CMC Data Visualization: PSYC167

Final Report for

Claremont-Mudd-Scripps

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Investigating the Performance of the CMS Track and Field Throwing Team

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1 Abstract

The Claremont-Mudd-Scripps (CMS) throwing team plays an integral role in the success of the overall CMS track and field team. The current project focuses on organizing the data from the throwing team to give coaches a better understanding of how performance may vary under different circumstances. We aimed to investigate 4 problems that are crucial to understanding the throwing team's performance: 1) General performance, 2) The impact of COVID-19, 3) Recruiting, and 4) Coaching. We utilized data from TFRRS to examine performance in the 4 different throwing events (discus throw, hammer throw, javelin throw, and shot put) from 2010 to 2023. We employed various data visualization techniques, including box plots, violin plots, and scatter plots to look at variations in performance, as measured by the Mark variable, across different seasons, events, teams, locations, and coaches. Findings suggest experience improves performance, while the meet location has minimal impact on performance. Findings also indicate performance generally improved after COVID-19 and that individual athletes showed both improvements and decreases in performance after the pandemic. Freshman recruits often fall short of the recruitment standards initially but improve over their college careers, and the Stags tend to have better average performance compared to recruitment standards than Athenas. Finally, there are unique coaching trends over the past 13 years, and we see CMS throwers consistently improving across the season. Overall, these findings will support coaches in determining which circumstances lead to the greatest success for their athletes.

Keywords: Track and field, throwing team, team success, general performance, COVID-19, recruiting, coaching

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2 Acknowledgments

We extend our sincere gratitude to Coach Venglass of the Claremont-Mudd-Scripps track and field team. This project would not have been possible without his consistent support and valuable feedback. We also wish to express thanks to the Claremont-Mudd-Scripps athletic department for overseeing this project and providing us with the resources that were necessary to complete it. Acknowledgment is also due to Claremont McKenna College and the individuals from their Psychology department who made this Data Visualization course possible. This project has been an important learning experience for us, and we are grateful to have been allowed to partake in it. Lastly, our appreciation goes to Professor Cook who taught us everything we needed to know to make this project successful. His guidance has been invaluable, and we are thankful for his mentorship.

3 Introduction

3.1 *Client Context*

The Claremont-Mudd-Scripps (CMS) athletic department is a D3 collegiate athletic department located in Southern California. The CMS athletic department aims to provide a rich and competitive experience to students both athletically and academically. CMS has been highly successful since its establishment in 1947, winning 361 SCIAC championship titles and 62 NCAA national championships (Digital Wall of Fame: Rocket Alumni Solutions). For this project we worked closely with the CMS men's and women's track and field team who have also recently achieved much success, winning both the men's and women's 2023 SCIAC championships. The current project dove into the performance of the throwing team that competes on the broader CMS track and field team and is headed by Coach Venglass. The throwing team plays a large part in the success of the overall track and field team. Therefore, they need to use various approaches to maintain and improve their performance. Our visualizations addressed their needs by organizing their data in a way that would facilitate this team's success and provide coaches with valuable insights into how their team's performance may vary under different circumstances.

3.2 *Project Description*

Coach Venglass expressed that he knew there were potential trends or patterns within the throwing data that could likely enhance his team's success or improve the efficacy of his coaching. However, interpreting these patterns can be challenging due to the sheer amount of numbers and variables that are in this data set. Coach Venglass also mentioned that he was interested in seeing the data presented in an organized manner so that he could grasp and comprehend these identified trends more effectively. Therefore, the goal of our project was to organize the data to facilitate understanding of the team's performance, focusing on 4 main issues.

The first problem we focused on was general performance, which included variations in performance based on class year and meet location. By examining the class year, we could determine if athletes were showing improved performance during their time at CMS, which would be an indicator of effective coaching and training. By looking at how performance at home compared to performance away, we provide an initial understanding of the locations in which CMS throwers have the greatest advantage. The second problem we focused on was the impact of COVID-19. This is significant because it provides insights into the events, teams, and individual athletes who may have been negatively impacted by the COVID-19 pandemic and need extra support. Next, the third problem we focused on was recruiting. This highlights how CMS recruits are performing compared to the NCAA D3 standards and if they eventually meet recruitment standards after more experience. The final problem we addressed was the effectiveness of coaching and training. This problem is crucial because it demonstrates how successful coaches have been since 2010 and determines if training plans have been effective.

We used data visualization techniques to address these problems, providing a clear visual means of interpreting data. This method simplifies the interpretation of data compared to the manual comparison of a large number of results, a task the throwing team

had to perform previously. The visualizations also highlighted trends across a wide range of seasons and events. Identifying these trends can be challenging to do without organized visualizations. Overall, the visual representations sought to facilitate clear interpretation of performance variations under different circumstances.

3.3 *Scope*

The objective of this project was to use 2 to 3 different data visualization methods to address each problem. We focused on the 4 key throwing events: discus throw, hammer throw, shot put, and javelin throw. To complete this project, we first defined the general question for each visualization we were making. Then, we identified the relevant variables, organized the data frame to answer that question, and finally plotted the data. While creating these final visualizations, we considered research on cognitive functioning to ensure that each visualization was perceptually efficient. The methods we used to ensure our plots were perceptually efficient included using direct labeling, adding colors to facilitate understanding, adjusting labels, axes, and legends, annotating, adding titles and captions, and faceting.

3.4 *Methodology and Approach*

To address these problems, we focused on the 4 key throwing events. Our data spanned across 13 years from 2010 to 2023. The performance variable was the throwing Mark, which measures throwing distance in meters. We did not use mathematical models or equations to predict performance. Instead, we focused on creating visualizations to communicate trends or patterns in these 4 events across the past 13 years.

To describe trends in general performance, the main variables of interest were Team (Stags vs. Athenas), Class Year, Location, and Event. Furthermore, performance at various locations was assessed between individual athletes on the team. The specific athletes included were Jason Bowman, Emily Burger, Amanda Gallop, Sarath Kakani, Carly Kirsch, Maxwell Knowles, Reese Peterson, and Belen Yudess. To examine performance before and after COVID-19, the main variables of interest were Team, Season, and Event. Performance before and after COVID-19 for individual athletes was also investigated. The athletes included were all on the team before and after COVID-19, and their names were Ezra Bacon-Gershman, Maxwell Knowles, Truman Knowles, Tyson Saena, Amanda Gallop, and Robin Peterson. To describe recruitment, the variables of interest were Class Year and Event. Moreover, a new variable was created that represented the difference between the average mark and the lower end of the recruitment standards. To describe coaching and training effectiveness, the variables of interest were Event, Coach, and Month. The 6 throwing coaches since 2010 were included while addressing this issue: Goldhammer, Christa, Luthey, Angel, Caleb, and Venglass.

3.5 *Tools and Techniques*

The main tools used to complete this project were the integrated development environment RStudio and the programming language R. The dplyr library was used for data wrangling and adding new variables to the original TFRRS data. The ggplot library provided us with the functions that were necessary to assemble and layer plots. This library also allowed us to customize the plots and make them more perceptually efficient. Other libraries used included colorspace to add colors, ggrepel to add labels, and magrittr for piping.

To evaluate general performance, violin plots and point range plots were used, offering insights into average performance, as well as the range and distribution of throwing distances. To address the impact of COVID-19, sina plots and point range plots were selected for their ability to highlight variations in the range and distribution of throwing distances before and after the pandemic, across teams, events, and individual athletes. Shifting focus to recruitment, sina plots and density plots were created. These techniques provided information on the distribution of throwing distances and average performance, as well as how these metrics compared to the D3 recruiting standards. To delve into coaching patterns, we utilized scatter plots and violin plots. Through these techniques, we gained insights into the increases, declines, and fluctuations in averages in performance across various coaches and months.

4 Data

4.1 *Description*

The data for this project were sourced from multiple locations. The primary performance data came from the Track and Field Results Reporting Service (TFRRS) internal database, which was obtained from https://www.tfrrs.org. Next, the data that provided Division III recruitment standards came from Next College Student Athlete (NCSA), an external source, and can be found at https://www.ncsasports.org/mens-track-and-field/scholarship-standards and https://www.ncsasports.org/womens-track-and-field/scholarship-standards. Finally, roster data were scraped from the Claremont-Mudd-Scripps (CMS) Athletics website, and can be located at both https://www.cmsathletics.org/sports/mtrack/2022-23/roster and https://www.cmsathletics.org/sports/wtrack/2022-23/roster. While this data did not prove to be very applicable for any visualizations, the data were scraped using a Google Chrome extension called Web Scraper.

Data were originally stored as Comma-Separated Values (CSVs). After filtering for and combining only the throwing event performances, there were a total of 6761 observations. Originally, there were 10 variables: "Athlete" (character), "Year" (character), "Mark" (character), "Conv" (character), "Meet" (character), "Meet_Date" (character), "Team" (character), "Event" (character), "Season" (character), "Wind" (character) and "Location" (character). The "Athlete" variable included the full names of the CMS athletes. The "Year" variable included the ranking of each athlete (Freshman, Sophomore, etc.). The "Mark" variable included the distance thrown in meters. The "Conv" variable included the conversion of "Mark" into feet and inches. The "Meet" variable included the meet/competition. The "Meet_Date'' variable included the month, day, and year in which a meet took place. The "Team" variable included the team that the athlete was from (Athena or Stag). The "Event" variable included the throwing event that was being competed (disk throw, hammer throw, javelin throw, or shot put). The "Season" variable included the season in which a performance took place. The "Wind" variable was supposed to include a value for the amount of wind during a competition. Finally, the "Location" variable included whether the competition occurred indoors or outdoors.

4.2 *Cleaning*

Missing values were generally removed in analyses, although they were not taken out of or imputed in the combined data frame. This generally occurred using "na.omit = T". Although this led to the removal of entire rows of data, it was decided that there were enough observations for this to be reasonable. Outliers were not excluded. It was decided that outlier performances still represented possible conclusions (ex. Many low outliers could indicate athletes performing poorly under stress). The limitations of this data included the missing data for "Wind" and "Location". While the questions of how wind and meet location may affect performances are important, it was not possible to further investigate these questions without this data.

4.3 *Preprocessing*

Thorough data preprocessing occurred to create a tidy and concise data frame. It was decided that "Conv" was redundant with "Mark" and it was found that "Location" only contained cases of "Outdoors", and thus these two variables were removed. In addition, the "Wind" variable did not contain any data and was also removed. While all the variables were originally of character type, the "Mark" variable was transformed into a numeric double type to allow continuous analyses. "Mark" was chosen over "Conv" due to its simplicity; while "Mark" provided a single value to represent meters, "Conv" provided values for both "feet" and "inches". Finally, it was found that there were differently spelled names in "Athlete" that represented the same athlete (e.g., "Gallop, Amanda" and "Gallop, Amanda Jeanne". These cases were transformed to be the same. Created variables included "Coach", which described the coach that was employed, and "Month" which described in which month a performance occurred. The variable "Away_Home" was created by identifying the home meets (CMS Track and Field Schedule), then assigning TRUE to home meets and FALSE to all other meets. The final cleaned dataset can be retrieved by emailing jmatejka2005@scrippscollege.edu.

5 Findings

5.1 *General Performance:*

5.1.1 *How does experience impact performance?*

The first area investigated for general performance was the relationship between "Year" and "Mark" for each "Team" to determine if college experience impacted throwing performance. Figure 1 provides a baseline interpretation of athlete performance throughout their college career on the CMS throwing team. "Year" represents the ranking of each athlete (Freshman, Sophomore, Junior, Senior). "Mark (M)" represents the distance in meters. "Team" represented whether an athlete was an Athena or Stag. Firstly, a violin plot was created so that the distribution of "Mark" (y-axis) for each "Year" (x-axis) could be examined. Wider areas have a higher concentration of marks, while narrower areas have a lower concentration of points. The mean for each "Year" and "Team" was chosen as the point of central tendency after comparing the mean with the median. Both the mean and median demonstrated the same upward trend from Freshman to Sophomore for Athenas and Stags. However, the median consistently appeared higher for each violin, while the mean consistently appeared near the middle. Thus, the mean was chosen to reduce clutter.

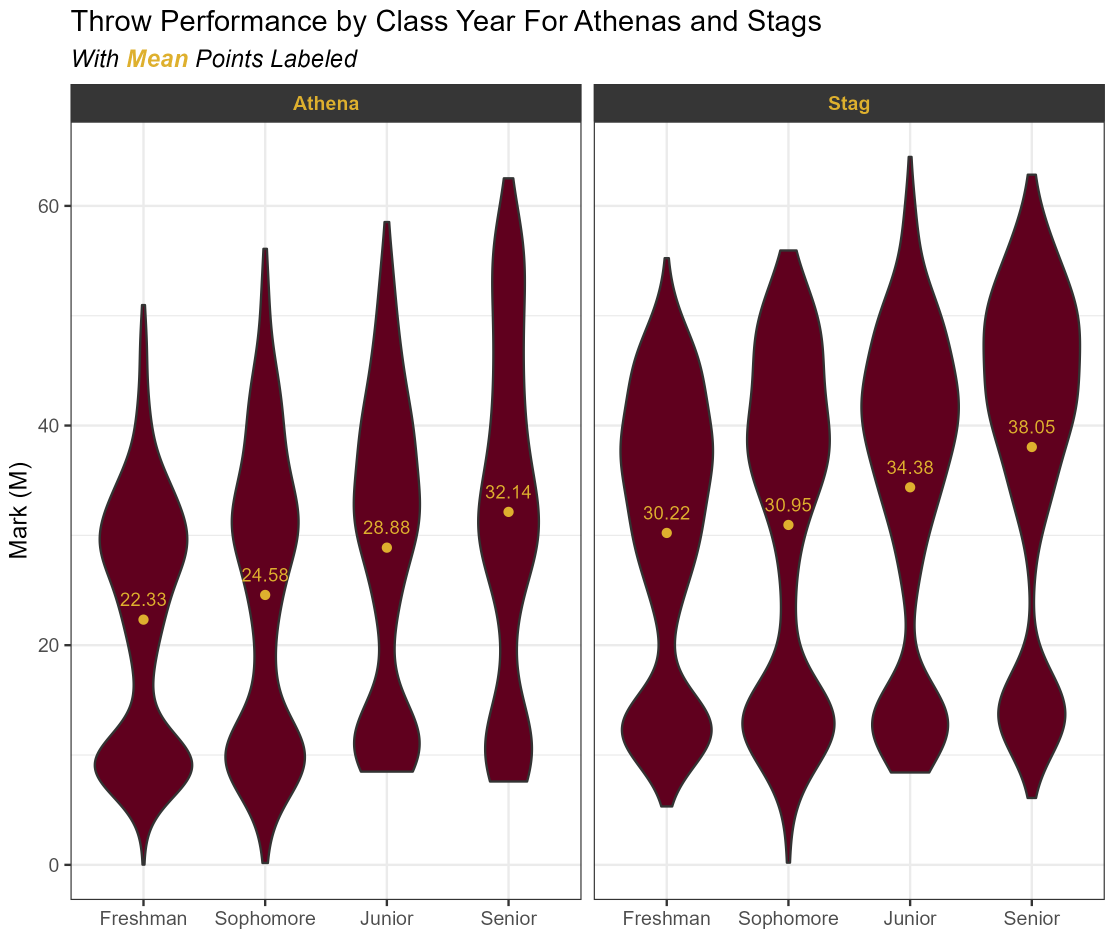

Figure 1: The distribution of throw performance for Athenas and Stags are displayed in ascending class years from 2010-2023. Violins display the distribution of the data, where wider areas have a higher concentration of points. The yellow bars represent the average performance. Overall, the graph implies that more experience increases performance for both Athenas and Stags.

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By examining each "Year" for Athenas and Stags in Figure 1, the mean points (labeled in yellow) demonstrate an improvement per one unit increase in "Year". Even though most violins display a wide area above and below the mean, the wide area above the mean tends to be longer, implying that more marks appear above the mean. For Athenas and Stags, the higher minimum of the violin plots from Sophomore to Junior year demonstrates a higher baseline performance. Furthermore, both Athenas and Stags showed higher maximums, demonstrating higher peaks in performance.

Figure 1 has a couple of notable limitations. First, team attributes such as specific athletes and team sizes in each "Year" may influence the distribution of each violin. For example, the lowest-performing Sophomore Athena may have quit the team, which could explain the lower range increasing from Sophomore Athenas to Junior Athenas. Additionally, changes in coaching may influence athlete performance which will be covered in a later section. Nevertheless, Figure 1 demonstrates that performance increases as CMS

throwing athletes progress in their college careers, regardless of additional influential factors.

5.1.2 *How does competing Home vs. Away impact performance?*

The second area investigated for general performance was the relationship between "Away_Home" and "Mark" from 2019 to 2023 to determine how performance varied between competing at away and home. Figure 2 infers if the CMS throwing team (Athenas and Stags) gains a home advantage across events. The point range plot was chosen to represent the mean performance, where the range extends from mean - standard deviation to mean + standard deviation and smaller ranges indicate greater consistency. Each plot represents a different "Event" (Discus Throw, Hammer Throw, Javelin Throw, Shotput). The x-axis displays either away or home. "Mark (M)" represents the distance in meters. The mean was chosen as the measure of central tendency since there were no significant outliers that overly skewed the data.

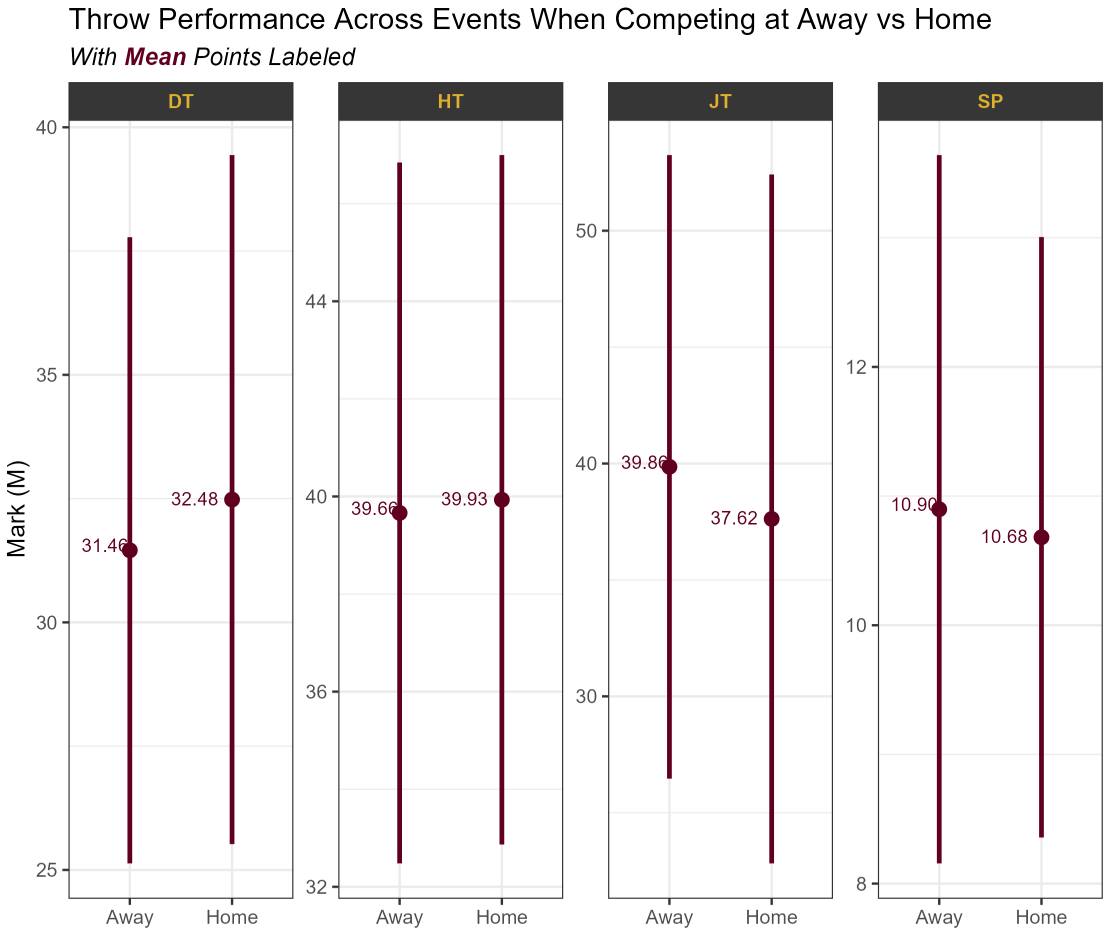

Figure 2: During the 2019-2023 seasons, competing at Home potentially has an advantage for Discus Throw and Hammer Throw, but a disadvantage for Javelin Throw and Shotput. Plots for Away are likely more precise than Home, seeing how there are 1955 observations at Away and 502 observations at Home. However, differences in mean performance for each event are small, implying that meet location does not impact performance.
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Figure 2 demonstrates that Discuss Throw and Hammer Throw events have a slight home-field advantage, while Javelin Throw and Shotput have a slight home-field disadvantage. The away and home point plot ranges only significantly differ for Shotput, where Shotput athletes perform worse at home but are more consistent. Otherwise, differences in performance consistency between away and home seem to be minuscule.

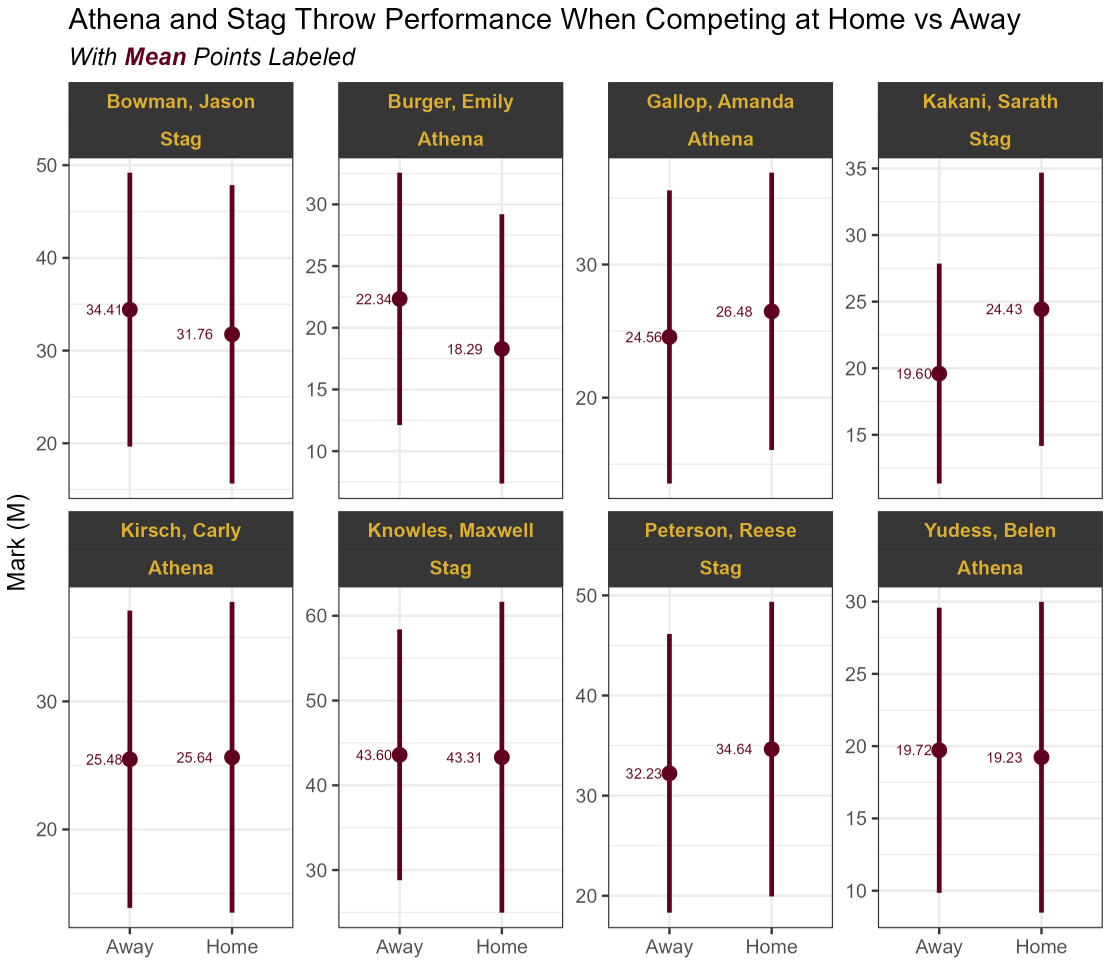

Figure 3: Represented Athenas and Stags were identified by selecting 4 athletes from each team who participated in the highest number of meets from 2019 to 2023. By comparing the means of Away and Home for each athlete, it seems that certain athletes may gain a home advantage.

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Figure 3 takes a similar approach as Figure 2 but displays whether certain athletes gain a home-field advantage. Each plot displays an athlete's name and team. The 4 Athenas and 4 Stags that participated in the most meets were chosen. Figure 3 shows that Jason Bowman, Emily Burger, and Belen Yodess do not gain a home-field advantage; Amada Gallop, Sarath Kakani, and Reese Peterson gain a home-field advantage; Carly Kirsch and Maxwell Knowles do not perform much differently at away and home. Overall, Figure 3 demonstrates that certain athletes may gain a home-field advantage.

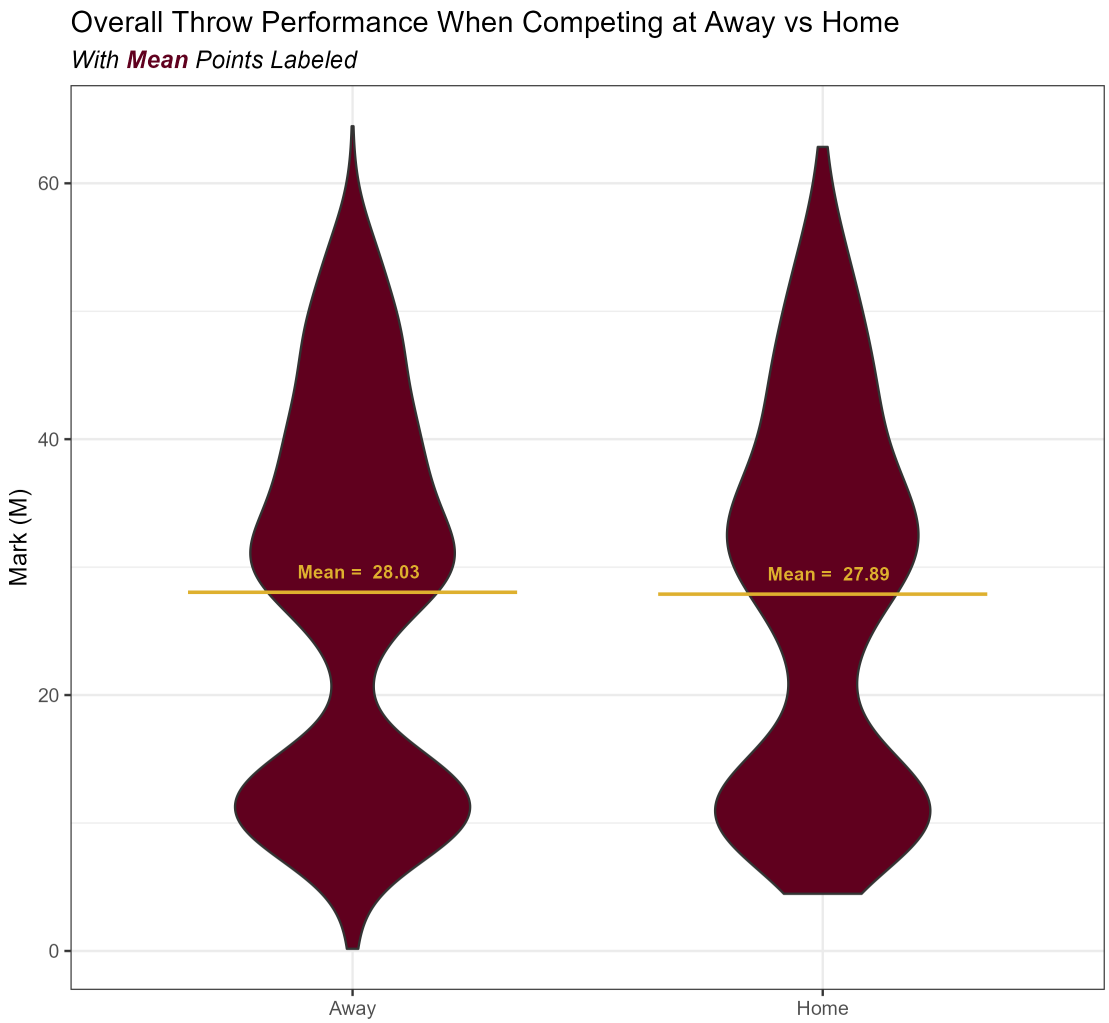

Figure 4: The figure demonstrates that during the 2019-2023 seasons, the average performance does not differ significantly when competing at Home vs Away.
Plot Created By: cli100601@gmail.com

Figure 4 combines all events and athletes during the 2019 to 2023 seasons to determine the overall throw performance when competing at away and home. The violin plot was chosen to display the range and shape of away and home distributions. Figure 3 demonstrates that the range is slightly greater for away, while the shape of away and home are similar. Looking at the mean values, performance at away is slightly greater than performance at home. However, the small difference implies that for all events and athletes, performance does not differ significantly when competing at away and home. Therefore, although certain events and athletes may gain a home field advantage, the average performance of the entire team seems to be the same at away and home.

Additional plots were created to examine performance at away and home during April (the most crucial month where athletes peak for SCIAC Championships) and between Athenas and Stags. However, the results highly resembled Figure 4, where differences between away and home were insignificant. As a result, additional plots were not included.

5.2 *The Impact of COVID-19:*

The COVID-19 pandemic caused the 2020 season to come to an abrupt end. During this time, the athlete's on the track and field team were forced to go home. For the throwing athletes in particular, gaining access to practice equipment at home was challenging. As a result, throwing athletes may have exhibited variations in performance upon their return to campus and competition.

5.2.1 *How did performance vary before and after COVID-19 for each team and event?*

We started by answering a broad question about the impact of COVID-19: How did performance change before and after COVID-19 for each team and event? To answer this question, we created 4 grouped-sina plots, each representing 1 of the 4 throwing events. These plots incorporated data from the 2 seasons before the pandemic (2019 and 2020) and the two seasons immediately following the pandemic (2022 and 2023). We segregated the data for the "Stag" and "Athena" teams to facilitate a comparison of performance between the teams.

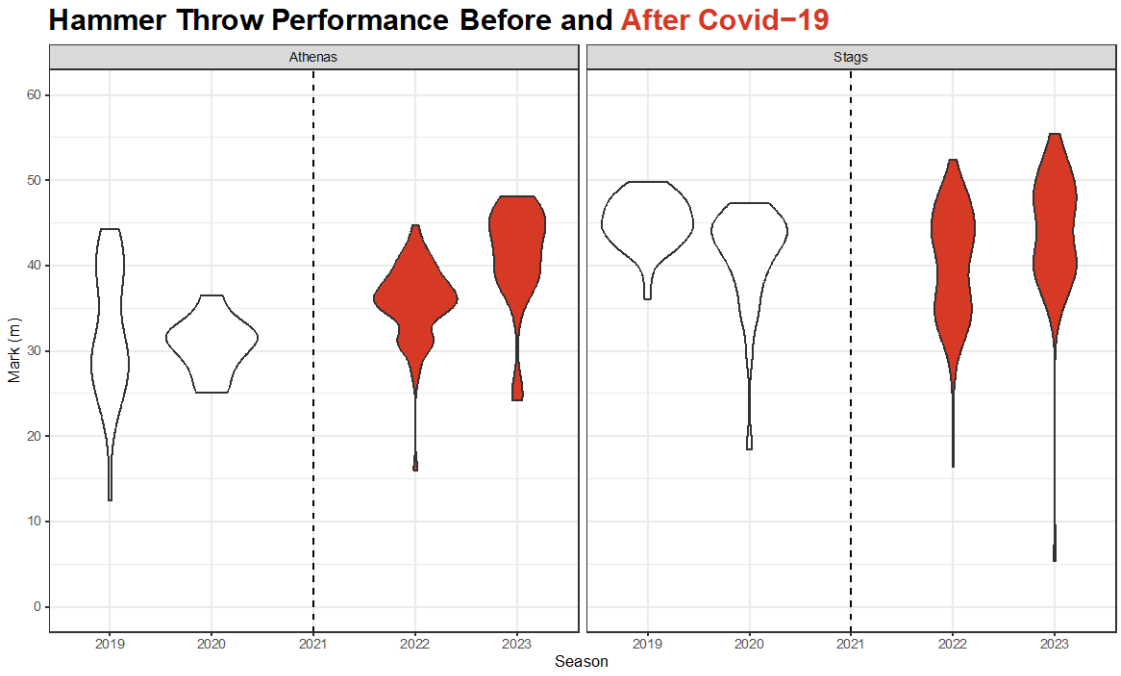

Figure 5: The Athenas demonstrate improved maximum and minimum Hammer Throw performance, and their throwing distance with the highest density increases after Co vid−19. The Stags exhibit a signifigant increase in their maxim um, but a decrease in their minim um Hammer Throw performance after Covid−19.
Plot Created By: marissamarkey12@gmail.com
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In Figure 5, we present Hammer Throw performance for Stags and Athenas before and after COVID-19. The Hammer Throw exhibited the most extreme changes in performance after the pandemic. The x-axis illustrates the season, while the y-axis represents throwing performance measured in meters. The length of each cluster represents the range of throwing distances observed in each season. We opted for the range as a representative metric, as it effectively showcases the variability between minimum and maximum throwing distances across each season. The shape of the distribution is illustrated on this plot through the area of each cluster. The shape of the distribution was chosen as a metric because it displays which throwing distance was most

frequently recorded or has the highest density. The throwing distance with the highest density is denoted by the part of the cluster with the widest area. In Figure 5, the Athenas display improvement in both their maximum Hammer Throw distance and their throwing distance with the highest density following the pandemic. These trends indicate an overall improvement in Hammer Throw performance for the Athenas in the post-pandemic period. The Stags exhibited an increased maximum throwing distance after the pandemic coupled with a decreased minimum throwing distance. The post-pandemic minimum throwing distances are likely attributable to outliers, as indicated by the low density of throws at these minimum values. The trends observed for the Stags suggest an overall improvement in Hammer Throw performance after the pandemic, with a few outliers that fall below the minimum performance levels observed before the pandemic.

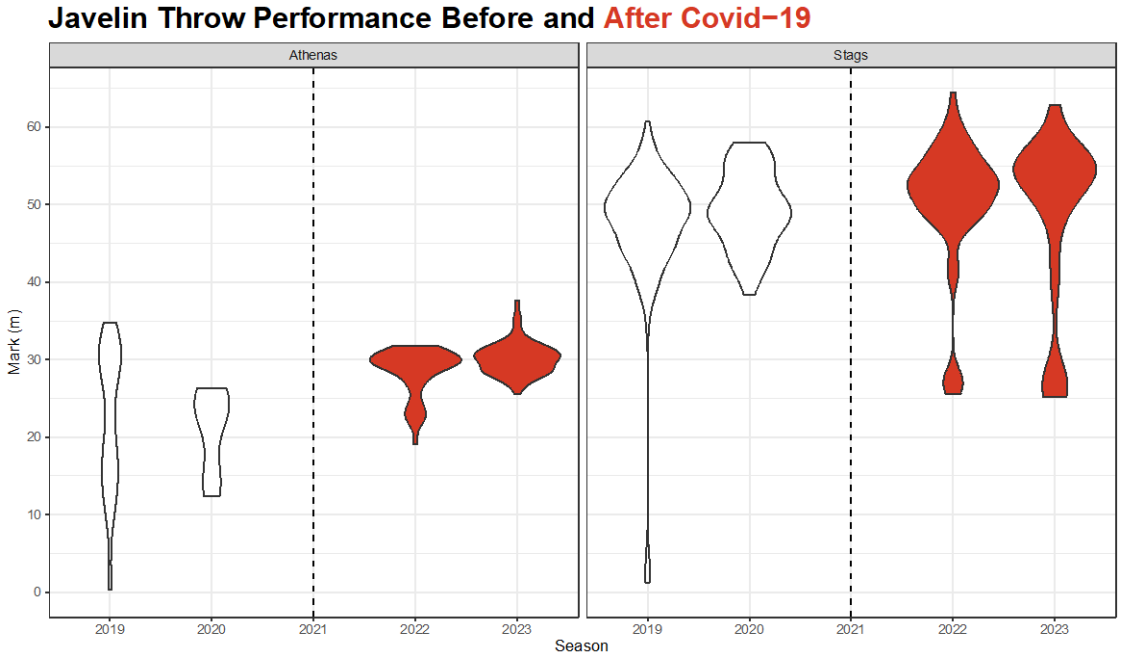

Figure 6: The Athenas demonstrate improved maximum and minimum Hammer Throw performance, as well as an increased throwing distance with the highest density after Co vid−19. The Stags show an increase in their maxim um and decrease in their minim um Javelin throw performance, as well as a slight increase in their thro wing distance with the highest density after Covid−19.
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In Figure 6, we present the Javelin Throw performance for Stags and Athenas before and after COVID-19. Javelin Throw performance also significantly changed after the pandemic, although these differences were less pronounced than the Hammer Throw. The Athena's display improved performance after the pandemic in the Javelin Throw. The Stags also display improved performance after the pandemic, based on their increased throwing distance with the highest density and improved maximum throwing distance. However, they also exhibited some extreme decreases in their minimum Javelin Throw performance after the pandemic.

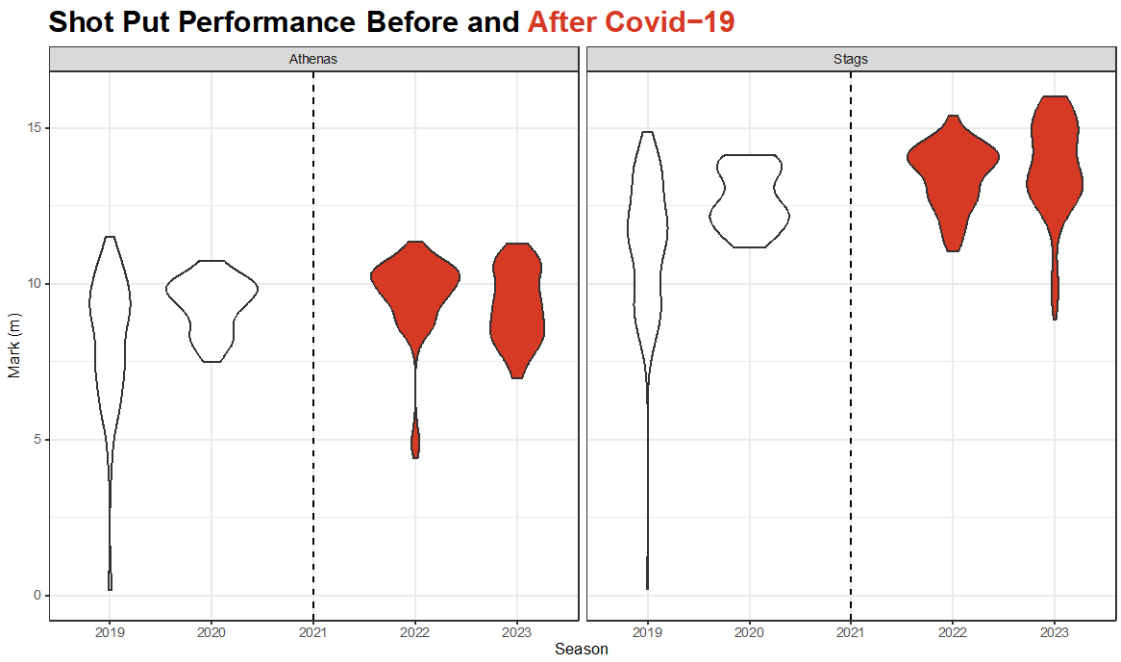

Figure 7: The Athenas exhibit a stable maximum and minimum Shot Put distance after Covid−19, while the throwing distance with the highest density remains consistent. The Stags experience an increase in their maxim um Shot Put throwing distances and a slight decrease in their minim um Shot Put throwing distance following Covid−19. For the Stags, the throwir distance with the highest density slightly increased.
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In Figure 7, we present the Shot Put performance for Stags and Athenas before and after COVID-19. The Athenas performance remained relatively stable after the pandemic. The Stags also had relatively stable performance after the pandemic, accompanied by small improvements in maximum throwing distance and small decreases in minimum throwing distance.

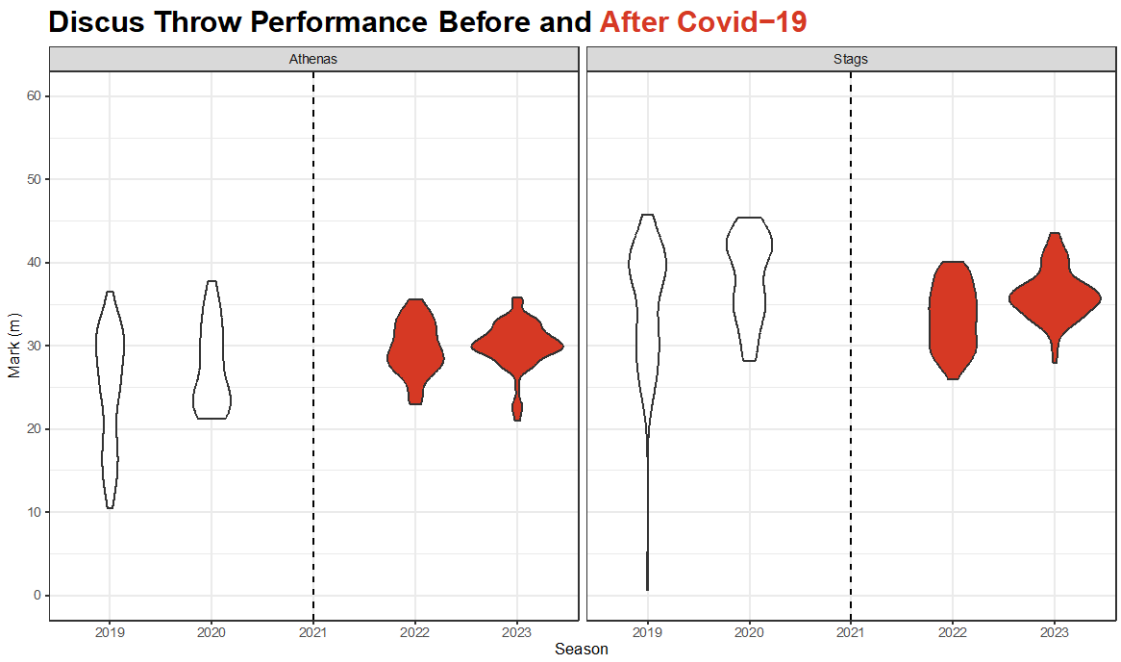

Figure 8: The Athenas exhibit relatively stable performance in the Discus Throw after Covid−19, with a slightly decreased maxim um throwing distance. The Stags, also show a decreas maximum throwing distance after Coid−19 and their thro wing distance with the highest density slightly decreases . Performance for both the Stags and Athena's has less v ariation after Covid−19, as indicated by the height of the clusters.
Plot Created By: marissamarkey12@gmail.com
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In Figure 8, we present the Discus Throw performance for Stags and Athenas before and after COVID-19. Although there were little differences in performance for this event, one noteworthy trend for both teams is a decreased maximum throwing distance after the pandemic. Along with this, the throwing distances for both teams showed significantly less variability after the pandemic. The decreased variability is evident from the fact that the clusters before the pandemic are much longer and less condensed than the clusters after the pandemic. Overall, most teams and events exhibited improved performance after the pandemic. However, there were some exceptions to this finding, specifically seen in the decreased maximum throwing performance in the Discus Throw for both the Stags and Athenas.

5.2.2 *How did the performance of individual athletes vary before and after COVID-19?*

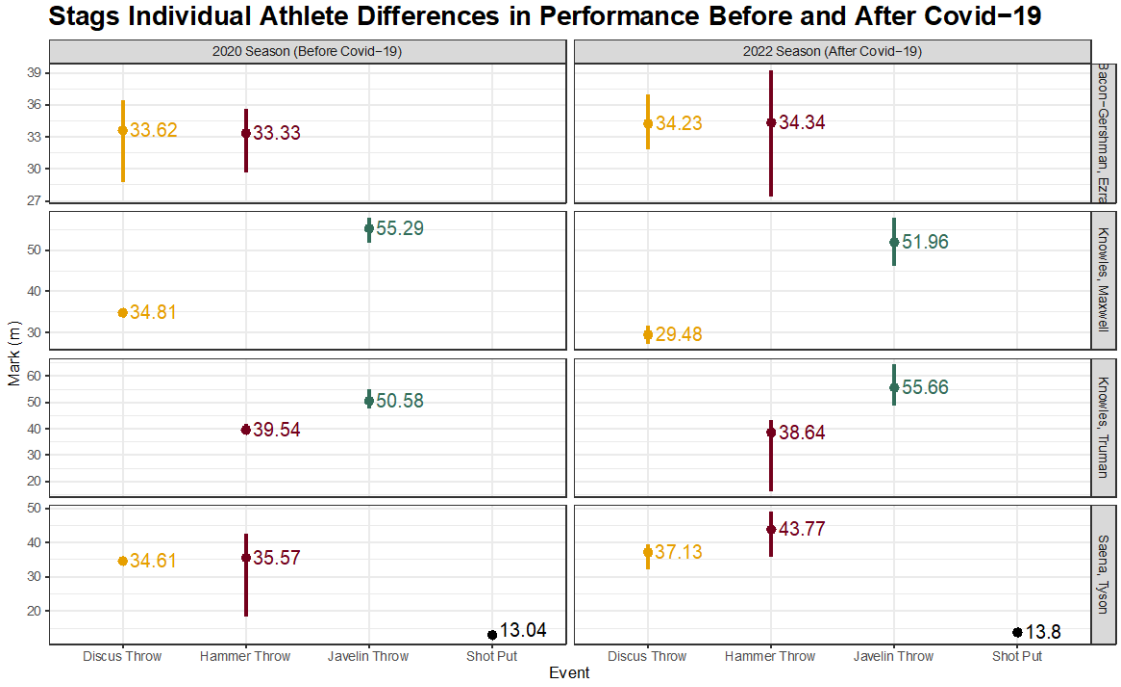

Figure 9: Minimum and maximum throwing distances are illustrated by line length. Mean throwing distance is represented by a point. Athletes performance before and after Covid−19 was dependent on event. Stable mean throwing distances does not always indicate stable maximum or minimum throwing distances.
Plot Created By: marissamarkey12@gmail.com

In Figure 9, we present the performance of Ezra Bacon-Gershman, Maxwell Knowles, Truman Knowles, and Tyson Saena in each of their events before and after COVID-19. The Stags had more returning athlete's after COVID-19, compared to the Athenas. As a result, returning athletes may have had a more significant impact on improving the performance for the Stags team compared to the Athenas team. In Figure 9, the x-axis illustrates the event, while the y-axis represents throwing performance measured in meters. The columns denote the Season and the rows correspond to an individual athlete. Using a point-range plot, the mean throwing distances for each individual athlete and event is represented by a point. The mean was selected as a representative metric because it clearly displays the general performance of each athlete and event. The range is visually represented on this plot by line length. We chose the range as a representative metric because it signifies the variability in the athlete's throwing distances, helping determine if most of their throwing distances were clustered around the mean or if they were more dispersed. In Figure 9, Maxwell Knowles still achieved his maximum throwing distance in the Javelin Throw after the pandemic. However, he likely had an increased number of throws at lower distances in 2022, as his mean throwing distance decreased after the pandemic. Truman Knowles had a stable mean throwing distance in the Hammer Throw after the pandemic, but his minimum throwing distance significantly decreased. Therefore, Truman Knowles' Hammer Throw performance may have declined after the pandemic. Finally, Saena exhibited improvement in his Hammer Throw performance after the pandemic, as evidenced by increases in his mean, maximum, and minimum throwing distances in this event.

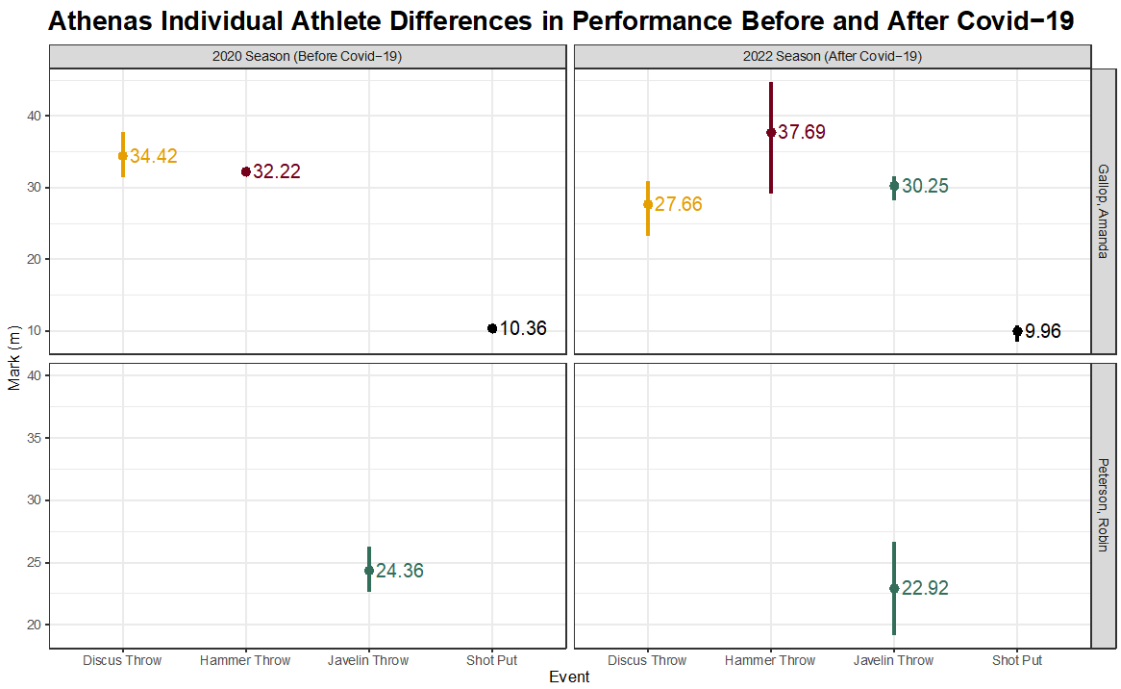

Figure 10: Minimum and maximum throwing distances are illustrated by line length. Mean throwing distance is represented by a point. Athletes peformance before and after Covid−19 was dependent on event. Stable mean throwing distances does not alw ays indicate stable maximum or minimum throwing distances.
Plot Created By: marissamarkey12@gmail.com

In Figure 10, we showcase the performance of the two Athenas, Amanda Gallop and Robin Peterson, who remained on the team before and after COVID-19. Gallop had substantial decline in her performance in the Discus Throw after the pandemic. Peterson maintained a consistent maximum throwing distance in the Javelin Throw; however, her overall performance in this event declined after the pandemic, due to a decrease in both mean and minimum throwing distances. Figures 9 and 10 indicate significant variations in pre and post-COVID-19 performance depending on the athlete and event. Therefore, some of the improved performance seen in section 4.1 may be attributed to individual athletes on the team performing better. However, because several athletes performed worse in various events after the pandemic, it could also be that other confounding influences, such as new recruits joining the team, contributed to the general improved performance. Since there were only two Athenas on the team both before and after the pandemic, and they both predominantly exhibited decreases in throwing distances after the pandemic, it is likely that other variables had a more significant impact on the overall improved performance after the pandemic for the Athenas compared to the Stags. It is important to note that even when an athlete's mean throwing distance remains stable across these 2 years, it does not guarantee stability of their maximum and minimum performance. Therefore, it is important to examine all three of these performance metrics when comparing the performance of athletes across two different time periods.

5.3 *Recruitment:*

The CMS athletics department belongs to the NCAA Division III (D3), actively participating in D3-level conferences. The NCAA organization has established official

recruitment standards for events within each division, including a lower and upper bound, providing a standardized measure for the performance ranges that are expected at the D3 level. This framework can allow us to gain a better understanding of how CMS throwing performances compare to other schools that compete and recruit at the same level.

5.3.1 *Does performance improve across class years? How does performance compare to recruitment standards?*

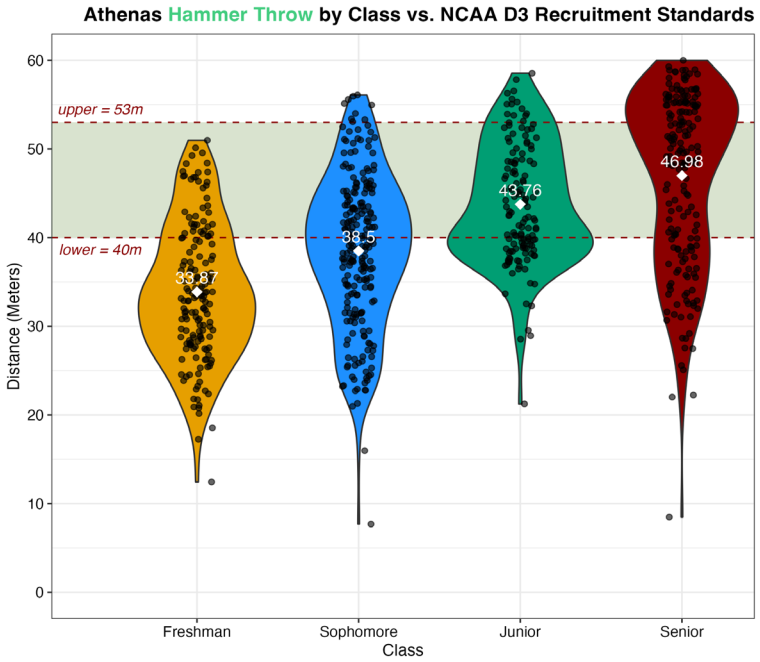

Figure 12: The Athenas' average hammer throw performance exhibited a consistent upward trend across class years, progressing from slightly below the recruitment standards range to within it. Notably, the distribution of performances alsc demonstrated improvement over the class years such that performances increasingly fell within or above the range.
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

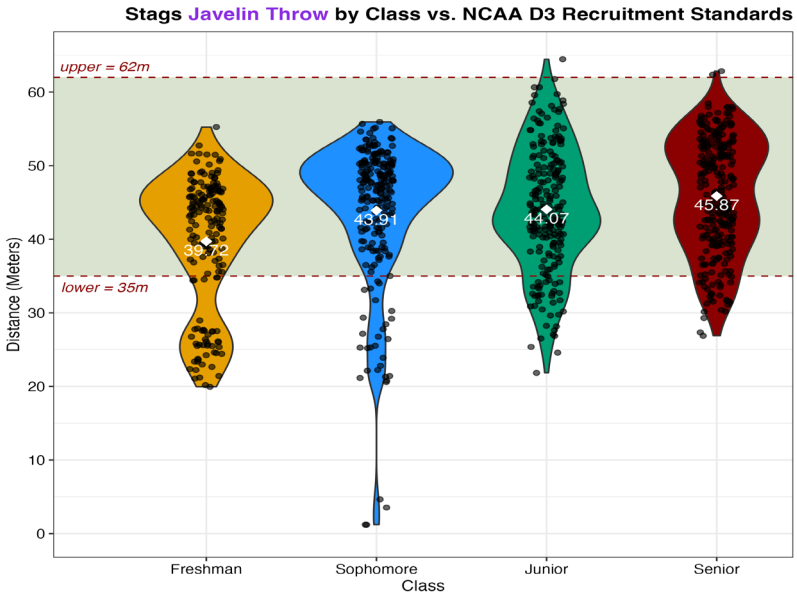

Figure 13: The Stags' average javelin throw performance displayed steady improvement across class years, moving from the lower end of the recruitment standards range to the middle. The shapes of the distributions also show that as class year progressed, less performances fell below the lower end of the recruitment standards range.
Plot Created By: chou24@students.claremontmckenna.edu
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In Figures 12 and 13 above, we present a detailed breakdown of Stags' and Athenas' Hammer Throw performances by class year, compared to corresponding NCAA D3 recruitment standards for this event. The x-axis illustrates athletes' class years from "Freshman" to "Senior," while the y-axis represents throwing performance measured in meters. Utilizing violin plots, we depict the distribution of performances for athletes in each class year, where wider areas indicate a higher concentration of data points. Within each violin plot, a white point and numerical value signifies the average throwing distance of athletes within a class year. The average, or mean, was chosen as a representative metric because it provides the most intuitive and holistic understanding of general performance within each class year. The recruitment standards are visually represented by the light green shaded region and dashed lines, showing the lower and upper bounds of established recruitment standards by the NCAA D3 organization. A notable trend emerges through examining these figures. In both the Stags and Athenas teams, the average performance and distribution of freshman athletes initially fall slightly below the lower limit of the NCAA D3 recruitment standard for the Hammer Throw. However, there is a consistent upward trajectory in performance across class years, wherein average performance and distribution are improving. By the junior and senior years, athletes from both teams tend to perform comfortably within the range specified by the recruitment standards. This suggests that as CMS athletes received more coaching and training, their throwing performances improved over the course of their college careers to meet NCAA D3 recruitment standards.

Refer to Appendix A for Figures 13-18 related to the other three events, which exhibit similar patterns.

5.3.2 *How do individual athletes' average performances compare to recruitment standards?*

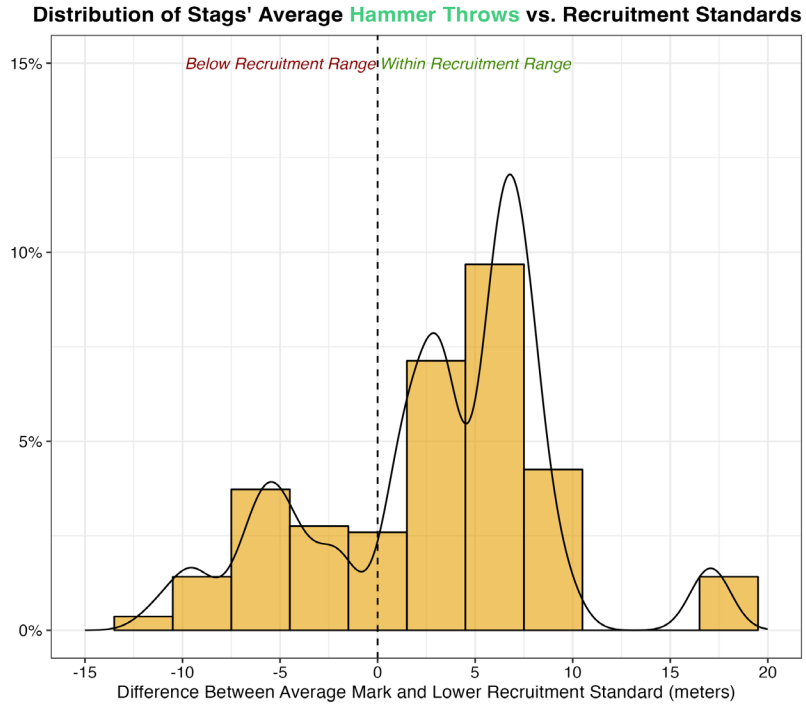

Figure 19: The distribution shows a slight left/negative skew, with more observations (n=24) falling above 0. This indicates that most Stags' average javelin throw performances were above the lower end of the recruitment standard (41 meters).
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

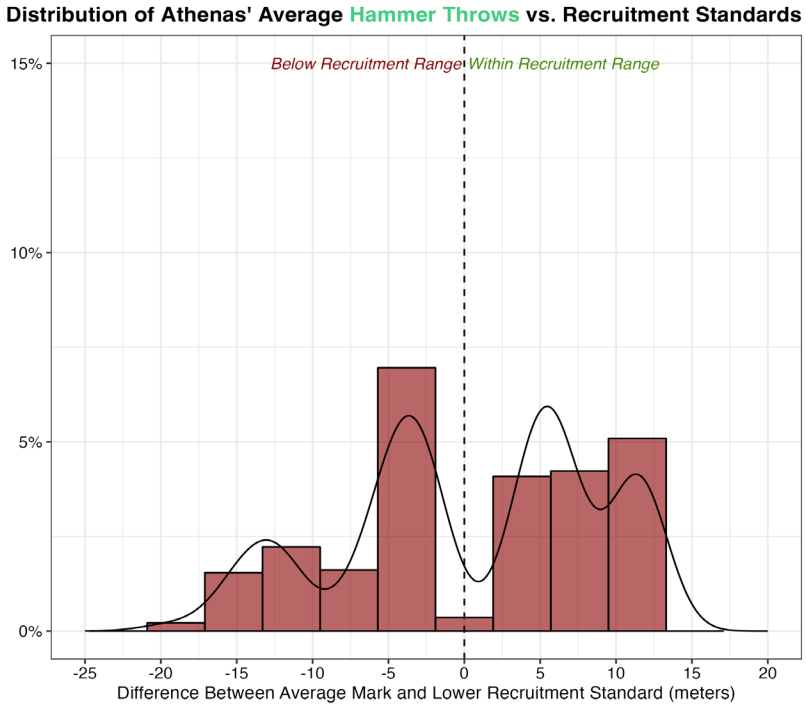

Figure 20: The distribution appears to be somewhat bimodal, with most observations (n=21) falling slightly below 0 or slightly above 0, indicating that most Athenas' average hammer throw performances were concentrated around the lower end of the recruitment standard (40 meters).
Plot Created By: chou24@students.claremontmckenna.edu
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Figures 19 and 20 above show the distribution of Stags' and Athenas' average Hammer Throw performances compared to NCAA D3 recruitment standards. Importantly, the x-axis represents a 'Difference' metric, which refers to the difference between athletes' average throwing performance for that event and the lower end of the recruitment standard. This was calculated by finding the average mark of each athlete that competed in this event, and subtracting the lower end of the corresponding recruitment standard from it. As such, a positive value indicates an average performance falling within the recruitment standards range, a negative value indicates an average performance falling below the range, and zero indicates an average performance at the lower threshold of the range. The y-axis represents the percentage of observations falling within a certain range. As we examined general performance in relation to recruitment standards in the previous figures, looking at an explicit 'Difference' measure allows for a more in-depth and individualized analysis of how CMS throwing athletes are performing in relation to recruitment standards. Each figure represents the average throwing performances of around 20-30 athletes.

In examining the figures, there appears to be differing patterns for Stags and Athenas. For Stags, more observations seem to fall above 0, with the distribution showing a slight negative skew. This distribution indicates that most Stags' average Hammer Throw performances are above the lower end of the recruitment standard. On the other hand, Athenas show a slightly more mixed distribution, with most observations falling slightly below or slightly above 0. This distribution suggests that most Athenas' average Hammer Throw performances are concentrated around the lower end of the recruitment standard, with some athletes falling within the range and some athletes falling below it.

Refer to Appendix B for Figures 21-26 related to the other three events. Notably, the other events demonstrated a similar pattern, with more Stags having average performances falling within respective recruitment ranges compared to Athenas.

Two main trends emerge across these figures. First, freshman athletes tended to perform below the recruitment standards range for most events, showing improvement across class years as they progressed through their college athletic careers. This pattern aligns with the recruiting practices at CMC, as communicated by Coach Venglass. He expressed that official D3 recruitment standards act primarily as a baseline or suggestion for performance and that athletes who do not quite meet the standards but show potential for improvement are also commonly recruited. This is reflected in the data, in which newly-recruited freshman athletes tend to fall short of the recruitment range, but as they received more coaching and training over time, their performance was able to improve to meet NCAA D3 standards in most cases.

Second, there seem to be gender differences in athletes' performances compared to recruitment standards. Stags tended to improve more across class years, more so falling within the recruitment range over time than Athenas. Similarly, Stags' average performances more frequently surpassed the lower end of the recruitment standard compared to Athenas for all events. Both results suggest that Stags are better at meeting D3 recruitment standards than Athenas. One potential explanation for the observed gender differences in improvement across class years is the tendency for male athletes to undergo more pronounced physical growth during college-age years compared to their female

counterparts. This physical development may contribute to greater performance improvement over time among Stags. Furthermore, Coach Venglass shed light on another factor contributing to Athenas' comparative struggle to meet recruitment standards. Particularly, there is typically a smaller pool of female throwers to recruit from. As a result, female athletes performing within the D3 recruitment range may be more likely to be recruited by higher divisions, while this occurs less frequently for male athletes. Thus, this helps explain why Athenas may not meet these standards to the same degree as Stags. Nonetheless, Athenas also showed clear improvement across class years for all events, bringing them closer to the D3 recruitment range over time.

5.4 *The Impact of Coaching:*

While coaches are not the only impactful factor in an athlete's success, they are a large one. The following visualizations address how performance varies between coaches, as well as the effectiveness of coaching on a team-wide level.

5.4.1 *How does average performance vary by coach?*

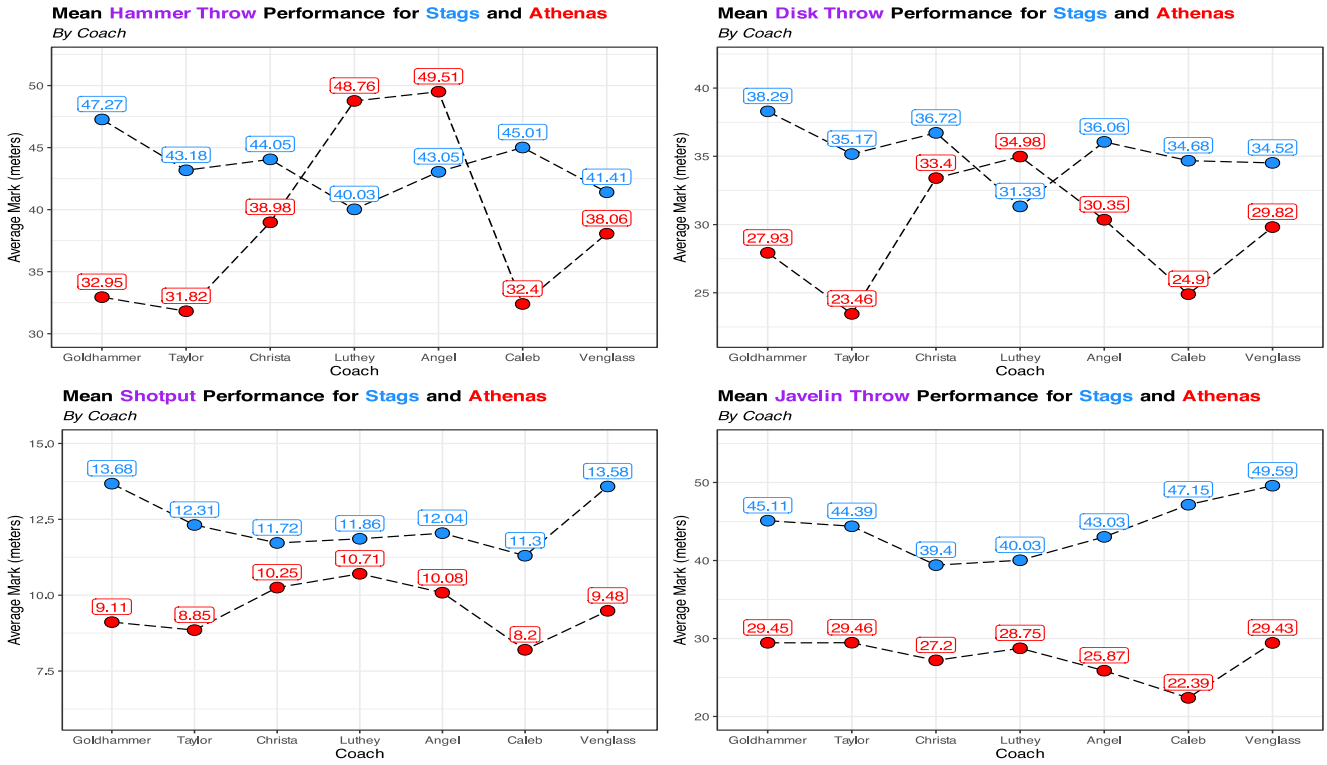

Figure 27. Athenas demonstrate a large performance increase under Coach Christa. Athena performance increase often concurrent with Stag performance decrease. Coach Venglass' Athenas all show increase in performance from Coach Caleb. Plot created by jmatejka2005@scrippscollege.edu PSYC167 - Data Visualization

Figure 27 displays the average pattern of performance by each coach. A few trends evidently emerge. First, a very apparent increase in Athena performance occurs beginning with Coach Christa. While this increase is most obvious in the hammer throw, there is also an evident increase in the disk throw and the shot put. One could propose a slight increase

in Athena performance in the javelin throw as well, although it is much less extreme. A second trend that appeared is the decrease in Stag performance that tends to occur concurrently with the increase in Athena performance. Particularly with the hammer throw and the disk throw (the events in which Athena performance was most amplified), there seems to be a drop in Stag performance. This could be due to differences in coaching styles and coaching effectiveness by team. Next, some trends emerge that are concerned with Coach Venglass' current coaching. First, it was noted that all of Coach Venglass' Athenas show a marked improvement in performance from Coach Caleb. The biggest improvement is seen in the javelin throw, where Athenas increased an average of 7 meters under Coach Venglass. Next, Coach Venglass has multiple "standout performers" - the Athena javelin throwers demonstrate the 3rd overall highest performance of all coaches, the Stag shot put throwers demonstrate the 2nd overall highest performance of all coaches, and the Stag javelin throwers demonstrate the best overall performance of all coaches.

5.4.2 *How does performance distribution vary by coach?*

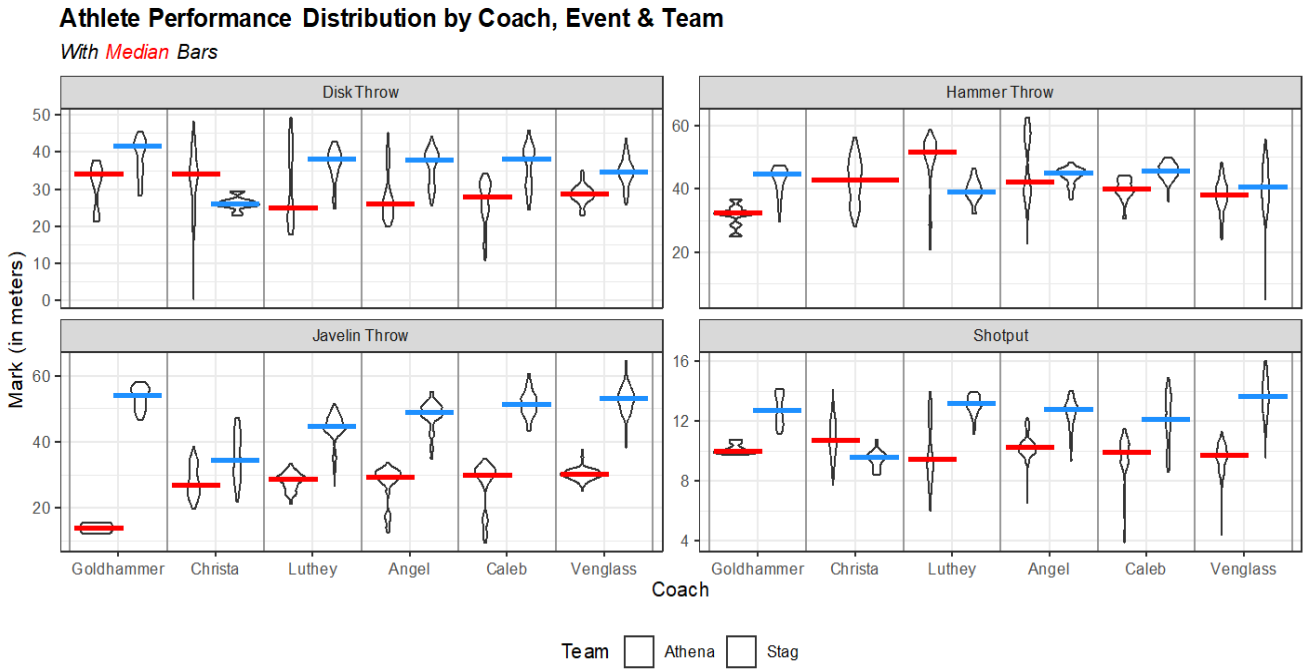

Fig. 28. While Stags generally perform better and more consistently than Athenas, this is not always true. Attention must be paid to the effect of team size and coach career length.
Plot created by jmatejka2005@scrippscollege.edu
PSYC167 - Data Visualization

Figure 28 displays the performance distribution of athletes by coach. The median performance is marked with a horizontal bar. This visualization reveals several patterns that are worth highlighting. First, Stags are generally more consistent performers. This can be seen in the generally short and wide blue violins. On the other hand, the Athenas are generally less consistent. This can be seen in the generally long and thin red violins. However, this pattern is not consistently true. For example, the current Stag hammer throwers demonstrate high variability (probably due to a handful of low-performing outliers), and the current Athena disk throwers and javelin throwers demonstrate very low variability. In addition, the Stags generally perform better than the Athenas. This, of course,

makes sense with our physiological understanding of how gender affects muscular makeup. However, it is worth noting that this pattern is not always true. Specifically, Coach Christa's Athena disk throwers and shot put throwers, as well as Coach Luthey's Athena hammer throwers outperform their Stag counterparts. Of course, a large limitation of this data is that it is sensitive to team size and coaching length.

5.4.3 *Is coaching effective? Do athletes demonstrate expected patterns of performances across the season?*

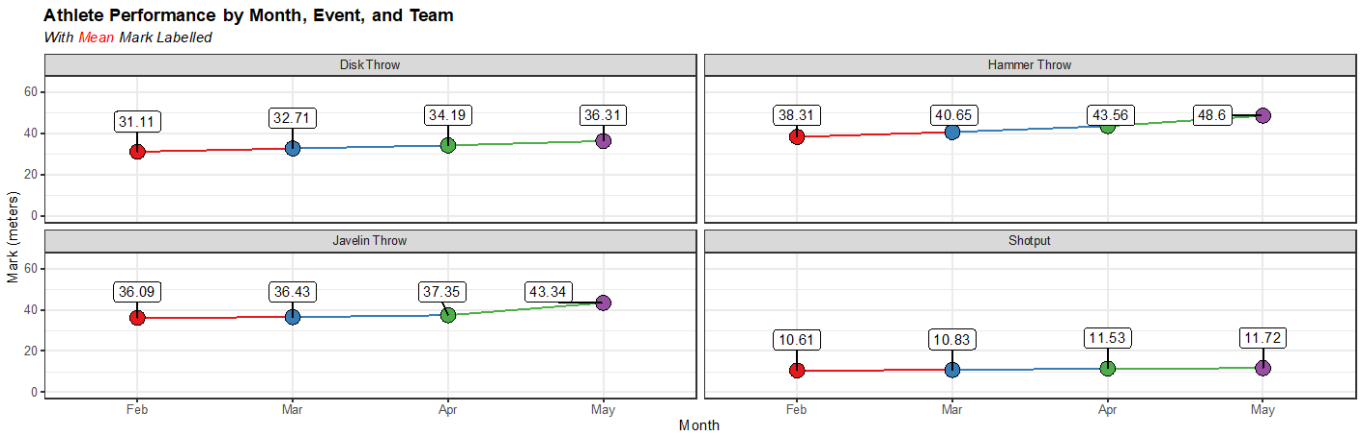

Fig. 29. The CMS throwers demonstrate a consistent linear increase in performance as the season progresses.
Plot created by jmatejka2005@scrippscollege.edu
PSYC167 – Data Visualization

Figure 29 demonstrates the seasonal pattern of mean performance. We were hoping and expecting to see a linear increase in performance from February to May, and we are happy to share that this was the pattern that was discovered. There were no instances in which average performance decreased from one month to the next, and all average performances in May constituted a significant increase from February. This is a strong indication of coaching effectiveness; that athletes are truly learning skills and strength throughout the season so that they may end up better in May than they were in April, and so on. Different events displayed different amounts of variability between February and May. For example, the average hammer throw performance increased over 10 meters from 38.21m in February to 48.6m in May. On the other hand, the average shot put performance increased just over 1 meter from 10.61m in February to 11.72m in May. This obviously has so much to do with the nature of these events. A final trend worth noting is the particularly big increase in performance for the javelin throw from April to May. Athletes, on average, increased their javelin throw performance by about 6 meters this month. Overall, it is highly encouraging to see consistent, linear results that demonstrate effective coaching.

6 Discussion

General Performance:

The investigation into general performance revealed interesting findings about two main factors potentially affecting performance. First, general performance appeared to improve with class year, suggesting that athletes with more experience performed better. While this trend has been intuitive to the coaching staff as they perceive athletes developing over the course of their college careers, it is helpful to have this pattern supported by the data. Second, the influence of meet location on performance varied across events, with some indicating a home advantage and others favoring away meets. Overall, however, there does not seem to be a clear relationship between meet location and performance. This finding challenges preconceptions that coaches might hold regarding the impact of a home advantage, clarifying that athletes are equally capable of performing at home and away events.

COVID-19:

The occurrence of COVID-19 had an undeniable impact on CMS, placing the 2020-2021 academic year and athletic season on hold. Coach Venglass expressed keen interest in understanding how throwing performance may have been affected pre- and post-COVID, recognizing the potential complex effects the pandemic may have had on athletes. Moreover, having a few athletes present at both time points allowed for direct comparisons. Our investigation into how performance compared pre- and post-COVID yielded intriguing yet mixed results; while some events like Hammer Throw showed great improvements post-COVID, other events like Shot Put and Discus Throw remained unaffected or showed a decline. Ultimately, a range of confounding factors may lead to these different trends, such as pools of new recruits or the presence of super seniors on the team post-COVID. Analysis of individual athletes' performances also revealed mixed results, as we discovered that an athlete's progress pre- and post-COVID heavily varied by individual. For instance, some athletes may have engaged in more rigorous training regimens while at home than others. Overall, the complexity of factors involved makes it difficult to pinpoint a uniform trend in how the pandemic affected throwing performance across the team.

Recruitment:

We compared athlete performance to official NCAA D3 recruitment standards in two ways: 1) by examining general performance across class years, and 1) by explicitly comparing athletes' average performances to recruitment standards. Our analysis provided further evidence that throwing performance improves across class years, a trend that held true even when examining performance by specific events and teams (Stags and Athenas). Additionally, our findings demonstrated that while freshman athletes tended to initially fall short of the D3 recruitment standards range, there was consistent improvement in performance across class years for all events. Athletes gradually met and, in many cases, exceeded the recruitment standards, perhaps pointing to the effectiveness of coaching and training at CMS that enabled athletes to progress over their college careers. While Stags'

average performances aligned better with D3 recruitment standards than Athenas, female athletes also demonstrated pronounced improvement over class years. Overall, our investigation suggests that CMS throwing athletes are performing at a satisfactory and competitive level in accordance with D3 standards.

Coaching:

While definitive coaching skill is a difficult variable to fully investigate with the data we have, there are many interesting patterns that emerge when we look into the data. First, our findings indicate that coaches may be more effective for either the Stags or the Athenas. This is illustrated in the boost in Athena performance for Coaches Christa, Luthey, and Angel, concurrent with a drop in Stag performance. We also can see that Coach Venglass has had some very high-performing team/event combinations compared to other coaches. Upon looking into performance distribution, it was found that while the Stags generally perform better and more consistently, this is not always the case. Finally, we showed that coaching is overwhelmingly effective, as average athlete performance increases linearly over the course of the season.

7 Conclusion

7.1 *Limitations*

While our visualizations showcase and support interesting trends, we acknowledge that limitations exist that should be kept in mind when interpreting the data.

First, when analyzing performance based on class year (Figure 1), team attributes such as specific athletes and team sizes in each "Year" may influence the distribution of each violin. For example, the lowest-performing Sophomore Athena may have quit the team, which could explain the lower range increasing from Sophomore Athenas to Junior Athenas. Additionally, changes in coaching may influence athlete performance which will be covered in a later section. This echoes limitations for Figures 11-18, which depict throwing performances across class years by event and team. Nevertheless, these figures all clearly indicate that performance increases as CMS throwing athletes progress in their college careers. Potentially, an interesting way to explore this further could involve conducting statistical tests to determine whether the observed improvements in performance across class years are statistically significant or merely a result of inherent variability.

A limitation in analyzing performance at home and away (Figures 2-4) is in observation counts. Plots for away are likely to be more precise, as the data set contained 1955 away observations and 502 home observations. Additionally, Discus Throw and Shotput plots may be more precise (719 and 791 observations respectively) than Hammer Throw and Javelin Throw plots (413 and 534 observations respectively). Nevertheless, observation counts are representative of the typical frequency of meet locations and events for the CMS throwing team.

A limitation in analyzing the performance of individual athletes before and after the pandemic (Figures 9 and 10) is that all of the data points from 2020 are from the beginning of the season before it abruptly ended. There appears to be a trend of performance improvement towards the conclusion of the season (Figure 29), so the absence of performance data from the end of the season in 2020 might have contributed to lower mean and range values than would have been observed if the 2020 season had not been cut short. To address this limitation in future analyses, it would be beneficial to identify a particular meet in which an athlete participated in 2020 and compare their performance in that specific meet with the corresponding meet in 2022. If an exact match of meets is not possible, selecting a meet that occurred around the same time in both seasons could provide a more accurate comparison. This approach ensures that trends are not unduly influenced by the specific time period within the season in which the athletes were able to compete.

A limitation in understanding how coaching affects performance (Figures. 27 and 28) is the variability in coaching career length. Coaches that do not stay for extended periods of time have fewer performance observations, thus affecting the true accuracy of the conclusions. In addition, a limitation of Figure 29 (efficacy of coaching based on across-season average) is that more high-performing athletes are probably chosen to compete in

later meets. Thus, the pattern shown is not necessarily accurate on an athlete-by-athlete basis.

7.2 *General Conclusion*

Overall, our project sought to shed light on different facets of the performance of the CMS Track and Field throwing team and offer data-driven insights to explore and describe the team's achievements. We took a multifaceted approach, examining the data from four distinct perspectives: 1) General Performance; 2) The impact of Covid-19; 3) Recruitment Standards; 4) Coaching. All four yielded some interesting and robust results, in which we strove to provide a more comprehensive and nuanced understanding of CMS throwing performances to the coaching staff.

As Coach Venglass articulated at the project's outset, there was a wealth of data available, yet limited time and opportunity for him to delve into it. We are optimistic that the visualizations and investigations we have provided will assist Coach Venglass and the coaching team in gaining a more empirically-backed understanding of the data, potentially offering valuable insights for further analysis and decision-making.

Moving forward, we suggest a few future avenues that could be interesting and helpful to explore for the throwing team. First, we had initially aimed to gather strength training data from the throwing athletes during this semester, but time constraints limited our ability to fully explore this data. Nevertheless, we propose that in the future, it would be worthwhile to investigate how athletes' strength training correlates with their performance, identifying potential benchmarks for healthy performance. This information could not only enhance our understanding of the factors influencing performance but also offer valuable insights for future recruitment efforts. In this regard, if possible, we recommend that the CMS throwing team could engage in more regular fitness evaluations and document relevant strength data in order to establish a clearer connection between strength training and performance. This proactive approach would enable coaches to make more informed and strategic decisions, ultimately contributing to the overall success and improvement of the team.

Additionally, we believe that continued cross-collaboration with the Psychology and Data Science departments could be extremely valuable. For example, our current dataset includes only a limited span of performance data post-COVID. However, as time progresses, additional years of data will become available, allowing for a more comprehensive and robust comparison between pre- and post-COVID performance. As teams following ours continue to work closely with the CMS track and field team, we are hopeful that even more patterns and nuances in the data can be identified and provide value to the coaching staff.

8 References

Digital Wall of Fame: Rocket Alumni Solutions. History of Claremont-Mudd-Scripps Athletics. (n.d.-a). https://site.rocketalumnisolutions.com/entry/150/627066d8ddc3a4a1f41dbe63/62706e8346d83126576adcfa

8.2 *Raw Data Sources*

https://www.tfrrs.org
https://www.ncsasports.org/mens-track-and-field/scholarship-standards
https://www.ncsasports.org/womens-track-and-field/scholarship-standards
https://www.cmsathletics.org/sports/mtrack/2022-23/roster
https://www.cmsathletics.org/sports/wtrack/2022-23/roster

9 Appendix

9.1 *Appendix A*

Figures 13-18: Stags' and Athenas' Performance by Class Year vs. NCAA D3 Recruitment Standards for Javelin Throw, Shot Put, and Discus Throw

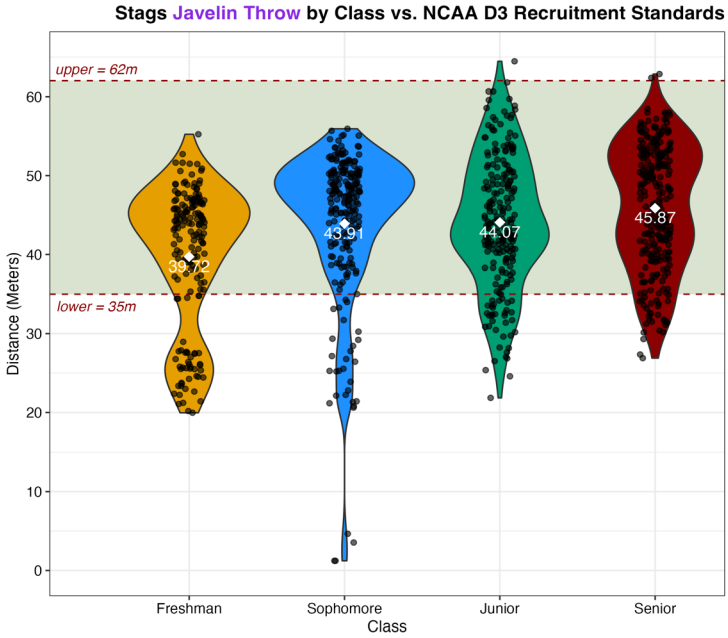

Figure 13: The Stags' average javelin throw performance displayed steady improvement across class years, moving from the lower end of the recruitment standards range to the middle. The shapes of the distributions also show that as class year progressed, less performances fell below the lower end of the recruitment standards range.
Plot Created By: chou24@students.claremontmckenna.edu
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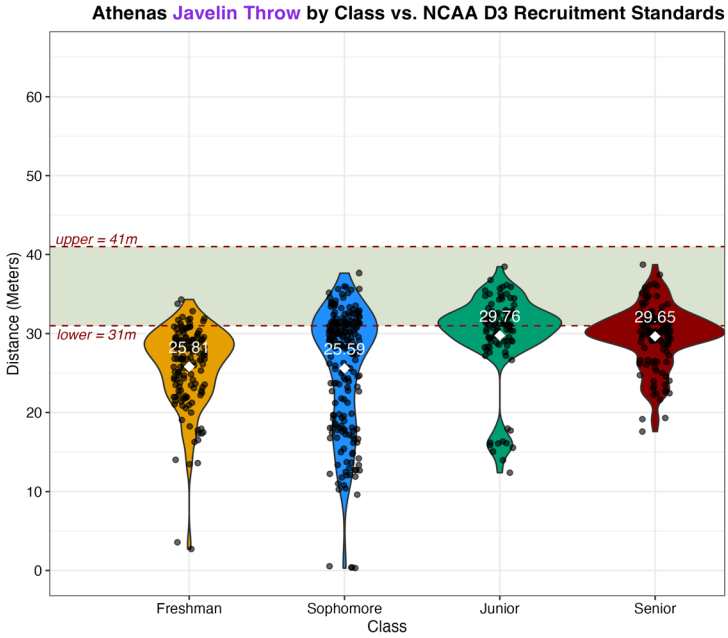

Figure 14: The Athenas' average javelin throw performance showed some improvement with class year, although it remained slightly below the recruitment standards range. The shapes of the distributions suggest that as class year progressed, the gap between performances and the lower end of the recruitment range narrowed.
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

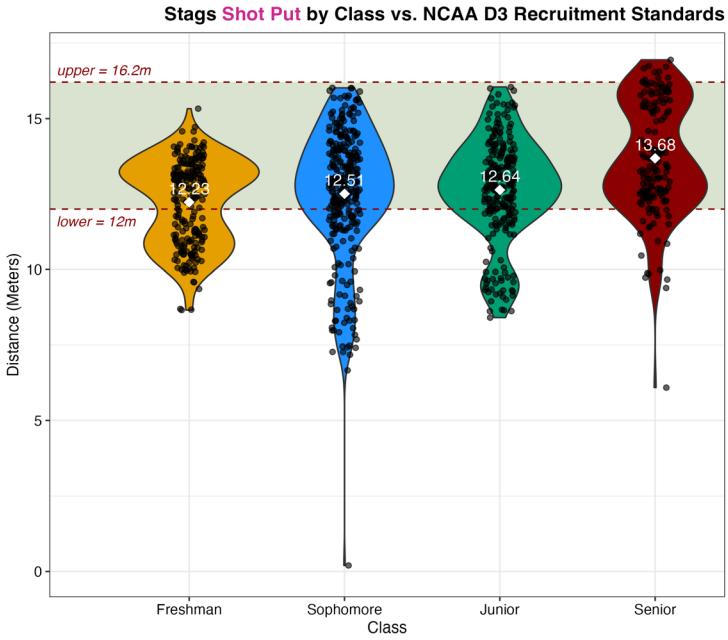

Figure 15: The Stags' average shot put performance demonstrated a slight upward trend across class years, progressing from the lower end of the recruitment standards range into the middle. The shapes of the distributions also indicate that performances were increasingly falling within the recruitment standards range over class years.
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

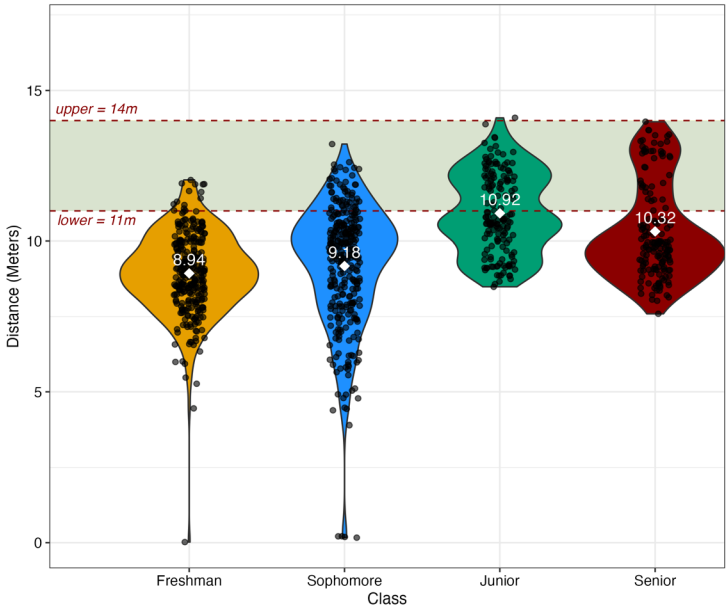

Figure 16: The Athenas' average shot put performance showed a slight upward trend across class years from freshmen to juniors, but exhibited a more complicated pattern as seniors performed worse than juniors. Average performance remained slightly below recruitment standards range.
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

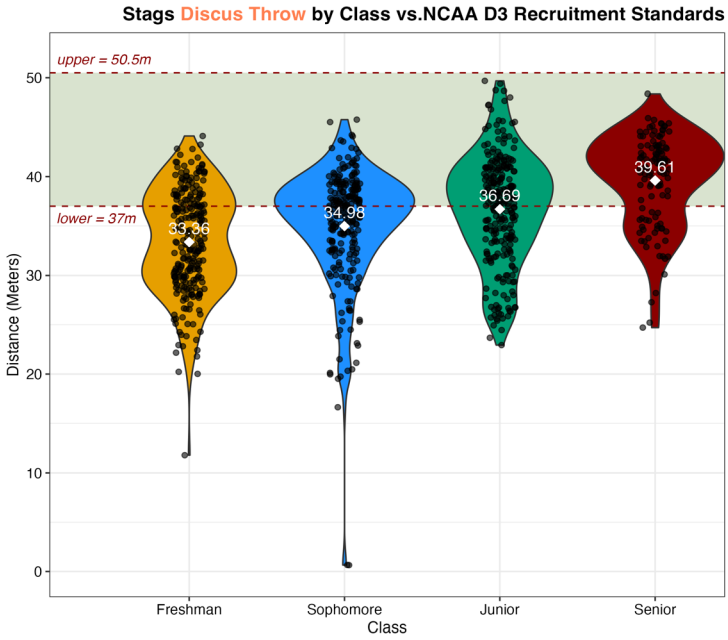

Figure 17: The Stags' average discus throw performance showed a consistent upward trend across class years, improving from slightly below the recruitment standards range to within it. The distributions also indicate that performances were increasingly falling within the recruitment standards range over class years.
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

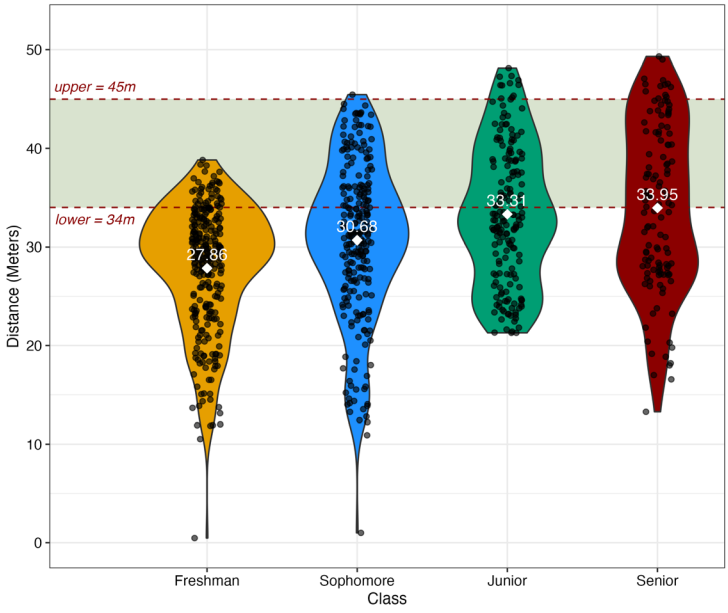

Figure 18: The Athenas' average discus throw performance showed a consistent upward trend across class years, improving from below the recruitment standards range to being at the lower end. The shapes of the distributions also suggest that the minimum and maximum throwing distance increased across class years.
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

9.2 *Appendix B*

Figures 21-26: Distribution of Stags' and Athenas' Average Performance Compared to Recruitment Standards for Javelin Throw, Shot Put, and Discus Throw

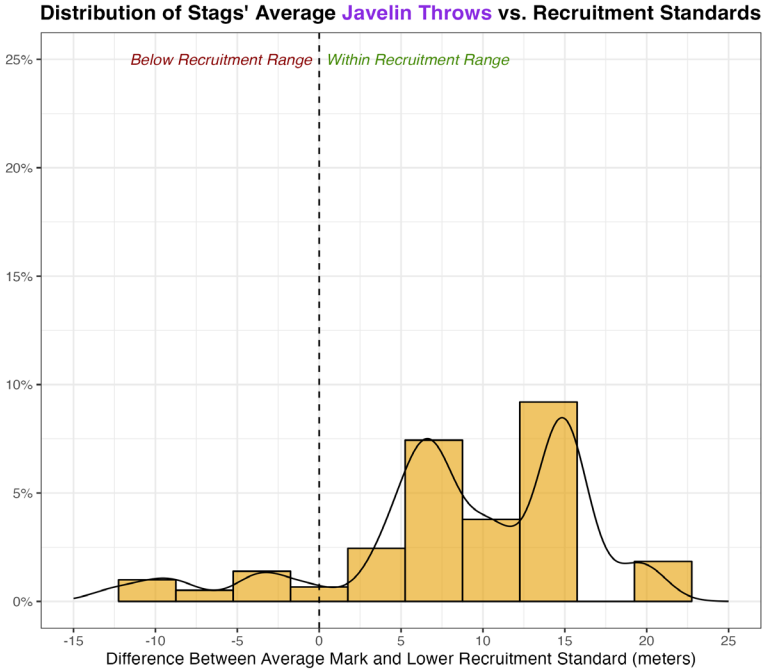

Figure 21: The distribution shows a slight left/negative skew, with more observations (n=31) falling above 0. This indicates that most Stags' average javelin throw performances were above the lower end of the recruitment standard (35 meters).
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

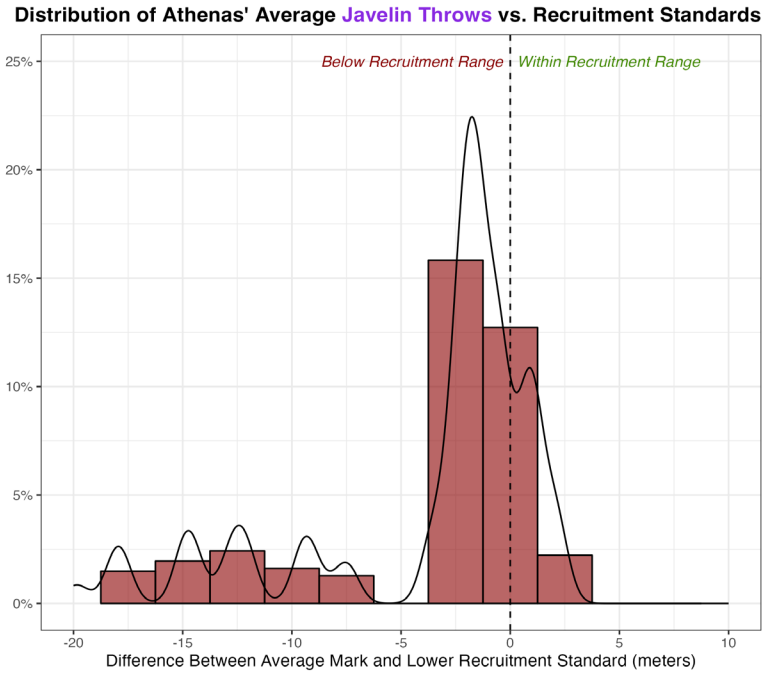

Figure 22: The distribution shows a slight left/negative skew, with most observations (n=23) falling slightly below 0 or at 0. This indicates that most Athenas' average javelin throw performances were slightly below the lower end of the recruitment standard (31 meters).
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

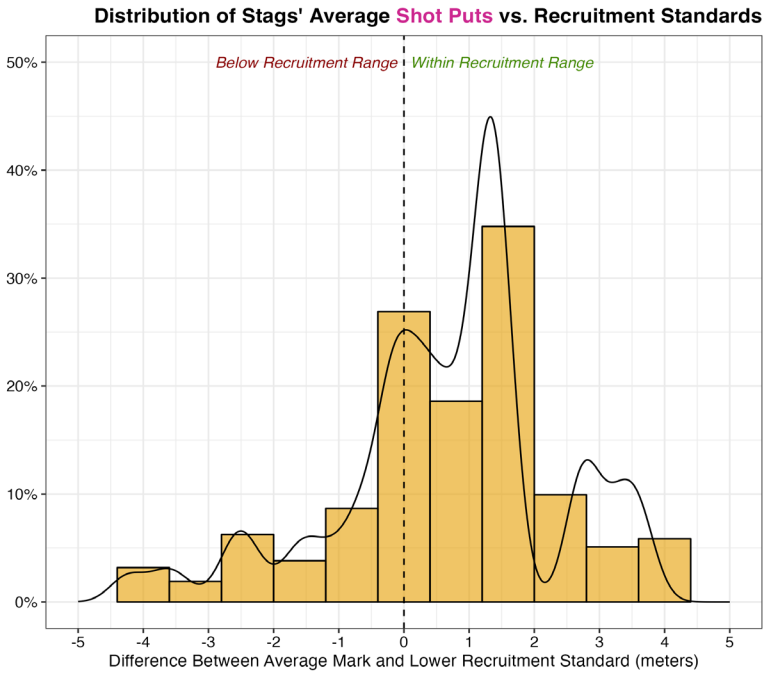

Figure 23: The distribution appears to be mostly normal (n=31). The mode is between 0 and 2, indicating that most Stags' average shot put performances were either at or slightly above the lower end of the recruitment standard (12 meters).
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

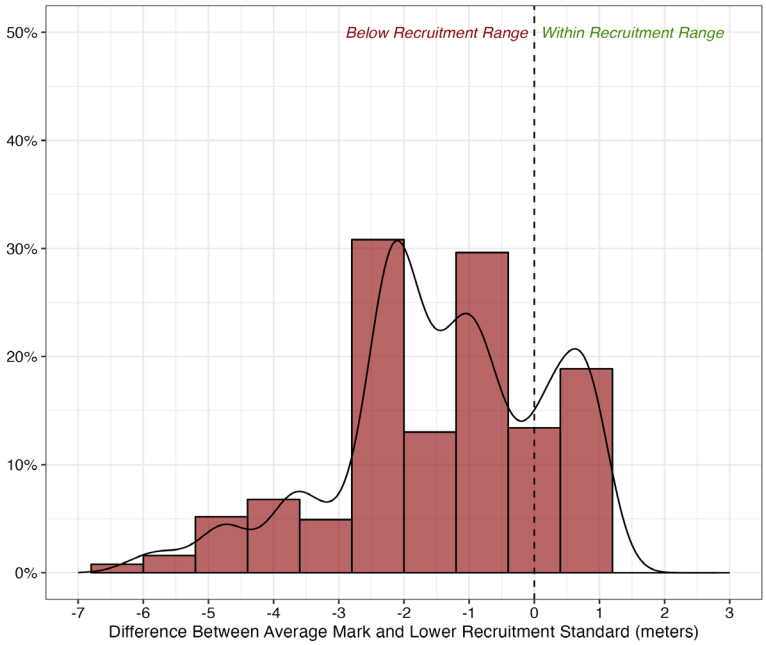

Figure 24: The distribution indicates that most observations (n=32) fall below zero and concentrate around -2 and -1. This suggests that most Athenas' average shot put performances are slightly below the lower end of the recruitment standard (11 meters).
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

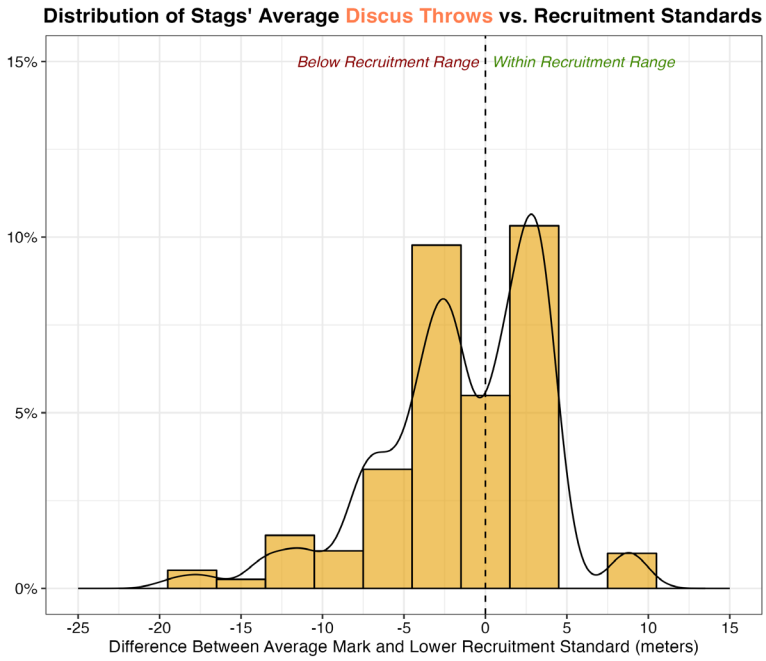

Figure 25: The distribution appears to be somewhat bimodal, with the most observations (n=32) falling between -5 and 0, and 0 and 5. This indicates that while many Stags' average discus throw performances exceeded the lower end of the recruitment standard (37 meters), a considerable portion also fell slightly short of the recruitment standard.
Plot Created By: chou24@students.claremontmckenna.edu
PSYC167: Data Visualization

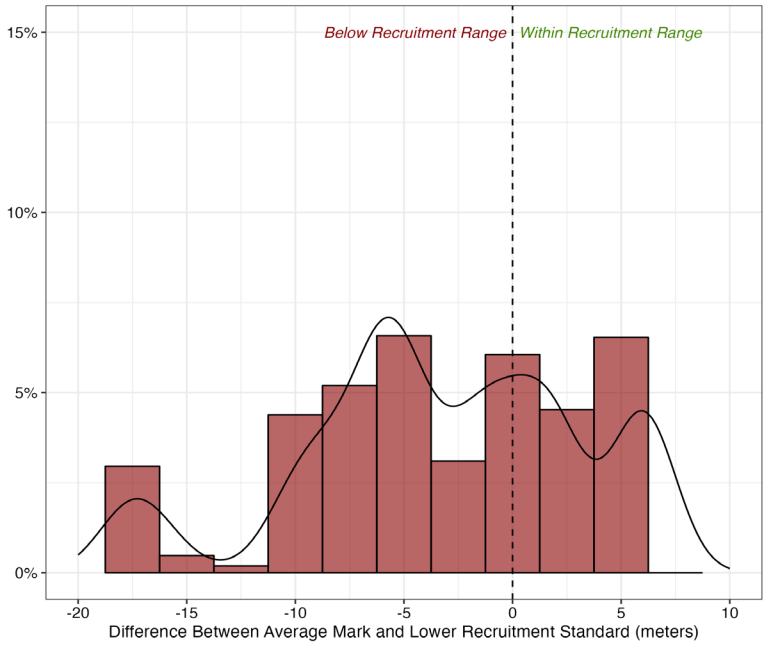

Figure 26: The distribution appears to be somewhat symmetric (n=26), indicating that while many Athenas' average discus throw performances exceeded the lower end of the recruitment standard (34 meters), many also fell slightly below the recruitment standard.
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