>36.72</td>
<td>51.84</td>
</tr>
<tr>
<td>TRED-TNEC</td>
<td>-1.332</td>
<td>-7.56</td>
<td>7.56</td>
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<tr>
<td>TRED-TNIR</td>
<td>-4.428</td>
<td>-51.84</td>
<td>-36.72</td>
</tr>
</tbody>
</table>

**Table 4b.** Tukey multiple comparisons of means 95% family-wise confidence level for algorithms for Landsat 8 data OLI processed through ACOLITE. * (Mean difference is significant at the 0.05 level.)
Figure 3a. Correlations between in situ chlorophyll concentration and chlorophyll concentration obtained through four different algorithms for MSI data processed through ACOLITE.

Figure 3b. Correlations between in situ chlorophyll concentration and chlorophyll concentration obtained through two different algorithms for OLI data processed through ACOLITE.
Figure 3c. Correlations between in situ turbidity and turbidity obtained through five different algorithms for MSI data processed through ACOLITE.
The relationship between chlorophyll concentration and turbidity in the in situ data was low, with an $r$-value ranging from -0.01 to 0.35 (Table 3). This could be due to limitations in the collection methods of in situ data. Although all 52 buoys provided chlorophyll concentration measurements, only 15 buoys provided turbidity level measurements. The addition of more buoys or inclusion of more days could reveal a relationship between chlorophyll concentration and turbidity in the Puget Sound. In other words, with a greater sample size, the team could have more confidence that the sample represents the population.

The Pearson correlation analysis showed that there was no significant correlation between the in situ chlorophyll concentrations and chlorophyll concentrations obtained through each of the
algorithms derived from ACOLITE. In other words, all \( P \)-values were > 0.05 at the \( \alpha = 0.05 \) level. This means that the team was 95% confident that the lack of relationship between these two variables was not due to chance alone. The 0.05 \( \alpha \) level was chosen as a reasonable level of certainty for MSI and OLI data (Table 5). Similarly, the turbidity values from in situ data were not significantly correlated with the turbidity values obtained through each of the algorithms using MSI and OLI (i.e. all \( P \)-values were > 0.05). In addition, the \( r \) values produced ranged from -0.47 to 0.26, showing that the linear relationship between the two variables was not only low but was also sometimes a positive relationship and a negative relationship at other times (Table 5). To visualize this low correlation, the team graphed the chlorophyll concentration and turbidity values from in situ data and satellite data (Figure 3a – Figure 3d).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Algorithm</th>
<th>( r )</th>
<th>( P )-value</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorophyll</td>
<td>CH2</td>
<td>0.25</td>
<td>0.362</td>
<td>15</td>
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<tr>
<td>Chlorophyll</td>
<td>CH3</td>
<td>0.19</td>
<td>0.508</td>
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<td>Chlorophyll</td>
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<td>-0.26</td>
<td>0.377</td>
<td>14</td>
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<td>Chlorophyll</td>
<td>MO</td>
<td>-0.25</td>
<td>0.392</td>
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<tr>
<td>Turbidity</td>
<td>T</td>
<td>0.25</td>
<td>0.631</td>
<td>6</td>
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<td>TNIR</td>
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<td>0.620</td>
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<tr>
<td>Turbidity</td>
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</tr>
</tbody>
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Table 5. Pearson Correlation Analysis between in situ and satellite data

These algorithms measure the same parameters; therefore, the team compared them to see if the outputs were consistent. The comparison of algorithms produced different results for chlorophyll and turbidity. For both MSI data and OLI data, the ANOVA results showed that there was no significant difference between the chlorophyll algorithms (i.e. \( P \) was > 0.05) (Table 6). However, a significant difference was evident among certain algorithms of turbidity (i.e. \( P \) was < 0.05). The result of Tukey’s HSD analysis specifically explained which algorithms were different from each other (Table 4a and Table 4b). The algorithm TNIR was significantly different from T, TGAR, TNEC and TRE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Algorithm</th>
<th>F-value</th>
<th>( P )-value</th>
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<tr>
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<td>Turbidity</td>
<td>TNEC</td>
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Table 6. ANOVA analysis of chlorophyll concentration algorithms and turbidity algorithms
The ACOLITE Analysis Map of chlorophyll concentration displays OLI imagery processed through ACOLITE using the algorithm CHL_OC2 (Figure 4a). The buoy interpolation of chlorophyll concentration uses Empirical Bayesian Kriging Interpolation (Figure 4b). Interpolation is inherently biased towards areas with higher density of point data; therefore, it has limitations when being used in decision-making processes. The Buoy Interpolation of Chlorophyll Concentration Map symbology scale was set to 0.80-24.5 µg/L. Areas of high chlorophyll concentration were spatially similar in both maps, specifically appearing in Tacoma Inlet and Skagit Bay. These results were also apparent in our time series analysis, which identified Tacoma Inlet and Skagit Bay as two areas that had consistently high indicators of HABs (Figure 4a).

Figure 4. (a) The ACOLITE Analysis Map was created using the August 20, 2013 OLI image that was processed through ACOLITE to show chlorophyll concentration. The scale represents low values of 0 µg/L to high values of 24.5 µg/L. (b) The Buoy Interpolation of Chlorophyll Concentration Map was created using the Empirical Bayesian Kriging Interpolation method.

IV. Conclusions and Future Work

Conclusions

Given that the team did not find a strong correlation between ACOLITE algorithms and in situ data for turbidity and chlorophyll in the Puget Sound, the ACOLITE estimates should be used guardedly for Puget Sound monitoring until further studies can establish conclusive relationships. Incorporating atmospheric corrections, additional parameters, and/or additional algorithms could potentially yield more useful results. Since there were no significant differences between the chlorophyll algorithms tested, the team hypothesizes that if one algorithm can be validated, then the others can be as well. There were significant differences in certain turbidity algorithms. The team believes this is because TNIR is the only algorithm to rely solely on the 859 nm wavelength band. Although the values of turbidity and chlorophyll concentration have very low correlation with the in situ data, after interpolating the in situ data and visually comparing them with the ACOLITE processed data, the areas of high chlorophyll concentration were spatially similar. These areas of high chlorophyll concentrations, such as Skagit Bay and Tacoma Inlet, also spatially align with the areas that continuously show high chlorophyll concentrations over time. This indicates that with proper calibration, satellites can be used to identify parameters indicating HABs in the Puget Sound.
Areas identified as having relatively high chlorophyll concentrations are primarily within and along inlets, particularly Skagit Bay and Tacoma Inlet. Skagit Bay is surrounded by agricultural lands, and the Tacoma Inlet is surrounded by an industrialized community. Both water bodies receive large amounts of nutrient-rich runoff, increasing algal growth and thus causing those areas to have relatively high chlorophyll concentrations. Thus, further work to calibrate ACOLITE settings when processing chlorophyll concentrations is advised.

**Future Work**

The team suggests a thorough investigation of the advanced settings within ACOLITE, testing alternative algorithms, and including more indicators of HABs. As explained by the Royal Belgian Institute of Nature Sciences (2017b), the advanced settings within ACOLITE include options for atmospheric corrections and adjustments for specified atmospheric pressures. Previous work has proved more successful when manipulating different ACOLITE settings and obtained greater turbidity estimates (Simonson, Alvarado, & Crowley, 2017). While pressure would not have a large impact on results within the near sealevel Puget Sound, utilizing an atmospheric correction for a study period spanning years is appropriate and could impact the algorithm output (Song, Woodcock, Seto, Lenney, & Macomber, 2001). Other algorithms that identify chlorophyll concentrations without being processed in ACOLITE exist and may produce more accurate results for the Puget Sound area. For example, the floating algal index (Hu, 2009) and the normalized difference chlorophyll index (Mishra & Mishra, 2012) were designed for MODIS and incorporate improvements to atmospheric corrections designed specifically for inland waters (Page & Mishra, in progress). Both algorithms utilize bandwidths contained by the high spatial resolution MSI and OLI sensors. The team identified turbidity and chlorophyll concentration as indicators of HABs; however, the inclusion of more parameters could improve results. For example, sea surface temperature could improve HAB identification, as algae thrive in warmer water (Singh & Singh, 2015).

An increase in available in situ data would allow for more comprehensive statistical analysis between the in situ data and the satellite data. The lack of in situ buoy comparisons made it difficult when aligning the timestamps between buoy measurements and the overpass of the satellite image. With further study, spatial and temporal gaps in in situ data collection in the Puget Sound could be filled, enhancing water quality management in the region.

**V. Acknowledgements**

Dr. Jeffrey Luvall (NASA Marshall Space Flight Center), Science Advisor
Dr. Robert Griffin (University of Alabama in Huntsville), Science Advisor
Dr. Juan L. Torres-Pérez (Bay Area Environmental Research Institute, NASA Ames Research Center), Science Advisor
Leigh Sinclair (University of Alabama in Huntsville/Information Technology and Systems Center), Mentor
Maggi Klug (University of Alabama in Huntsville), Mentor
Benjamin Page (NASA SERVIR), Mentor
Mercedes Bartkovich (NASA DEVELOP), Project Coordination Fellow

This material contains modified Copernicus Sentinel data (2015-2017), processed by ESA.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration.

This material is based upon work supported by NASA through contract NNL16AA05C and cooperative agreement NNX14AB60A.
References


The Pilot Shortage Explained

Hans Gorowsky
Department of Economics

Abstract – In the United States for the next 20 years the demand for commercial airline pilots is expected to be at an all-time high. Boeing estimates a need for 117,000 new pilots in North America alone. The demand for pilots is increasing and the number of airline transport pilots (ATPs) are also increasing from year to year. From 2016 to 2017 the percent change in passengers was up 3.03% while the percent change of pilots was only up 1.22%. (U.S. Civil Airman Statistics 2018). The number of people traveling has increased in the last decade to almost a billion passengers per year. “over the next 10 years, IATA forecasts that passenger trips will grow by 4.3% annually”. The supply of pilots is analyzed through the number of certificates held in the following three categories. certified flight instructor, commercial pilot, and airline transport pilot certificate. The trend for the total amount of commercial pilots is falling from 2008 to 2017 which tells us that the airline industry is either losing pilots or is not hiring enough to replace retirees. The trend for new commercial pilots is increasing from 2015 to 2017 and this is a response to the industry recognizing a shortage. Each airline will have to make decisions based on their needs. Well qualified, certified pilots are an important factor for safe air travel and the airline industry needs these pilots for a profitable future.

I. Introduction

The United States will be at an all-time high for demand of commercial airline pilots spanning over the next twenty years. The acting Administrator for the Federal Aviation Administration (FAA) Daniel K, Elwell said “Air travel in the United States and around the world is growing rapidly with no signs of slowing down. Last year the international air transport association forecast the number of air passengers traveling will nearly double by 2036. The Boeing pilot outlook project’s this growth will require 117,000 new pilots in North America alone. But at a time when we need to see interest in aviation careers going up the data is actually trending in the opposite direction.” (AOPA 2018) For the data to be trending in the wrong direction it means there are less people pursing an interest at the beginning stages of aviation. If actions are not taken to bring more interest into aviation the airline industry will face a shortage. The question this paper aims to solve is why there is a shortage.

A shortage is when the quantity demanded of a product or service exceeds the quantity supplied in that market. The focus of this study will be on airline transport pilots (ATPs). The Airline Transport Pilot Multi-Engine certificate is the crown jewel of pilot ratings and is required for pilots flying passengers or cargo under Part 121 and some Part 135 operations. (Bergqvist 2015) The airline industry has seen shortages in the past resulting from the 9/11 terrorist attack and during the 2007 and 2008 economic downfall.

The demand for pilots is increasing and the number of pilots (ATPs) are also increasing from year to year. From 2016 to 2017 the percent change in passengers was up 3.03% while the percent change of pilots was only up 1.22%. (U.S. Civil Airman Statistics 2018) However, with air travel rapidly increasing and the mandatory retirement age of 65 the number of ATP’s will have to increase as demand rises. For instance, “Passengers on US airlines as of September 2018 was at 75.8 million which was up 11.5% from last year and up 3% from the previous month.” (Airline Traffic Data 2018)

The supply of ATP pilots comes from the civilian route or the military route to the airlines. This study focuses on the civilian side of the pilot market. The supply of pilots depends on the pathways to the airlines. There are three certificates that make a pilot employable in commercial air and the historical number of these certificates suggest there is a growing supply shortage. These pilot certificates are private pilot, commercial pilot, and Airline Transport pilot certificate. Each certification requires time and money and together they constitute a significant barrier to entry for commercial pilots. In addition, there have been times in the industry during which pilots were furloughed. “Furloughs occur when airlines contract.
They lay off pilots without pay until they start hiring again, at which point they offer those positions back to the furloughed pilots.” (McGee, 2015, p.18) Finally, the airline industry is unique because of the mandatory retirement at the age of 65. “About 42% of the pilots flying today for U.S. airlines will retire in the next 10 years. Most will do so upon reaching the federally-mandated retirement age of 65.” (Reed 2017).

The decrease in flow of pilots into the cockpit combined with an increase in flow of passengers traveling is leading to canceled flights. For example, according to Baker (2014), “A year ago, Great Lakes Airlines had 300 pilots. Today, the company has 78. The shortage of pilots led the company to suspend its mid-day flight service at the Cortez Municipal Airport.” To date, the growing shortage shows in the growing ratio of passengers to pilots, as shown in Figure 1.

One of the factors influencing this ratio is the size of the airplane. However, many pilots have decided to not work in the passenger airline industry. There are several reasons that help to explain this lack of transition including there is a large population of pilots that are working in another profession. An airline pilot does not need a degree in aviation. Another reason for the pilot shortage would be the debt that a college graduate would incur along with low entry level pay and other additional inconveniences such as uncertain living arrangements. “The data further indicates that approximately 8.53% of future pilots are no longer considering a career as an airline pilot due to the new ATP airline requirements and an additional 32.54% of future aviators are reconsidering their career as an airline pilot.” (Higgins, et al., 2013) The ATP requirements will be addressed specifically below. As the United States and the rest of the world rely so heavily on the airlines for transportation for reasons such as business, leisure and evacuation to name a few, it is important that this issue is investigated, and actions are taken to prevent a potential economic crisis.

II. Literature Review

In a comprehensive study entitled “An Investigation of the United States Airline Pilot Labor Supply,” Higgins, et al., (2013) conclude that the U.S. faces a shortage of airline pilots. They project a shortage of 35,000 pilots between 2013 and 2031. The authors list a set of reasons including:

- The increasing cost of flight training and declining potential for hire at major airlines
- Airline retirements are accelerating
- Growth of customers
- Certified flight instructors do not intend to work in the airline industry as a long-term career
- The requirement of an Airline Transport Pilot certificate prior to operating as a line pilot for an air carrier is seen as an obstacle.
They also predict that the major airlines may not experience the shortage over the next three to five years, but regional carriers may be affected by the shortages at a larger scale.

Lutte, et al., (2014) conducted an in-depth study of the pilot shortage. One of their findings was that over 45% of the commercial written exams for flight instructors were foreign pilots who had no intention of working as an airline pilot in the U.S. They project a shortage of 35,000 pilots, given that it takes five to seven years for a pilot to obtain all of their required certification to become eligible for employment at an airline.

Michael McGee in his dissertation called “Air Transport Pilot Supply and Demand”, (2014) surmises that one of the major reasons for a shortage includes the 2009 Colgan air crash, and the legislation that followed, changing rules governing requirements for airline transport pilots.

The FAA’s investigation of Flight 3407 led to the conclusion that the crash was pilot error. As a result, they recommended 25 new changes to Federal Aviation Regulations (FAR). These changes included:

- Flight and duty time
- Safety management systems
- Crew member training
- Crew member screening/qualifications
- ATP certificate requirement
- Mentoring
- Professional development
- Leadership
- Stall/upset recognition and recovery
- Remedial training programs

This was followed by congress passing the Airline Safety and Federal Aviation Administration Extension act of 2010. McGee states that two rules coming out of this legislation has exacerbated the pilot shortage. The two new rules are:

(i) Pilot Certification and Qualification Requirements for Air Carrier Operations
(ii) Flight Crew Member Duty and Rest Requirements.

The Pilot Certification and Qualification Requirements for Air Carrier Operations prolonged flight training. Flight Crew Member Duty and Rest Requirements was a safety measure, but it also limited the number of hours a pilot can log in a day which lowers the amount a pilot can amass in a month.

Lovelace and Lutte (2016) also investigate the pilot supply shortage focusing on the collegiate aviation flight students’ level. The main focus of their research was to survey collegiate aviators on the First Officer Qualification (FOQ) rule change and the perception of students on a career path to the regional airlines. Firstly, the FOQ was a direct result from the Colgan air crash in 2009. It now “requires all second-in-command pilots (first officers) to hold an Airline Transport Pilot (ATP) certificate, requiring that a pilot be 23 years of age and have 1,500 hours total flight time” (FAA, 2013a). As a result of the survey the students said in summary that it has a negative impact on career plans. The reason it has a negative impact was the increased time and money needed to meet the requirements. Besides the added requirements it is transparent that the first year pay at the regionals is unacceptable. Leaving college with more than $100,000 in debt and entering the regional airline payroll with somewhere in the mid $20,000 doesn’t necessary seem reasonable. Even the CEO of Republic stated, “There is no doubt entry level pilot pay at regionals is insufficient” (Bedford 2015).

III. The Pathways to The Airlines

Selecting the Right Flight School

The Federal Aviation Administration (FAA) provides rules for getting a pilot license (certificate) and the kind of certificate depends on the type of aircraft one wants to fly. Pilot licenses range from student pilot all the way up to airline transport pilot. Airline pilots start as commercial pilots and should have the FAA-issued Airline Transport Pilot (ATP) certificate. (“Summary” 2018) Along the way pilots must pass a written exam on the ground and a practical flying exam, called a check ride, in the right aircraft for each certificate. Specific requirements can be found in Federal Aviation Regulations (FAR). Flight schools can train student pilots either using rules from part 61 or from part 141.

Part 61 is very flexible for part time students who are training on a less regular schedule. The downside it may take longer and cost more money in flight time to finish out ratings. It requires 40 total hours of
flight time, 10 hours of solo time, 5 hours of solo cross-country flight time, 20 hours of dual instruction, 3 hours of each of the following: Instrument instruction, Night flying, and Cross country flying.

**Part 141** is a much more structured training environment and better for full-time student pilots who are 100% sure on becoming a professional pilot. Part 141 follows a strict FAA-approved syllabus and the strict enforcement of the demanding schedule allows the student to obtain a Certificate in only 35 total hours of flight time. Of those 35 hours 5 of them are solo time, 3 hours of cross country, 20 hours of dual instruction, and 3 hours each of the following: Instrument instruction, Night flying, and Cross country flying.

**Ratings and Certificates**

After finding the right flight school a student pilot will work towards their Private Pilot License. “The instrument rating, which requires the student pilot the exact skills needed to fly in the clouds and under conditions of reduced visibility, it is the most frequent “next step” taken by private pilots seeking to advance their aeronautical education. If the private pilot certificate is the airman’s bachelor’s degree, the instrument rating is graduate school.” (Gruber 2016). After obtaining a Private Pilot Certificate and an instrument rating the next certificate to get a pilot closer to the airlines will be a Multi-Engine rating. The Multi-Engine rating is the cheapest and quickest to obtain. It will vary with each school and type of plane used but should be no more than $1500 with 8 hours of instruction. This rating will enable the pilot to operate aircrafts with two or “twin” engines. Twin engine aircraft can be challenging but extremely safe for skilled pilots. Having a multi-engine rating makes flying over mountains, water, and poor weather much safer and at the same time one can fly further and faster than single engine airplanes. After the multi-engine student will work towards a commercial pilot certificate. The commercial pilot certificate is similar in training to the private pilot license, but it requires the pilot to log longer cross-country flights and the check ride maneuvers are much stricter. As for the written portion of the training its questions are related to Commercial operations in aviation. The next certificate is not a required one but it’s extremely common and it is tough to build hours without it. Obtaining a Certified Flight Instructor Certificate allows a pilot in training to build hours as well as getting paid for it. In the wake of the pilot shortage there are actually too few of CFI’s because it is a job in aviation that is used as a stepping stone to build hours and move on. At the same time, it is the most rewarding rating or certificate a pilot can receive because it is giving back to the aviation community.

At this point in a pilot’s pathway to the airlines he or she will be at the building hours stage. This means that they are short of 1500 hours of total flight time and above 500 total flight hours, so they need to fly the remaining hours to be eligible to get their Airline Transport Pilot Certificate. However, pilots are able to apply for other types of flying jobs such as banner towing, private charter operation, and skydiving jump pilot to name a few. This is a very difficult time in a pilot’s career because these jobs are not high paying. The most important thing for a pilot during this period is the experience in flying and the flight time that will prepare them for airline interviews.

Furthermore, the student will get an Airline Transport Pilot Certificate, but the ATP certificate requires a pilot to have logged 1500 hours to even apply for it. Lastly, for a pilot to be competitive in the airlines it is required that they have a four-year degree. It is clear why there is a pilot shortage when all of the student loans and pilot training keep building up. This whole flight training process from 0 hours to 1500 can take anywhere from 2 to 3 years depending on how motivated and competent the student is.

**IV. Barriers to Entry**

In the theory of economics, “the barriers to entry” for any market is an obstacle or economic cost that a new entrant of any industry must incur that an incumbent of the industry does not. When looking at the airline industry a major reason for an insufficient number of pilots comes down to the barriers to entry. The decision to become an airline pilot is a consumer decision as Higgins states in An Investigation of the United States Airline Pilot Labor Supply. When he or she successfully lands a job at a major airline it is a reward. The airline industry can be looked at as a risk reward career. The risk is all in the early stages of the career, spending thousands on ratings and certificates to “potentially” one day have those investments pay off tenfold. “Pilots say more people would spend the $150,000 to $200,000 to acquire a commercial license if regional airlines paid more to starting pilots.” (Jansen 2015). Data on average cost of becoming a pilot is not easy to calculate as different types of flight
training have different requirements. A quick learner may spend less, and some students may require multiple repeat lessons costing more.

The lifestyle and salary of the starting pilot is not very attractive. In the article “‘Pilot Shortage’: For the Airline Industry, it’s an Inside job” Michael Boyd could not have said it better. “Today, the biggest barrier to entry to the airline piloting profession isn’t the cost of gaining requisite hours and qualifications. It’s the sacrifice these individuals must make after they’re hired. Take the $60,000 that Envoy air, Piedmont, and others are promising… for the first year or maybe two. Then it’s back to the basic $40,000 plus benefits, only to grow slowly until the pilot gets to transition to the major carrier.” (Boyd 2018).

On July 15th, 2013, the barriers to entry in the airline industry only got worse. The Federal Aviation Administration finished The First Officer Qualification (FOQ) Rule change.

The third column in Table 1 lists the additional requirements for added with the first officer rule changes. These additional requirements greater increase the difficulty, time and expense of progressing through the early stages of an airline pilot’s career. While these rules increase passenger safety and reassurance, they also squeeze out potential pilots. Without some offsetting incentive, the shortage will grow even more rapidly.
<table>
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<th>Qualifications</th>
<th>Previous Requirements</th>
<th>New Requirements</th>
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| Receive an ATP certificate with an airplane category and multi-engine class rating | ● Be at least 23 years of age  
● Hold a commercial pilot certificate with instrument rating  
● Pass the ATM knowledge and practical test  
● Have 1500 total hours as a pilot | ● Meet all the previous requirements  
● Successfully complete an ATP Certification Training Program prior to taking the ATP knowledge test  
● Have 50 hours minimum in class of airplane |
| Receive an ATP certificate with restricted privileges (Restricted to serving as Second in command in part 121 operations – multi-engine class rating only) | ● None | ● 21 years of age  
● Hold a commercial pilot certificate with instrument rating  
● Completion of ATP Certification Training Program prior to taking ATP written test  
● Pass ATP practical and knowledge test  
● Meet Aeronautical experience requirements of §61.160. A pilot may be eligible if he or she was a military-trained pilot: a graduate of a four-year bachelor’s degree program with an aviation major; graduate of a two-year associate degree program with an aviation major; or has 1500 total time as a pilot |
| Serve as Second in Command (first officer) in part 121 operations               | ● Hold at least a commercial pilot certificate with an appropriate category and class training  
● Hold an instrument rating  
● Hold at least a second-class medical certificate | ● Hold an ATP certificate with appropriate aircraft type rating or – An ATP certificate with restricted privileges and an appropriate aircraft type rating  
● Hold at least a second-class medical certificate |
| Serve as Second in Command (first officer) in a flag or supplemental operation requiring three or more pilots | ● Hold an ATP certificate with appropriate aircraft type rating  
● Hold a first class medical | ● Hold an ATP certificate with appropriate aircraft type rating  
● Hold a first class medical |
| Serve as Pilot in Command in part 121 operations                                | ● Have at least 1500 hours of total time as a pilot  
● Hold an ATP certificate with appropriate aircraft type rating  
● Hold a first-class medical certificate | ● Meet all of the previous requirements  
● Have a minimum of 1000 flight hours in air carrier operations as Second in Command in part 121 operations. A PIC in operations under either §135.243(a)(1) or §91.1053(a)(2)(i), or any combination of these. |
V. Pilot Demand

Between passenger growth, airplane fleet growth, and retirement, the demand for airline pilots is going to be high for many years to come. “By 2015, demand has surpassed 3000 new pilots/year, and by 2020 it passes the 4000 pilot/year threshold. The 15-year average is over 3900 pilots/year, creating uncharted territory for majors hiring of this duration.” (McGee, 2015, p. 45) Airline pilots make up a very small proportion of the overall pilot population. So, as the demand grows, wages should increase and hopefully more pilots will transition careers to the airlines.

The total number of pilots include Sport, Private, Rotorcraft, Glider, Student, and remote pilots. Pilots in these categories use their pilot ratings as a hobby, to join a club, to become a corporate pilot, crop duster, or fly themselves and not use the airlines. Unfortunately, only a fraction of these pilots become professionals. Thus, to increase the total number of pilots we can either increase this transition rate or attract more people to aviation.

However, the last two decades have been a rollercoaster for the major airlines. In this time the 9/11 attack made air travel unpopular, major airlines went bankrupt, consolidated, and even merged into other airlines. Some years later the great recession drastically reduced the demand for flight and once again many pilots were laid off. Now that the industry has recovered and is growing rapidly the airlines need to find ways to recruit these pilots back. The four major airlines in the U.S. are American Airlines, Delta, United, and Southwest. It is not likely there will be another merger or consolidation. What happened in the last two decades will likely not happen again.

The number of people traveling has increased in the last decade to almost a billion passengers per year. “Over the next 10 years, IATA forecasts that passenger trips will grow by 4.3% annually”. (CAE 12) Efficiency and aircraft utilization will be crucial to help maintain the pilot to aircraft ratio. There are three aircraft categories that are used to classify pilots. The regional aircraft which seats anywhere from 19 to 100 passengers and goes on trips from 30 minutes to 2 hours. The Narrow-body jets seats 100-200 passengers and its average flight time is between 3 to 5 hours. Wide-body jets seat 220 or more passengers and are fuel efficient as they can fly up to 15 hours non-stop. The Regional aircraft has a ratio of 10 pilots per plane, the Narrow-body jets have 11 pilots per plane and the Wide body Jets have 16 pilots per plane. By 2027, the global commercial fleet is expected to grow by 12,000 aircraft to roughly 37,000 aircraft. (Airline Pilot Demand Outlook, p.14) It is crucial that the airlines increase efficiency without deterring working conditions and employ enough pilots to keep the same ratios as demand rises.

![Figure 2. FAA Civil Airman Statistics 2018](image-url)
Major Airlines Mergers and Bankruptcies

Figure 3. Source McGee, 2015, p. 82

Passengers In the Airlines

Figure 4. Bureau of Transportation Statistics Annual Passengers on All U.S. Scheduled Airlines (Domestic & International), 2003-2017
VII. Pilot Supply

The supply of pilots is analyzed using the number of certificates held in the following three categories. Certified Flight Instructor, Commercial Pilot, and Airline Transport Pilot certificate. Any of the three certificates make a pilot eligible for employment. When examining the pilot shortage in the airlines it is important to look at the number of certificates held compared to the number of new certificates held per year.

As described in the pathways to the airlines section above the Certified Flight Instructor (CFI) is a stepping-stone to becoming an airline Transport Pilot (ATP). The graph in Figure 5 compares the total certified flight instructors and the New Certified Flight instructors per year. Notice that there are two different ranges of values on the right and left axis. The left side of the figure (in red) measures the total certified flight instructor population and the right side represents new certified flight instructors coming into the industry each year. Thus, the total number of new CFI’s are increasing each year, however two observations are needed. First there may be many young professionals recognizing the shortage and beginning their training for the airlines. However, these data don’t specify whether these new instructors are full or part time. If too many are only part-time instructors, this growth will be insufficient.

Ultimately, the most important certificate when looking at the supply of pilots for the airlines is the ATP certificate. Daniel K Elwell states “But at a time when we need to see interest in aviation careers going up the data is actually trending in the opposite direction” (AOPA 2018) Figure 6 shows this decline from 2016 to 2017. This decline in combination with the rising demand for air travel will continue to put pressure on airline services.
VIII. Conclusion

“It is clear from the data that the United States faces a shortage of airline pilots.” (Higgins 2013 p. 29). However, the shortage will not affect the major airlines for several years. In the meantime, the regional airlines are already feeling the pinch and it is likely to get worse in years to come. Regional airlines will have to become aggressive in recruiting and rely on an increase in wages as well as offering large signing bonus to attract qualified pilots.

“In regard to research question one, results indicated that the FOQ rule had an impact on the career plans of the collegiate aviation students surveyed. As noted, 8% of respondents indicated that they no longer plan to fly for the airlines due to the rule change, and another 28% are reconsidering the airline career path due to the rule change.” (Lutte and Lovelace 2016) With the FOQ rule change will take more time and money to get to the regionals where the pay is sub-par. Aspiring pilots need to be better educated on the career earning potential as a pilot versus entry level pay.

Regional airlines are very important in providing air service throughout the U.S. Regional airlines serve 681 airports all over the U.S. If the “regional airlines have to reduce service due to the inability to hire qualified pilots, many communities will see a reduction in air service” (Higgins 2013). Higgins also suggests a twofold solution. One is to reduce costs related to flight training with scholarships and funding with future employment and provide a pathway to the major airlines and the other to recruit CFI’s. Currently about 47% of the CFI’s do not intend to become airline pilots. However, if these pilots could be lured into the industry, the shortage may be mitigated.

The Marsh Report (2016) also states that the airlines will have find creative ways to attract and retain crew beyond just increasing salaries. One would be to put in place an aviation employee benefits program.

Each airline will have to make decisions based on their needs. “Many industry experts believe that this decision will be reactive rather than proactive” Duggar, et al., (2015). Well qualified, certified pilots are an important factor for safe air travel and the airline industry needs these pilots for a profitable future.
References


Effects of a Weighted Pitching Sleeve on Range of Motion, Shoulder Strength, and Throwing Velocity in Collegiate-Aged Baseball Players

William Myers, Chelsea George, Heath McRae, & Adam McMahan
Department of Kinesiology

Abstract – Ample research has been done on the use of weighted implements, such as weighted balls, for increasing throwing performance in baseball pitchers. Research on weighted pitching sleeves, however, is far less available. The purpose of this study was to observe the effect of a weighted pitching sleeve on range of motion (ROM), strength, power, and throwing velocity in collegiate-aged baseball players. Six collegiate-aged baseball players were randomly assigned to one of two groups. The first group (n = 3; age 17.67 ± 1.03 yr; height 180.97 ± 5.01 cm; weight 84.03 ± 3.57 kg) consisted of subjects who wore a weighted pitching sleeve throughout a four-week throwing program. The second group (n = 3; age 19.00 ± 0.00 yr; height 177.25 ± 1.54 cm; weight 78.38 ± 5.71 kg) served as the control group and performed the same four-week throwing program without wearing a pitching sleeve. The throwing program consisted of 12 total sessions. Shoulder internal and external ROM, shoulder strength and power, and throwing velocity were tested both before and after the 4-week throwing program. A decrease in shoulder internal rotation ROM was found, while external rotation ROM increased for both groups. Both external rotation strength and power increased in the pitching sleeve group and decreased for the control group at each of the test speeds. No significant differences were observed between the groups for throwing velocity. These results indicate that the pitching sleeve had a positive effect on external rotation ROM, strength, and power.

I. Introduction

For baseball players, increasing throwing velocity, arm strength, and range of motion (ROM) is a common goal. Pitchers rely on strategy, ball movement, accuracy, and velocity to outsmart and outplay the batter. Greater velocity of the ball reduces the amount of time the batter has to visualize the ball’s movement and location, which makes it more difficult to achieve a hit, single, double, triple, or home run. Increased ROM can lead to decreased risk of injury and more optimal performance (Miyashita, et al., 2008). Figuring out the best methods of training to induce these improvements while decreasing the risk of injury is a mission that coaches spend a tremendous amount of time and resources trying to achieve. Current programming found in the literature (DeRenne, et al., 1990; Escamilla, et al., 2010; Syzmanski, et al., 2011) often focuses on high volume pitching programs as well as programs that include weighted implement training.

Using weighted balls to try and improve throwing velocity is something that has been studied and shown to have varying results throughout the literature. In a study by DeRenne, Ho, and Blitzblau (1990), the effects of both training with an over-weighted ball, as well as training with an under-weighted ball were observed and analyzed. The results of this study showed that the control group, the group that used under-weighted balls, and the group that used over-weighted balls all saw an increase in throwing velocity. The under-weighted and over-weighted ball groups, however, had a significantly greater improvement in throwing velocity than the control group. These results indicate that both training with an over-weighted and an under-weighted ball has a positive effect on throwing velocity. However, neither type of training delivered significantly better results than the other (DeRenne, et al., 1990). In another study looking at the effects of weighted implement training on throwing velocity, Symanski, et al. (2011), put participants through an eight-week training program in which half of the subjects trained with over-weighted ball, and the remaining subjects in the control group trained with a standard five oz. ball. Both groups also engaged in a resistance training program as a part of their training protocol. Results from this study showed no significant difference between using a weighted
While findings related to weighted balls are inconsistent, preliminary research on weighted pitching sleeves indicates they may provide more reliable results and be a useful training modality for baseball players (Phantom Weights: Phantom Studies). The sleeve of choice for this study was the Phantom Throwing Sleeve (U.S. Patent No. 287,681, 2015). The Phantom Throwing Sleeve (Figure 1) and its effects on throwing velocity has been examined in other studies. In a study with the Rice University baseball club, all players exhibited an increase in velocity after a six-week training program, with an average increase of 3.8 miles per hour (Phantom Weights: Phantom Studies). In a similar study conducted with subjects from the Texas A&M University baseball club, subjects saw an average increase of six miles per hour at the end of an eight-week training program (Phantom Weights: Phantom Studies). In our study, only a throwing program was used rather than also incorporating a resistance training program as in the Symanski, et al. (2011) study. With this study, our goal was to add to the existing research pertaining to the effects of the Phantom Throwing Sleeve on performance in baseball players. By doing so, strength and conditioning professionals can better plan effective training programs for these athletes.

The purpose of this study was to look at the effect of a weighted pitching sleeve on ROM, strength, power, and throwing velocity, in collegiate-aged baseball players. Our hypothesis was that at the end of a four-week throwing program (Escamilla, et al., 2010), participants who wore the pitching sleeve during training (Figure 2) would see greater increases in ROM, shoulder strength and power, and throwing velocity.
II. Methods

Subjects
Six collegiate-aged (17-19) baseball players participated in the study. Subjects were excluded if they had a history of upper extremity injuries, such as rotator cuff, labral, or ulnar collateral ligament injuries. Players that throw from the side arm slot or submarine style were also excluded. Subjects were recruited via word of mouth and were informed of the study using a script. All subjects were required to sign an informed consent document as well as fill out an injury questionnaire to determine whether they were eligible to participate in the study (Yancy, 2018). The study was approved by the Institutional Review Board at the University of Alabama in Huntsville.

Instrumentation
Before performing a study for overhead athletes, it is necessary to measure the ROM on the dominant/throwing arm of each participant. The ROM data is essential in understanding what effect the throwing program and sleeve have on each participant pre and post data collection. A goniometer was used to measure the shoulder external and internal rotation ROM for the six athletes in the study (Sueyoshi, et al., 2017; Hurd, et al., 2011; Yu & Lee, 2012). All measurements were taken three times and the average was used for further statistics.

Strength and power of the shoulder muscles are important factor to measure when assessing overhead athletes. We measured strength and power of the internal, subscapularis, and external (infraspinatus and teres minor) shoulder rotators using an isokinetic dynamometer (Yin-Chou, et al., 2010; Baltaci & Tunay, 2004). If the participant has weak shoulder muscles, or performs poorly on dynamometer strength and power testing, a study involving numerous throws may lead to an increase in soreness of the shoulder girdle and possible overuse injury.

To precisely measure velocity of the ball, a Stalker Radar Gun (Applied Concepts Inc., Richardson, TX) was used with similar methodology to Huang, et al. (2011). A radar gun is more efficient than using a stopwatch to measure the time from the pitcher’s release of the ball to the initial contact with the catcher’s mitt. For this study, the radar gun was manually operated by pointing the gun directly at the pitcher’s torso. Results were displayed with a digital reading in miles per hour.
displayed a number in miles per hour (mph) that is directly correlated with the velocity of the ball with accuracy to within +/- 0.5 mph (Crotin, Bhan, Karakolis, & Ramsey, 2013). For this study, the subjects threw 10 maximal throws, and their highest throwing velocity was recorded and analyzed.

Subjects were then randomly assigned into the control group (n=3) or the weighted sleeve group (n=3). All six subjects completed a four-week throwing program in which they threw three times a week, for 12 total sessions, similar to the training protocol for a study performed by Escamilla, et al. (2010). The throwing sessions were conducted with a researcher observing and directing each stage for all sessions. Throwing sessions began by having subjects perform a proper warm-up using a tubed rubber band with wrist attachments that can be affixed to fences or poles using the metal clip attached (Jaeger Sports: Training Programs). Resistance bands are used to stretch and activate muscles used in throwing. Following the warm-up, the throwing program was performed. All subjects performed the same training regimen from warm-up to cool-down. Once the four-week training program was complete, ROM, muscular strength and power, and throwing velocity were again tested using the same instruments and procedures performed for pretest measurements.

Statistical Analysis

In order to compare pretest data with post-test data for the group wearing the weighted sleeve as well as the control group, a 2-way mixed design analysis of variance (ANOVA) was performed for the variables. The ANOVA shows whether there was a significant statistical difference in ROM, strength, power, and throwing velocity within the two groups pre and post, as well as across groups. An alpha level of $p \leq 0.05$ was set as the significance level. Effect size was evaluated with $\eta^2$ (Eta partial squared), where $\eta^2 < 0.06$ constitutes a small effect, $0.06 < \eta^2 < 0.14$ shows a medium effect, and $0.14 < \eta^2$ is a large effect (Cohen, 1988). All statistical analyses were performed using SPSS (v23, SPSS Inc., Chicago, IL).

III. Results

Pretest data showed a statistically significant difference in age ($p = 0.016$) between the pitching sleeve and control groups. There was no significant difference in height or weight between the groups (Table 1). Pre- and post-intervention data is presented as mean ± SD for ROM, strength, power, and velocity (Table 2). No significant differences were found for ROM ($F \geq 0.013, p \geq 0.895, \eta^2 \leq 0.002$). No significant differences were observed for strength at any of the tested speeds ($F \geq 0.092, p \geq 0.554, \eta^2 \geq 0.045$). For power, no significant differences were observed for any of the tested speeds ($F \geq 0.106, p \geq 0.701, \eta^2 \geq 0.013$). No significant changes were found for velocity ($F \geq 0.289, p \leq 0.605, \eta^2 \geq 0.035$).

Although no significant changes were found, there were some trends found within the data. For ROM, a loss of IROM and an increase in EROM were noticed in both the control and the pitching sleeve groups. For external rotation strength (ERS) and external rotation power (ERP), an increase was observed in the pitching sleeve group and a decrease in the control group. Minimal changes were observed for velocity between tests and across groups.
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### Table 1: Descriptive data of subjects (mean ± SD)

<table>
<thead>
<tr>
<th>Group</th>
<th>Pitching sleeve, n = 3</th>
<th>Control, n = 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>17.67 ± 1.03</td>
<td>19.00 ± 0.00</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>180.97 ± 5.01</td>
<td>177.25 ± 1.54</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>84.03 ± 3.57</td>
<td>78.38 ± 5.71</td>
</tr>
</tbody>
</table>

### Table 2: Changes in dependent variables between pitching sleeve and control group across the training period

<table>
<thead>
<tr>
<th></th>
<th>Pitching Sleeve Group (n=3)</th>
<th>Control Group (n=3)</th>
<th>Effect Size ($\eta^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ROM</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>IR (°)</td>
<td>Pre 42.43 ± 11.61</td>
<td>Post 42.13 ± 15.58</td>
<td>0.002</td>
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<tr>
<td></td>
<td>53.19 ± 8.88</td>
<td>51.07 ± 9.16</td>
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<tr>
<td></td>
<td>ER (°) 65.22 ± 10.59</td>
<td>67.20 ± 15.79</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>73.22 ± 5.67</td>
<td>76.57 ± 7.09</td>
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<tr>
<td><strong>Strength</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IR 60 (N/m)</td>
<td>Pre 36.00 ± 7.21</td>
<td>Post 37.33 ± 5.69</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>39.00 ± 21.93</td>
<td>34.67 ± 16.77</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ER 60 (N/m)</td>
<td>32.67 ± 4.51</td>
<td>0.111</td>
</tr>
<tr>
<td></td>
<td>35.67 ± 9.29</td>
<td>30.33 ± 7.77</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IR 120 (N/m)</td>
<td>Pre 26.33 ± 9.07</td>
<td>0.011</td>
</tr>
<tr>
<td></td>
<td>31.00 ± 3.00</td>
<td>30.67 ± 20.75</td>
<td></td>
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<tr>
<td></td>
<td>ER 120 (N/m)</td>
<td>29.33 ± 2.89</td>
<td>0.116</td>
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<tr>
<td></td>
<td>28.33 ± 12.10</td>
<td>27.00 ± 6.93</td>
<td></td>
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<tr>
<td></td>
<td>IR 180 (N/m)</td>
<td>Pre 20.00 ± 5.20</td>
<td>0.045</td>
</tr>
<tr>
<td></td>
<td>25.67 ± 3.79</td>
<td>26.00 ± 16.09</td>
<td></td>
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<tr>
<td></td>
<td>ER 180 (N/m)</td>
<td>24.33 ± 4.62</td>
<td>0.124</td>
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<tr>
<td></td>
<td>23.00 ± 9.85</td>
<td>20.33 ± 9.71</td>
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<tr>
<td><strong>Power</strong></td>
<td></td>
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</tr>
<tr>
<td>IR 60 (W)</td>
<td>Pre 28.33 ± 6.43</td>
<td>Post 30.67 ± 3.51</td>
<td>0.019</td>
</tr>
<tr>
<td></td>
<td>31.67 ± 18.50</td>
<td>28.33 ± 15.37</td>
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<tr>
<td></td>
<td>ER 60 (W)</td>
<td>24.33 ± 2.31</td>
<td>0.202</td>
</tr>
<tr>
<td></td>
<td>28.33 ± 3.51</td>
<td>30.67 ± 7.37</td>
<td></td>
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<tr>
<td></td>
<td>IR 120 (W)</td>
<td>Pre 36.67 ± 14.47</td>
<td>0.013</td>
</tr>
<tr>
<td></td>
<td>47.00 ± 4.58</td>
<td>43.00 ± 36.29</td>
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</tr>
<tr>
<td></td>
<td>ER 120 (W)</td>
<td>33.00 ± 7.81</td>
<td>0.124</td>
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<td></td>
<td>47.00 ± 7.00</td>
<td>42.67 ± 22.37</td>
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<tr>
<td></td>
<td>IR 180 (W)</td>
<td>Pre 34.00 ± 19.05</td>
<td>0.019</td>
</tr>
<tr>
<td></td>
<td>48.33 ± 5.51</td>
<td>45.00 ± 43.28</td>
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<tr>
<td></td>
<td>ER 180 (W)</td>
<td>31.67 ± 19.09</td>
<td>0.073</td>
</tr>
<tr>
<td></td>
<td>50.33 ± 10.69</td>
<td>41.33 ± 28.73</td>
<td></td>
</tr>
<tr>
<td><strong>Velocity</strong></td>
<td>m/s 36.06 ± 2.46</td>
<td>35.47 ± 2.70</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>35.17 ± 1.44</td>
<td>35.91 ± 1.81</td>
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</tr>
</tbody>
</table>
IV. Discussion

In this study, the effect of a weighted pitching sleeve on ROM, strength, power, and throwing velocity, in collegiate-aged baseball players was investigated. Although no significant changes were found, there were some similarities and differences in the data gathered. At baseline, the control group had considerably more ROM than the pitching sleeve group for IROM and EROM. An increase in EROM was seen from pre to post testing in both groups. However, at the end of the program, IROM decreased in both groups, showing similar changes in both groups. This shows that in a short throwing program ROM may not be affected drastically by a weighted pitching sleeve. In a previous study which utilized weighted balls (Donatelli, et al., 2000), results indicated an increase in EROM in subjects who used the weighted ball, as well as a decrease in IROM. The results of this study were consistent with those found in our study. Decreased IROM may be due to increased anterior humeral head translation and superior migration, but the exact cause needs to be further investigated (Donatelli, et al., 2000).

This study did not show any significant changes in ERS and IRS ($p \geq .318$). However, non-significant increases in ERS were observed in the pitching sleeve group opposed to a decrease in the control group. At 60 deg/sec the pitching sleeve group saw a 7.71% increase in strength whereas the control group had a decrease of 15.23%. At 120 deg/sec, the pitching sleeve group had a decrease of 11.6%. Although none of these changes were statistically significantly different between the two groups, a medium effect size ($\eta^2 = .124$) was seen in ERP at 120 deg/sec as the pitching sleeve group again experienced an increase in power of 6.68% while the control group decreased by 6.3%. These numbers indicate that while there was not a significant difference between the two groups, wearing the pitching sleeve did have a positive effect on ERP. An increase in ERP is consistent with the findings of a study by Wooden, et al. (1992) in which an increase in ERP was seen in baseball players participating in both isokinetic and variable resistance mode strength training programs. In our study, which would be comparable to the variable resistance mode of strength training in the study by Wooden, et al., no significant improvement in internal rotation power (IRP) was observed from incorporating weighted training.

Velocity pre and post testing measures show a decrease of 1.64% in throwing velocity over the course of the four-week throwing program for the pitching sleeve group. These results are consistent with the findings of Symanski, et al. (2011). In this study, both groups engaged in resistance training using resistance bands, which is similar to the protocol of that study. Neither study saw an increase in throwing velocity when using some form of weighted implement to train. In our study, the control group showed a slight increase in velocity (2.1%). These changes in velocity were not found to be statistically significant ($p = .605$). One subject in the control group saw an increase of three mph, creating an outlier in the data. With more subjects, this outlier would not have had affected the data as much as it did.

Some of the feedback gained through the throwing program from individuals using the pitching sleeve was that the throws performed had a better finish than before. This could be due to the weights in the sleeve making the arm follow through more consistently along with keeping the index and middle fingers pushing the ball. Another common comment was how the release point, the point at which the ball leaves the fingers of the thrower, was not affected with the increase or decrease of weight. A negative observation for the pitching sleeve was how the sleeve fit the arms of some of the participants. Each participant’s sleeve fit well when stationary and dry, but due to sweat the sleeve became wet and did not
A further limitation of this study was the sample size. Subject age was shown to be significantly different among the two groups. While the ages did not range much, one outlier has a large effect when dealing with a small sample size. Further studies containing more subjects should be performed in order to produce more definitive conclusions, and to have a more homogenous sample. We also believe that a longer training program would allow for better results. A final limitation to this study was that the only available training space was outdoors, which became an issue in the case of bad weather. We would have liked for the training days to be consistent from week to week, and this was not always the case depending on weather conditions. Future studies should utilize indoor training spaces in order to avoid this potential issue.

VI. Acknowledgements

The authors would like to thank the research participants for their time and cooperation with attending testing and throwing sessions. The authors would also like to thank Ryne Tacker from Phantom Weights for providing the pitching sleeves and warm-up bands used in this study.
References


The Effect of Familiar Location on Upper Body Strength Testing Using the 1RM Bench Press

Noah Pring and Maggi Welch
Department of Kinesiology

Abstract – Scientific literature has indicated that academic performance improves in the same environment that it is learned in. This implies that memory depends on physical context cues, which refers to the physical surroundings in which an event occurs. No literature thus far has shown how environmental cues could relate to performance in terms of upper body muscular strength. The purpose of this study was to see how the environmental reinstatement effect affects upper body strength. It was hypothesized that participants would achieve a higher one rep max (1 RM) score in the location they are familiar with than the location they are unfamiliar with. Twenty university students (18-30 years old) were assessed in upper body strength using the 1 RM bench press test. Students were split into two groups, based on the location: Spragins Hall (SH) and the University Fitness Center (UFC). One session took place in their familiar location and the other in the non-familiar location, with one week apart. The order of testing location was randomized, and the best 1 RM score for the participant was recorded. There were no significant differences in the 1 RM score within the two locations (p = .897). However, both groups did achieve a higher average 1 RM score in their familiar location. Although the results were nonsignificant, this knowledge can help in professional and non-professional sports testing. This information allows us to be confident that upper body strength testing can be administered in a setting unfamiliar to the test takers, and it should not be detrimental to their score.

I. Introduction

Scientific literature has indicated that academic performance improves in the same environment that it is learned in. Smith (1979) calls this the ‘environmental reinstatement effect.’ His research confirmed that environmental context information is a source of retrieval cues useful for recalling information learned in that context. This implies that memory depends on physical context cues, which refers to the physical surroundings in which an event occurs, including location, size of room, objects and persons present, odors, sounds, temperature, lighting, and so on. In addition, Franks, et al. (2000) posits that individuals demonstrate transfer-appropriate processing, which is the ability of individuals to be more efficient in performing a task on a stimulus when there has been previous experience in performing that same task on the same stimulus.

Though there have been similar tests for other components of fitness, such as reaction speed and coordination (Heinen, et al., 2017), no literature thus far has shown how environmental cues could relate to performance in terms of upper body muscular strength. Research in sport often shows the effects of a ‘home advantage’ (Pollard & Gomez, 2012). ‘Home advantage’ is the consistently better performance seen by teams in various sporting contexts when playing at home than playing away (Neave & Wolfson, 2003). According to Neave and Wolfson (2003), one explanation for this phenomenon could result from familiarity with the home venue, leading to increased spatial awareness. Therefore, using this theory could result in a ‘home advantage’ in upper body muscular strength testing.

In the field of strength and conditioning and sports science, the ability to perform an accurate fitness test is important for coaches and researchers. A fitness test allows the professional to accurately prescribe a fitness program (Haff & Triplett, 2008). In order for the program to be accurate and to encourage the client to achieve their full potential in a safe way, we need the fitness test to be as accurate as possible. Therefore, if we find that there is a similar correlation in terms of upper body strength and environmental cues, then this study could be used to get more accurate results within exercise prescription and fitness testing.
According to government statistics, there are 36,540 health clubs and fitness centers in the USA (Statista, 2016). In addition to this, the American College of Sports Medicine (ACSM) Health and Fitness Journal has found an increase in the trend of fitness activities (Thompson, 2014). This shows how much the health and fitness industry has grown. With such a substantial volume of people engaging in fitness, it is vital that they have an appropriate exercise prescription that is safe for them to follow. By having more information on the validity and reliability of the 1 RM testing for upper body bench press, we can help this population receive maximum benefits from training while ensuring safety. The 1 RM is defined as the maximum amount of weight that an individual can lift for one repetition (Haff & Triplett, 2008). This is the most common way of identifying upper body strength. This study benefits the population by providing information about the relationship between the environmental spatial cues and the outcome of their performance, which can help develop training programs to enhance their ability to achieve muscular strength. It also benefits the population to provide a safe 1 RM test and to present the participants with their score.

The purpose of this study was to see how the environmental reinstatement effect impacts upper body 1 RM scores. The issue being investigated was whether individuals would achieve a higher 1 RM value in a setting that was familiar to them or in a setting that was unfamiliar to them. When an individual knows their 1 RM score, it can be used to calculate a target set and repetition quantity in order to get the best results out of training.

According to Smith (1979), individuals may attend to their environment in a more anxious way in novel situations, which could manifest as a performance decrement. His more recent meta-analysis showed that environmental context effects are reliable and the use of non-contextual cues during learning and testing can reduce the effect of environmental manipulations (Smith & Vela, 2001). Therefore, with support from previous literature, we hypothesized that upper body 1 RM strength would be greater in the location that was familiar to the participant than one that they had never trained in.

II. Part 2

Participants

Our sample size consisted of 20 participants (males = 11, females = 9) from the university community divided into two groups. One group consisted of student-athletes who routinely train at Spragins Hall (SH). The other group consisted of university students who routinely train at the University Fitness Center (UFC). They had experience in a 1 RM bench press test, participated in regular resistance training (muscular strengthening/endurance activities 3-5 times a week), and had taken part in a regular resistance training schedule for at least three months prior to the data collection, which added to the reliability of the study (Riiti-Dias, et al., 2011). The inclusion criteria were monitored through screening upon application in order to participate in the research. By using this population, we helped educate the participants on the procedures of the 1 RM test protocol and presented them with their 1 RM value, so they could better prescribe their exercise protocols for the future.

Measurements/ Instrumentation

Our instruments included the equipment needed for a bench press exercise. An Olympic bar, standard weight plates, and a bench that participants laid on were utilized. All of these instruments had high validity and reliability (ICC = 0.997) (Goodman, et al., 2008). According to Levinger, et al. (2009), “The test-retest reliability of the 1 RM demonstrates high intra-class correlation coefficients (ICC > 0.99).” Levinger, et al. (2009) goes on to say that the 1 RM test is increasingly gaining acceptance as the gold standard for assessing muscle strength. We measured 1 RM in terms of kilograms to the closest tenth of a kg.

Procedures

First, we selected participants based on training location (SH or UFC). We advertised our study by hanging flyers around campus and by asking individuals who regularly exercise at both locations. Once recruited, participants were sent an email with a set of instructions, and we arranged a day and time for them to come participate in a familiarization session. The familiarization session consisted of the participants meeting us at the location of testing, going over procedures, allowing them to ask any questions, and giving them the forms to sign.
The instructions informed the participants to abstain from exercise 48 hours prior to the test, including the day they came in for the test. Participants were asked to record the food they had eaten 48 hours prior to the test on the diet log, so it could be repeated for the next test. The instructions also asked them to record the exercise they had participated in two days prior to abstaining from exercise for the test, so they could try to mimic those exercises before the next test. Lastly, the instructions explained what would take place on the day of the test, the instructions for the 1 RM test, the benefits of the test, and the risks of the test.

Before the day of the test, we randomized whether participants would test in their familiar or unfamiliar setting first. On the day of the test, we had participants come in and engage in a quick non-weight bearing warm up. After this, NSCA guidelines for 1 RM testing were followed (Haff & Triplett, 2008). These guidelines allowed the participant three attempts to warm up with a low weight on the bar and then five attempts to achieve their 1 RM score.

One week later, participants reported to the other setting and repeated the 1 RM procedures. We encouraged participants to continue regular sleeping patterns. This allowed us to see if there were any outside factors for a potential difference in scores. We also tested participants at the same time of day to avoid the confounding effects of metabolic factors.

### Study Design

Performing the 1 RM protocol from previous studies (Levinger, et al., 2009, Headley, et al., 2011), we assessed the values using a within-subjects design to see whether there was a difference in muscular strength performance in familiar and unfamiliar locations. This experiment utilized quantitative data by objectively measuring an individual’s 1 RM score. This was a quasi-experimental design due to the absence of a control group. We had a within-subjects design as the participants were being compared to themselves and we utilized a cross-sectional approach by measuring individuals at two separate times.

### III. Statistical Analysis

An analysis of variance (ANOVA) was used to compare the means of the two sets of data for the groups. The ANOVA has been used in similar studies to analyze results such as measuring the effect of competition location on individual athlete performance and psychological states (Bray & Martin 2003), the ability to recall a list of words in the same environmental context (Smith 1979), the reliability of the 1 RM strength test for untrained middle-aged individuals (Levinger, et al., 2009), and the contribution of visuo-spatial factors in representing a familiar environment (Meneghetti, et al., 2017). The data were analyzed using SPSS (v23, SPSS Inc., Chicago, IL). A univariate two-way ANOVA with the session and group being random factors and the 1 RM score being the dependent variable was analyzed to determine significance ($p < 0.05$) and to assess the means.

### IV. Results

A total of 10 participants from SH (Age = $21.6 ± 1.43$ years, height = $175.744 ± 13.87$ cm, weight = $73.678 ± 11.87$ kg; males = 4, females = 6) and 10 participants from the UFC (Age = $23.2 ± 2.69$ years, height = $176.75 ± 6.12$ cm, weight = $78.984 ± 9.43$ kg; males = 7, females = 3) completed the study (Table 1). The groups were not significantly different for height and weight ($p ≥ .117$), although there was a significant difference between groups for age ($p = .024$). The interaction between group and session were non-significant and had a low effect size ($F = .020; p = .887; ɳ^2 = .001$). There was no significant difference for session, lifting in a familiar environment compared to a non-familiar environment ($F = .017; p = .897; ɳ^2 < .001$). There was also no significant difference in 1 RM performance between groups, although there was a medium effect size ($F = 2.663; p = .111; ɳ^2 = .069$).

The mean 1 RM for the SH group in their familiar location was higher than the mean 1 RM in their unfamiliar location (Table 2). We also found higher mean 1 RM scores for the UFC group testing in their familiar location than in their unfamiliar location.
V. Discussion

The purpose of this study was to determine whether performing a 1 RM test in a familiar environment—an environment in which individuals usually weight train in—would yield higher upper body strength test scores than an environment that is unfamiliar—one which they had never trained in. The hypothesis was that participants would attain higher 1 RM scores in the familiar environment versus the unfamiliar environment. The results did not support this hypothesis with statistical significance. However, there were differences in the participants’ means in the familiar and unfamiliar environments. The mean scores show that student-athletes who are accustomed to weight training in SH had higher 1 RM scores when tested in their familiar environment than their unfamiliar environment. Furthermore, the results show that participants who were familiar with the UFC showed higher 1 RM scores in their familiar environment compared to performance when being tested in their unfamiliar environment. These results could indicate that participants were more comfortable lifting in their familiar environment. The student-athletes’ scores from the SH group were .18% (0.2 kg) higher in their familiar environment, and the participants’ scores from the UFC group were 3.21% (2.5 kg) higher in their familiar environment. This could suggest that the student athletes lifting at SH were less affected by the changes in the environment.
One potential rationale for the SH group being less affected by changes in the environment could be that athletes may be more resilient to change when performing in different environments because they do it on a regular basis. This is a skill necessary for athletes playing away games.

Our results also could demonstrate that being around similar stimuli may have helped them lift a heavier weight. Franks, et al. (2000) stated that transfer appropriate processing takes place with an individual being able to perform better in a similar environment due to familiarity. Other research has shown that it could also be linked to testosterone levels. Neave and Wolfson (2003) explain that testosterone has been linked to dominance and competitiveness in humans. In their study, they found that male soccer players had significantly higher levels of salivary testosterone in their system when performing at home versus performing away. This could be a possible explanation of the higher mean 1 RM scores of our subjects in their familiar environments, since it is where they are used to training. However, interpretations cannot be inferred due to the use of both genders in the current study and the use of only males in Neave and Wolfson’s (2003) study. It would be beneficial for future research to investigate this effect on females. Consistent with the current study, Bray and Martin (2003) also did not find a significant difference ($p > 0.05$) in familiar versus unfamiliar environments. They hypothesized that when competing at home, skiers would perform better than away due to more positive mood states, higher confidence levels, and less anxiety before the game. However, they found that there was no difference in psychological state anxiety in skiers when at home or away competing.

Alternatively, the study carried out by Heinen, et al. (2017) found significant results when testing gymnasts’ ability to use perceptual information for a strategy to time and regulate a movement in an event. Similar to our study, their results are intended to help coaches develop training programs to help athletes utilize this information when in unfamiliar environments during training and competition. Although we saw scores improve slightly from the first to the second session, the two sessions were not statistically significantly different ($p = .927$). This indicates that the order of testing of familiar or non-familiar first did not significantly affect the results of this study.

Limitations of this research include a small sample size. Due to the time frame and location of recruitment, we were limited in the number of subjects recruited. Future research should consider obtaining a larger sample size in order to test for more significant results. A second limitation involves controlling for sleep. Although participants were encouraged to keep a consistent sleep pattern between the testing days, this was not recorded. Antunes, et al. (2017) found that individuals who had seven or more hours of quality sleep presented better performance during an incremental Wingate test with higher values of maximum power output ($p = .043$), maximal aerobic power ($p = .034$), and lower values of maximum heart rate ($p = .01$), compared to individuals who had less than seven hours of sleep. Future research could control for sleep to ensure this does not impact the results. A third limitation could be the amount of weight that we were able to place on the bench press bar. We were only able to increase the amount of weight by 1.1 kg at the least amount, so if a subject wanted to only increase the weight by .05 kg, there was no way to do this. So, the subject either had to keep the smaller weight that they had already achieved, or they had to increase it by more than what they wanted to try to lift, which resulted in a failed attempt most of the time. It would be beneficial for future research to consider equipment that allows the weight to be manipulated by the smallest amount possible in order to test for more significant results.

VI. Conclusion

The results of this study indicate that testing in an unfamiliar environment might result in slight decreases in 1 RM tests scores for the upper body bench press. This could be taken into consideration in future fitness testing in professional and college sport environments. If athletes are tested in the same location in which they train, they could yield higher, more accurate results which could better represent the athlete. However, the differences were very minimal from this study, so professionals can be fairly confident that testing in an unfamiliar environment could provide accurate test results as well.

VII. Acknowledgements

The authors would like to thank the department and staff of the University of Alabama in Huntsville Kinesiology program and a special thanks to our participants.
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Parental Leave:
An Analysis of Job Protected, Paid Parental Leave in the United States

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Abstract – This article reviews the current literature on job protected, paid family leave policy in the United States. It examines the history of parental leave and the evolution of America’s social fabric by spanning the initial entrance of women into the workforce during WWII to the current prevalence of dual career families in America. The review reveals that family leave programs benefit the United States economy, employers and organizations, and mothers and their children. New York and California offer the most progressive family leave programs in the country and are used as a standard to explore the paid family leave policies that currently exist. The subsequent effect on the lives of citizens living in California after its family leave policy was introduced is used as a criterion to judge the economic prosperity and health of Californians in comparison to the residents of other states that do not offer family leave programs. This inquiry produced evidence suggesting that offering a federal job protected, paid family leave policy is an achievable endeavor which would greatly benefit the American people. However, there are significant hurdles which could prevent a federal plan from being accepted or successful such as lack of awareness and issues of mobilization. To this end, provisions that must be put in place for a future federal mandate to be effective are also discussed.

I. Introduction

This paper addresses the questions of why the United States needs paid parental leave, what exactly should be offered to employees, and how it works to benefit everyone involved. These questions will be answered by reviewing the history of parental leave in the United States, covering the main benefits of offering federally mandated paid parental leave, and outlining examples of how offering paid parental leave has been successful when introduced by various states. Section I introduces the paper and explains its motivation. Section II reviews the history of parental leave in the United States. Section III covers the benefits of offering paid parental leave. Section III is further divided into four subsections. Subsection A reviews the benefits for America’s general population. Subsection B reviews the benefits for employers offering leave. Subsection C covers the benefits for mothers. Subsection D reviews the benefits for children. Section IV details the most progressive parental leave policies offered in the United States. Section IV is further divided into Subsection A which reviews New York’s paid family leave policy and Subsection B which reviews California’s family leave policy. Section V explains the impacts of California’s paid leave policy. Section V is further divided into three subsections. Subsection A details the impacts of California’s paid leave policy on employers, Subsection B covers its impact on women’s labor force participation, and Subsection C reviews its impact on children and fathers. Section VI concludes with recommendations for the future.

Data from the Bureau of Labor Statistics shows that, in the United States, women’s wages are lower than men’s. This trend becomes more evident as women and men grow older. According to the Bureau of Labor Statistics 3rd Quarter 2018 data, the difference in wages between men and women in the 20-24 age range is 56 dollars. That number increases to 228 dollars for those between the ages of 35 to 44. For those who are 55 and over, the difference is 285 dollars. The effects of pregnancy and subsequent motherhood on women’s wages could be an explanation for the marked differences in the data (Figure 1). A review of literature on this topic would be the first step in determining the existence and cause of this discrimination between women and men. This paper examines the current status of family leave in America. The benefits of family leave for the family unit, organizations that employ mothers and fathers, and the United States economy are also examined. The status of family leave in two different states within the
United States are detailed to provide examples of existing coverage. The motivation for this paper was to review current literature and studies that provide comparison data on labor market outcomes for mothers who do and mothers who do not utilize paid parental leave. Women are subject to labor market discrimination because of their gender, and on average make less than their male counterparts (Figure 1). Employers who do not offer paid leave options for women who must miss work due to pregnancy and related complications put women at a further disadvantage.

The United States of America is the only developed nation without federally mandated paid parental leave (Sladek, 2017). The survey of 190 countries, conducted in 2010 in a study by Pressman, shows that only three countries failed to offer this kind of paid leave: The United States, Papua New Guinea, and Swaziland (Pressman, 2014). Other countries around the world, such as Finland, began introducing paid, job protected parental leave after World War II in the 1940’s and 1950’s (Clark, 2017). The United States did not introduce paid family leave programs during that period and still does not today (Figure 2).
II. History of Parental Leave in the United States

The push for parental leave began in the 1970’s as large numbers of women began to enter the workforce full-time (Paquette, 2016). Although the issues began in the 70’s, it was not until the Family and Medical Leave Act of 1993 that any significant legislation was passed (Ingraham, 2018). The Family and Medical Leave Act, also known as the FMLA, requires firms who employ fifty or more people to allow employees twelve weeks of unpaid, job protected leave. This leave is available for cases of birth, adoption, or sickness of a close family member. It excludes workers who have worked at a firm for less than one year and workers whose leave would cause substantial and grievous injury to the firm. This precludes 20% of new moms and as a result, only 0.7% of female workers between the ages of 16 and 44 can take advantage of the opportunity (Pressman, 2014). No federal mandates have been passed regarding parental leave for 25 years for the private sector. In 2015, President Barack Obama signed a presidential memorandum, requiring federal employees to have access to 6 weeks of paid sick leave to care for a new child or ill family members (Duncan, 2016).

The social and economic fabric of America has changed dramatically in the quarter of a century since the FMLA was introduced. Generation Y and Millennials now outnumber Baby Boomers in the workforce (Sladek, 2018). With this change in generations comes a shift in the prevalent family structure. According to the Population Reference Bureau:

In 2002, only 7 percent of all U.S. households consisted of married couples with children in which only the husband worked. Dual-income families with children made up more than two times as many households. Even families with two incomes and no children outnumbered the traditional family by almost two to one (Traditional, 2003).

This number has only grown since 2002. The shift in family structure affects these generations’ values and the criteria upon which they evaluate their employers. While older generations valued loyalty and a steady income, Millennials prefer flexibility, time off, autonomy, and greater involvement with their work (Sladek, 2017).

The number of mothers in the workforce has steadily increased since the 1940’s World War II era. In 1948, 17% of women with children under 18 years old were employed in the workforce. That number increased to 40% in the early 1970’s and reached 70% in the 1990’s (Pressman, 2014). As the number of mothers in the workforce has increased, the number of companies offering paid leave, especially for fathers, is quite low. Only one out of five companies offer paternity leave in the United States (Sladek, 2017). This number shows that most companies in America reinforce traditional gender roles and do not recognize the legitimacy of mothers who are the primary breadwinners of their families (Figure 3).

Figure 3. Share of all mothers who are breadwinners or co-breadwinners, 1967 to 2015

III. Benefits of Offering Paid Parental Leave

For America’s General Population

The benefits of paid parental leave do not only include those directly involved, but also the whole country. Paid parental leave is beneficial to the U.S. economy. Offering paid parental leave increases the likelihood of mothers returning to the workforce after the leave has been used. More women returning to the workforce means increased tax contributions from their income, which benefits the entirety of America. Women who are offered and use paid parental leave are also less reliant on public assistance, as they can care to the needs of their child while still returning to the workforce (“Expecting,” 2012).

For Employers Offering Leave

There are also benefits for organizations that support offering a paid parental leave policy for their employees. Companies do not have to necessarily support this leave financially, as funds can be raised through employee payroll taxes (Caldari, 2018). Companies have little to lose and much to gain. The unemployment rate is at the lowest it has been in
nearly fifty years. This means that companies must stay competitive in this evolving world in order to attract the greatest talent. One of the top employee-rated companies in the United States, Netflix, has recently expanded their paid leave offerings. Netflix is now offering one year of maternity leave to employees (Sladek, 2017). Successful companies that offer these benefits create a foundation of loyalty between themselves and their employees. Employees feel like their organization cares not only about their work life, but also their home life. Offering paid parental leave is an effective recruitment tool that also leads to reduced turnover and increased worker retention (“Expecting,” 2012). Offering paid parental leave also creates employees with higher levels of engagement who are more likely to return to the workforce after taking the leave (Sladek, 2017). Organizations that offer paid parental leave must also be supportive of it for their programs to be successful. As stated before, only 0.7% of female workers between the ages of 16 and 44 use the benefits offered to them by the FMLA (Pressman, 2014). There is also some evidence that finds that the FMLA’s unpaid parental leave has not increased the amount of time that parents take off from work around the birth of a child by a significant amount (Pressman, 2014). Although much of this is due to the exclusions from the FMLA, much of it is also due to the current corporate culture in America. If employers are offering paid parental leave but not seeing it utilized, a change in culture is required. Organizations should initiate a change of culture to create an environment in which people feel empowered and encouraged to make use of their benefits (Sladek, 2017). Paid parental leave policies are most effective and most beneficial when employees believe their employers are supportive of the policy (Allen, 2014) (Figure 4).

For Mothers

Many benefits exist for mothers regarding paid parental leave. According to Steven Pressman and Robert H. Scott III, “Studies have consistently shown that women who return to work shortly after giving birth suffer from increased fatigue, depression, and anxiety (Pressman, 2014).” Offering paid parental leave helps mothers strike a healthy work/life balance (Nandi, 2018).

For Children

Whereas many studies in the past have focused on the benefits for mothers from paid parental leave, focus has shifted to the benefits for children. Scholarly literature recognizes three key areas in which children suffer from maternal employment during their first year: stress, behavioral problems, and health issues. Stress on the mother causes stress on the child. This greater stress leads to slower learning, a lack of fine motor skills, and the inability to focus in school. Behavior problems include the inability to connect with other children and make social bonds. Employment during the first year has also been linked to lower scores on the language and cognitive skill portions of standardized testing. Studies done on children in Austria have found that boys with highly educated mothers benefitted from increased paid parental leave on standardized testing done at age 15 (Danzer, 2013). Health issues stem from the lack of breastfeeding done when mothers work during the first year (Pressman, 2014). Researchers have discovered that mothers who utilize paid parental leave are more likely to breastfeed. They are also more likely to breastfeed for a longer period of time (Pressman, 2014). Amanda Cooklin, Heather Rowe, and Jane Fisher, of the Melbourne School of Population Health completed a study that found that:

Employment participation in the first ten months post-partum is associated with lower maternal separation anxiety and shorter breastfeeding duration. Paid parental leave has public health implications for mothers and infants. These include permitting sufficient time to protect sustained breastfeeding, and the development of optimal maternal infant attachment, reflected in confidence about separation from her infant (Cooklin, 2012).

Mothers who utilize family leave are more likely to take their children to regular checkups with their pediatrician and this increased time spent with
the baby also reduces infant mortality (“Expecting,” 2012). Offering paid parental leave also aids parents in choosing better childcare options. Mothers, or fathers, who are given an income stream during that time often use it towards childcare options for their child once they return to work. If there are no paid leave options available, the most cost-efficient childcare facility will often be chosen. Unfortunately, many cost-effective options are not safe, hygienic, or mentally stimulating for the child (“Expecting,” 2012).

Offering paid parental leave helps alleviate childhood poverty. The costs of clothing, food, shelter, education, and childcare for children have substantially increased through the years, without a minimum wage adjustment for inflation. Steven Pressman and Robert H. Scott III wrote about poverty rates for children in the United States saying that:

Since the 1970s, child poverty rates in the United States have consistently been much higher than rates for other age groups, as well as being much higher than child poverty rates in other developed countries. Poverty rates in this country are particularly high for families with very young children (newborn to two years old) (Pressman, 2014).

IV. Most Progressive State Policies

New York’s Paid Leave Policy

New York’s Paid Family Leave program began on January 1, 2018. This program offers paid, job protected leave for employees who work 20 or more hours a week for an organization for which they have worked at least 26 weeks before the first day of leave. Employees who work less than 20 hours a week are eligible for the benefit after 175 days worked for their organization. This leave can be taken to care for a family member with a serious health condition, to bond with a new child, or to address health issues for a family member who is active in the military. Those who take the leave are eligible to receive 50% of the state average weekly wage for 8 weeks. Employers must also maintain existing health benefits for their employee during this period. The leave amount is set to increase incrementally until it hits 12 weeks and 67% by the year 2021. The current average state weekly salary is $1,305.92, so employees would be eligible to receive around $652.96 during 2018. Most employers will require their employees to contribute the entire premium for the benefit, but employers have the option to fund it as well (Caldari, 2018).

California’s Paid Leave Policy

California has the most progressive parental leave program which includes many options for workers in need of parental leave. California’s State Disability Insurance program was passed on September 23, 2002 and went into effect on July 1, 2004. This law provides six weeks of paid family leave that can be used by either parent with wage replacement given at 55% of previous weekly earnings to a max of $987.00 a week. Organizations do not bear

![State Policies on Paid Family Leave, 2017](image_url)
the weight of this insurance, which instead is funded by employee payroll contributions. This employee payroll tax is at 1.2% (Pressman, 2014). California also expands upon the rights granted by the FMLA to include leave rights for those caring for the child of a domestic partner. Under California’s anti-discrimination law, pregnant women are allowed up to four months of job protected leave to tend to a pregnancy related health condition. Once the disability concludes, a woman is eligible to request up to 12 more weeks to spend time with her newborn baby under the California Family Rights Act. Up to half of all sick leave earned can be used to care for a sick child or family member, including a partner with a pregnancy related disability. Nursing mothers are also guaranteed a private place other than a toilet stall to express milk at work while their children are still infants (“Expecting,” 2012).

V. Effects of California’s Paid Family Leave Policy

On Employers
Many skeptics doubted the ability of California’s parental leave program to make a positive, successful impact on the people of California. Employers worried that increasing the amount of leave for employees would greatly affect the organizations’ finances. A survey of companies in California done after California introduced their paid parental leave program, showed that paid parental leave positively affected most organizations. 89% of companies reported that this paid leave had a positive or no effect on employee productivity, 91% for profitability, 96% for turnover, and 99% for employee morale. Offering paid parental leave reduced employee turnover and associated costs (Pressman, 2014).

On Women’s Labor Force Participation
After California’s paid family leave program was introduced, the number of mothers who utilized maternity leave doubled. Specifically, the number of mothers from disadvantaged groups increased. The average length of time taken increased from three to six weeks (Rossin-Slater, 2012). Young women’s labor force participation also increased as a result of California’s Paid Family Leave (Das, 2015). After returning from leave, the weekly hours worked by mothers with children from up to three years old increased as well. These weekly hours worked increased by a rate of 10-17%, and wage incomes rose by a similar amount (Rossin-Slater, 2012). In a study completed by Tanya S. Byker included in the American Economic Review, found that:

The bump in labor force participation around birth due to the new California and New Jersey laws implies that brief labor-market separations are being replaced with time spent on job protected leave and less time spent searching for new employment after a birth (Byker, 2016).

Worker mobility and hiring also increased for young women after the introduction of the CPFL (Curtis, 2016). Studies done following birth trends around the time the program was introduced found that women shifted their conception plans to be eligible for the new benefit. Most of these effects were seen in young women, Hispanic women, and unmarried women (Lichtman-Sadot, 2016).

On Children and Fathers
Women were not the only ones positively affected by California’s new program. After the introduction of the paid parental leave program in California, there was also a decrease in children’s health issues which included hearing-related problems, obesity, and ADHD for those children whose parents utilized the leave (Lichtman-Sadot, 2016). The program increased joint leave taking by 28% and father only leave taking by 50%. Studies completed after the program’s introduction found that fathers are more likely to take leave during their baby’s first year when paid parental leave is available to them (Bartel, 2015).

VI. Steps for the Future and Conclusion
When creating and rolling out a federal plan for the United States, the government must be mindful of the hurdles that exist. Some perceive paid parental leave as a form of welfare for middle class households. It is essential that this perception be reversed and that leaders show support for the policy for it to be effective (Kalb, 2018). Activities that drive awareness should be implemented and printed materials that detail available benefits should be made available in all major languages to ensure success (Barrett-Falconer, 2017). Oftentimes, advantaged women reap the most benefits of paid parental leave (Hanratty, 2009). Much of this is due to lack of awareness for low economic groups or exclusions put in place that preclude some workers. Although it may be difficult and time consuming to craft a federal plan and issues with mobilization might arise, the benefits far outweigh the consequences (Gardinier, 2008). William Adema, Chris Clarke, and Valerie Frey sum
it up best in their paper “Paid parental leave and other supports for parents with young children: The United States in international comparison”:

Paid parental leave and subsidized child care help to get and keep more women in the workforce, contribute to economic growth, offer cognitive and health benefits to children, and give parents options in defining their preferred work life strategy (Adema, 2016).

This paper began with posing the questions of why the United States needs paid parental leave, what exactly should be offered to employees, and how it works to benefit everyone involved. The paper answered these questions by showing how the United States must offer paid parental leave to stay competitive with the offerings of other nations. Offering paid parental leave has economic benefits that provide for the entire country, health benefits for children, economic and career benefits for women, and recruiting benefits for employers. The paper also details California’s and New York’s family leave plans which can be used as successful examples if the federal government begins to craft a federal plan.
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