

# US Gymnastics Analysis

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## Introduction

The Olympic Games are a highly anticipated world-renowned multi-sporting event that takes place every four years. Particularly the Summer Olympic Games tend to have a wider variety of 32 sports and more viewers than that of the Winter Olympics (Olympics, 2021). Athletes from all over the world can participate granted they meet the criteria established by their nation's Olympic committees and the international sports federations. With female qualifying gymnasts from the United States placing with medals in the team all-around, individual all-around, and each individual apparatus in the 2020 Tokyo Olympics game, there has been a surge in media attention on the United States gymnastics teams (Olympics, 2020).

As the Paris 2024 Summer Olympic Games is approaching, the United States Olympic Men's and Women's Artistic Gymnastics aims to put together a team that best represents the country on the world's sporting stage by optimizing medal success amongst the team all-around, individual all-around, and individual apparatus events. This study aims to use the most recent Olympic Games and other world competitions' qualifying and final round results data to best assemble a team that is likely to produce optimal success in terms of medals within the Olympic qualifiers and final criteria (UCSAS, 2023).

The UConn Sports Analytics Symposium provisioned two clean data sets of the accumulation of results of teams worldwide that participated in the major domestic and international gymnastic qualifying and final competition events leading up to the 2024 Summer Olympic Games. The first data set includes the results of the 2020 (taking place in 2021) Tokyo Summer Olympics qualifying and final rounds, and the second data set includes competitions in the 2022 and 2023 seasons. Observations for both datasets are at the athlete- and apparatus-level score for an event in a round at a gymnastics competition—for example, Simone Biles's final uneven bars score at the 2023 US Gymnastics Championships. It is worth noting, however, that the data from the Tokyo Olympics only include results for women's gymnastics, while the data from 2022-2023 include results for both men's and women's gymnastics. The data are collected from the results on each corresponding competition's official website, which are results from the officially judged scores of each competition. Variables in the data sets include first and last names of each athlete, gender, country, date of competition, name of competition, the round of the competition (e.g. qualifier or final of an individual apparatus, individual all-around, or team event), the location of the competition, apparatus ("BB": balance beam, "FX": floor exercise, "HB": high bar, "PB": parallel bars, "PH": pommel horse, "SR": still rings, "UB": uneven bars, "VT": vault, "VT1" and "VT2": 2 different vaults required in individual apparatus qualifications and finals), the execution score, difficulty score, penalty, and final score for that athlete on that apparatus, and the rank of that athlete in that apparatus and round.

We decided to not proceed in using the data set of results from the Tokyo Summer Olympics since the data consisted only of female athletes and one competition (the Olympic Games). Additionally, in the context of Olympic gymnastics, athletes of age 16 and older are eligible to compete but gymnastics is a sport in which most athletes retire in their early to mid-twenties. Specifically in the summer 2020 Tokyo Olympics only three female athletes aged 27 or older qualified to compete (Camenker, 2021). Furthermore, the average age for female gymnasts in the 2020 Olympics was approximately 22 years of age, meaning we assume that many of the competitors in the older data set will not be competing in the 2024 Paris Summer Olympics (Meyers, 2021).

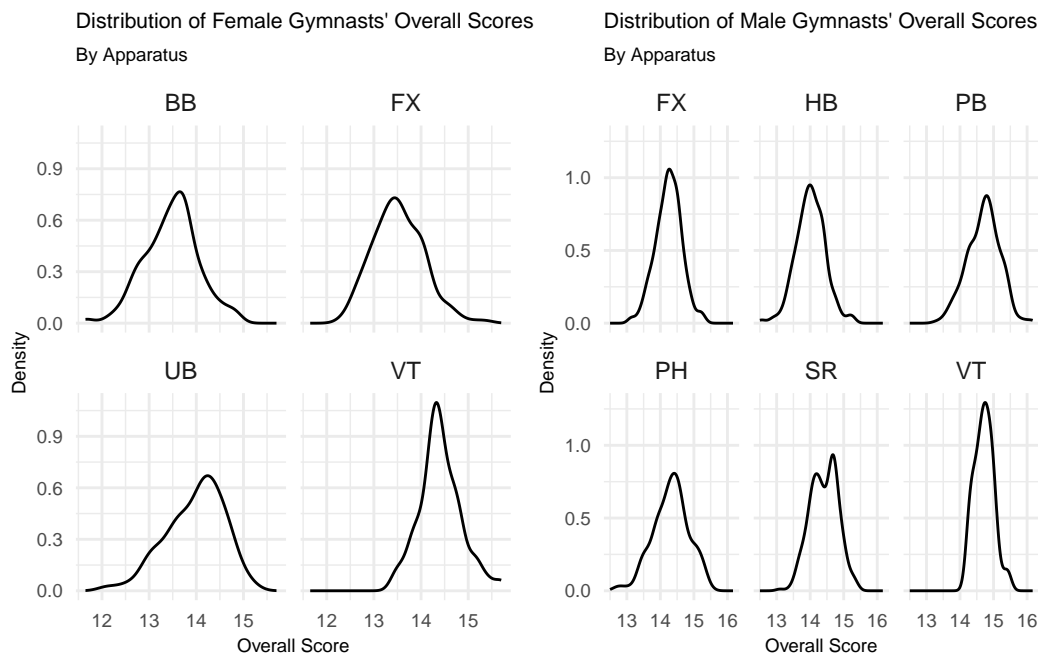
We have the following objectives for this study: (UCSAS, 2023)

- 1) Decide on whether to maximize total medal count, gold medal count, or a weighted medal count (e.g., 3 for gold, 2 for silver, 1 for bronze).
- 2) Decide on whether to value the medals of an event over others. For example, consider a team all-around medal to be more valuable than the individual all-around medals and/or consider the individual all-around medals to be more valuable than the individual apparatus medals.
- 3) Decide on whether Team USA should maximize its total medal count by selecting a team of five gymnasts who are all-around gymnasts, event specialists (gymnasts who focus on 1 or more apparatus but not all apparatus), or a combination of those. This should consider under what circumstances can Team USA maximize its total medal count by selecting a gymnast who only competes on 1 apparatus (e.g., Stephen Niderosik, 2021 pommel horse World Champion).
- 4) Identify the group of five athletes who will most likely enable the Team USA Olympic Men's and Women's Artistic Gymnastics team to maximize medals won in the Paris 2024 Summer Olympics using an analytical model.

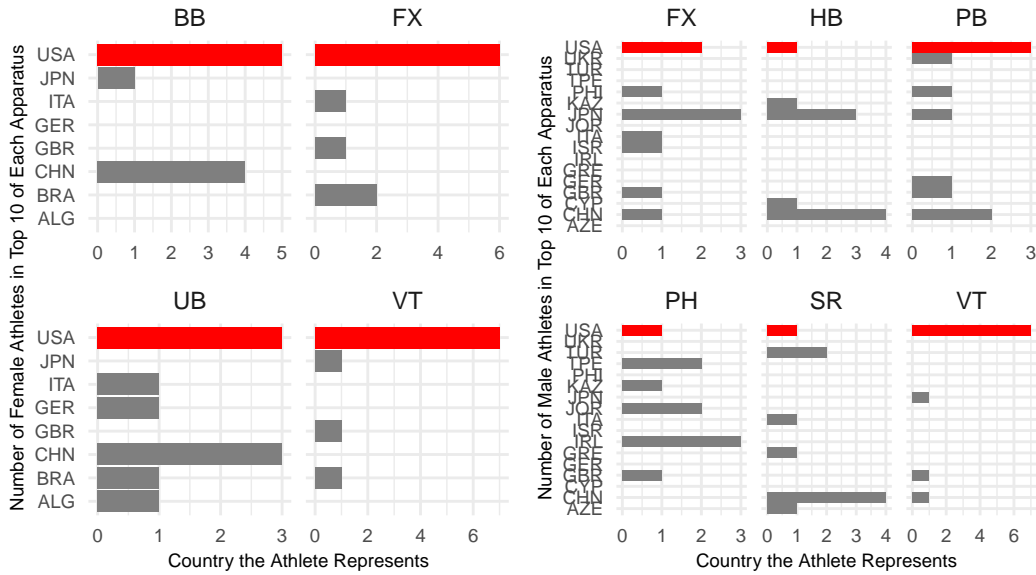
Addressing these objectives will assist the national Olympic Artistic Gymnastics teams in best approaching the Olympic gymnastics events in totality by offering recommended strategies to best approach team selection. In our analysis of the best fit US male and female gymnastics teams for the Paris Olympics, we will undertake a Bayesian approach to simulate outcomes of individual athletes' scores in an apparatus. Bayesian frameworks in sports analytics to simulate athlete's results are well-documented and have seen a rise in popularity in the past decade (Santos-Fernandez, et. al., 2019). For instance, Yang and Swartz use Monte Carlo Markov Chains to simulate the outcomes of baseball games (Yang et. al., 2022). We will build upon these analyses and choose the appropriate Bayesian method to simulate outcomes of gymnast results in each apparatus, after which we will analyze the top performers in each apparatus, assign medals, and find the best combination of athletes.

## Methodology

### Exploratory Data Visualizations



Number of Female Athletes in Top 10 of Each Apparatus By Athlete's Mean Apparatus Score and Country  
 Number of Male Athletes in Top 10 of Each Ap By Athlete's Mean Apparatus Scores and Country



## Simulations

### Female Athletes' Results

Table 1: Women's Floor Exercise Simulation Results

| Athlete     | Golds | Silvers | Bronzes | Total Medals |
|-------------|-------|---------|---------|--------------|
| SimBIL__USA | 34    | 13      | 15      | 62           |
| KalLIN__USA | 12    | 8       | 7       | 27           |
| JesGAD__GBR | 6     | 9       | 11      | 26           |
| RebAND__BRA | 12    | 7       | 4       | 23           |
| JadCAR__USA | 3     | 7       | 4       | 14           |
| FlaSAR__BRA | 4     | 8       | 2       | 14           |
| MarMAG__ITA | 4     | 4       | 4       | 12           |
| JorCHI__USA | 2     | 6       | 3       | 11           |
| YusOU__CHN  | 2     | 4       | 5       | 11           |
| ShoMIY__JPN | 2     | 3       | 3       | 8            |

Table 2: Women's Balance Beam Simulation Results

| Athlete     | Golds | Silvers | Bronzes | Total Medals |
|-------------|-------|---------|---------|--------------|
| SimBIL__USA | 26    | 14      | 8       | 48           |
| YaqZHO__CHN | 10    | 14      | 9       | 33           |
| KonMCC__USA | 16    | 11      | 5       | 32           |
| QinZHA__CHN | 10    | 9       | 12      | 31           |
| YusOU__CHN  | 5     | 6       | 3       | 14           |
| SunLEE__USA | 5     | 5       | 3       | 13           |
| EmmMAL__GER | 1     | 3       | 6       | 10           |
| HuaLUO__CHN | 1     | 4       | 4       | 9            |
| SarVOS__GER | 0     | 4       | 5       | 9            |
| LeaWON__USA | 2     | 4       | 1       | 7            |

Table 3: Women’s Vault Simulation Results

| Athlete    | Gold | Silver | Bronze | Total Medals |
|------------|------|--------|--------|--------------|
| SimBIL_USA | 42   | 9      | 18     | 69           |
| RebAND_BRA | 25   | 19     | 8      | 52           |
| JadCAR_USA | 10   | 18     | 19     | 47           |
| ShiJON_USA | 5    | 14     | 8      | 27           |
| JorCHI_USA | 2    | 8      | 15     | 25           |
| KonMCC_USA | 5    | 7      | 5      | 17           |
| OndACH_GBR | 2    | 9      | 3      | 14           |
| TiaSUM_USA | 1    | 2      | 10     | 13           |
| JosROB_USA | 3    | 6      | 3      | 12           |
| SkyBLA_USA | 4    | 3      | 3      | 10           |

Table 4: Women’s Uneven Bars Simulation Results

| Athlete    | Gold | Silver | Bronze | Total Medals |
|------------|------|--------|--------|--------------|
| KayNEM_ALG | 23   | 15     | 11     | 49           |
| QiyQIU_CHN | 17   | 10     | 9      | 36           |
| XiaWEI_CHN | 12   | 9      | 8      | 29           |
| ShiJON_USA | 6    | 10     | 13     | 29           |
| AliD A_ITA | 4    | 13     | 7      | 24           |
| ZoeMIL_USA | 6    | 7      | 6      | 19           |
| SimBIL_USA | 6    | 3      | 2      | 11           |
| RebAND_BRA | 5    | 3      | 2      | 10           |
| YunLEE_KOR | 2    | 3      | 4      | 9            |
| XijTAN_CHN | 1    | 4      | 3      | 8            |

## Male Athletes’ Results

Table 5: Men’s Floor Exercise Simulation Results

| Athlete    | Gold | Silver | Bronze | Total Medals |
|------------|------|--------|--------|--------------|
| CarYUL_PHI | 10   | 10     | 10     | 30           |
| RyoDOI_JPN | 11   | 7      | 4      | 22           |
| ArtDOL_ISR | 7    | 9      | 3      | 19           |
| BohZHA_CHN | 5    | 5      | 6      | 16           |
| DaiHAS_JPN | 3    | 5      | 5      | 13           |
| NicBAR_ITA | 6    | 3      | 4      | 13           |
| KazMIN_JPN | 1    | 3      | 6      | 10           |
| PauJUD_USA | 3    | 1      | 6      | 10           |
| ChiTAN_TPE | 2    | 5      | 3      | 10           |
| YulMOL_USA | 3    | 3      | 3      | 9            |

Table 6: Men’s Vault Simulation Results

| Athlete    | Gold | Silver | Bronze | Total Medals |
|------------|------|--------|--------|--------------|
| JakJAR_GBR | 18   | 14     | 11     | 43           |
| AshHON_USA | 16   | 10     | 10     | 36           |
| DaiHAS_JPN | 11   | 15     | 10     | 36           |
| BohZHA_CHN | 12   | 8      | 10     | 30           |
| DalHAL_USA | 6    | 11     | 11     | 28           |
| CurPHI_USA | 8    | 4      | 9      | 21           |
| DonWHI_USA | 5    | 8      | 5      | 18           |
| KhoYOU_USA | 9    | 4      | 5      | 18           |
| ColWAL_USA | 1    | 8      | 8      | 17           |
| TayBUR_USA | 2    | 8      | 7      | 17           |

Table 7: Men’s Pommel Horse Simulation Results

| Athlete    | Gold | Silver | Bronze | Total Medals |
|------------|------|--------|--------|--------------|
| MaxWHI_GBR | 13   | 13     | 4      | 30           |
| Mc CLE_IRL | 14   | 5      | 9      | 28           |
| ChiLEE_TPE | 7    | 10     | 10     | 27           |
| RhyMCC_IRL | 5    | 6      | 8      | 19           |
| AhmABU_JOR | 3    | 4      | 12     | 19           |
| NarKUR_KAZ | 5    | 8      | 5      | 18           |
| AhmSOU_JOR | 5    | 5      | 2      | 12           |
| SteNED_USA | 5    | 1      | 4      | 10           |
| DaiHAS_JPN | 1    | 4      | 5      | 10           |
| Yu-SHI_TPE | 3    | 4      | 3      | 10           |

Table 8: Men’s High Bar Simulation Results

| Athlete    | Gold | Silver | Bronze | Total Medals |
|------------|------|--------|--------|--------------|
| DaiHAS_JPN | 10   | 8      | 11     | 29           |
| BohZHA_CHN | 11   | 14     | 1      | 26           |
| ConSHI_CHN | 10   | 4      | 8      | 22           |
| BroMAL_USA | 5    | 4      | 7      | 16           |
| WeiSUN_CHN | 5    | 7      | 3      | 15           |
| MilKAR_KAZ | 4    | 4      | 6      | 14           |
| ShoKAW_JPN | 7    | 2      | 5      | 14           |
| WeiSU_CHN  | 2    | 5      | 6      | 13           |
| FreRIC_USA | 3    | 7      | 2      | 12           |
| YuyKAM_JPN | 5    | 2      | 3      | 10           |

Table 9: Men’s Still Rings Simulation Results

| Athlete    | Gold | Silver | Bronze | Total Medals |
|------------|------|--------|--------|--------------|
| YanLIU_CHN | 13   | 10     | 5      | 28           |
| XinLAN_CHN | 8    | 7      | 8      | 23           |
| JinZOU_CHN | 10   | 7      | 6      | 23           |
| ElePET_GRE | 8    | 9      | 4      | 21           |
| AdeASI_TUR | 5    | 8      | 5      | 18           |
| SalMAR_ITA | 5    | 4      | 5      | 14           |
| NikSIM_AZE | 1    | 4      | 9      | 14           |
| DonWHI_USA | 5    | 5      | 3      | 13           |
| HaoYOU_CHN | 5    | 1      | 6      | 12           |
| MahAHM_IRI | 2    | 5      | 2      | 9            |

Table 10: Men’s Parallel Bars Simulation Results

| Athlete    | Gold | Silver | Bronze | Total Medals |
|------------|------|--------|--------|--------------|
| JinZOU_CHN | 28   | 20     | 11     | 59           |
| BohZHA_CHN | 10   | 8      | 9      | 27           |
| LukDAU_GER | 8    | 11     | 8      | 27           |
| CarYUL_PHI | 7    | 6      | 7      | 20           |
| IllKOV_UKR | 5    | 7      | 5      | 17           |
| ColWAL_USA | 5    | 4      | 7      | 16           |
| JoeFRA_GBR | 3    | 2      | 8      | 13           |
| KaiSUG_JPN | 7    | 0      | 5      | 12           |
| CurPHI_USA | 1    | 6      | 3      | 10           |
| MilKAR_KAZ | 2    | 2      | 3      | 7            |

## **Objective 1: Choice of Medal Success Metric (Total Number of Gold Medals)**

From the dot plot visualizations of the women's simulation of the three considered success metrics (gold medal count, total medal count, and weighted medal count) for each apparatus by USA and non-USA teams, there looks to be at least one USA athlete that places higher than of all non-USA athletes in each medal metric for each apparatus except uneven bars (Appendix: Image 5). The women's USA team makes up 51% of the total women's gold medals in the simulation which is a higher proportion than the 47% of the total medal count and 48% of the weighted medals (Appendix: Image 7). From the dot plot visualizations of the men's simulation of the three considered success metrics, for each apparatus by USA and non-USA teams, there are non-USA athletes for each apparatus that exceed the USA in each medal success metric (Appendix: Image 6). The men's USA team makes up 24% of the total medal count in the simulation which is a higher proportion than the 21% of the total gold medal count and 23% of the weighted medals. (Appendix: Image 8) When viewing the top 5 most successful female athletes (top 5 most decorated by that medal metric) in each apparatus for each medal success metric, the USA makes a good portion of these athletes. There tend to be 2-4 USA athletes in the top 5 depending on the success metric and apparatus (Appendix: Image 7). When viewing the top 5 most successful male athletes in each apparatus for each medal success metric, there tend to be 0-3 (mostly 0) US male athletes present (Appendix: Image 8).

Considering that female USA medalists tend to represent a much higher proportion of medal successes (no matter the success metric) than male USA athletes, it is best to prioritize the success metric that the female team performs the best in. Also viewing the male top 5 most decorated athlete by each metric for each apparatus, the men's USA team has a higher proportion of athletes in the top 5 when using the total number of gold medals as a success metric (Appendix: Image 8). Therefore, the success metric that we aim to maximize to best ensure the USA team's success is the total number of gold medals.

## **Objective 2: Value of Medals for Each Event Type (Team AA > Individual AA > Individual Apparatus)**

From the table of the top 10 most decorated gold medal female athletes by apparatus, the USA, China, Brazil, and Great Britain make multiple appearances. The USA has athletes in the top 10 most decorated gold medalist for each apparatus as well as the top 5, but other countries do not (Appendix: Image 9). This allows us to assume that the USA has great potential in winning the team all-around since it is the only country with many of the most successful athletes in each apparatus in terms of the number of gold medals. In this case, valuing the team's all-around medal more than the individual all-around and individual apparatus will hopefully increase medal success in terms of gold medal count. Also when viewing the top 10 most decorated gold medal female athletes by apparatus, the USA's Simone Biles, appears in the balance beam as first, in floor exercise as first, in uneven bars as ninth, and in vault as first. Valuing the individual all-around events higher also may help team USA increase in our metric of success. Furthermore, since these events are harder to achieve than individual apparatuses because of the multiple sections within the event that need to also meet a standard, it will be harder for other countries to also benefit from this increased value.

From the table of the top 10 most decorated gold medal male athletes by apparatus, the USA, Japan, and China make multiple appearances. The only country that has an athlete in each apparatus for the top 10, is the USA (Appendix: Image 11). It could be slightly beneficial to the men's team to value the team's all-around success more than the other events. The US men's team also does not have a well-rounded athlete that places in the top 10 most decorated gold male athletes for each apparatus so we can assume valuing individual all-around successes over the other events would not help the US men's team but it also would not hurt it since other countries also do not have a highly decorated well-rounded competitor.

In the dot plots of the top 5 decorated gold medal female athletes' unique IDs by number of gold medals for each apparatus, US athletes make multiple appearances (Appendix: Image 10). In the dot plots of the top 5 decorated gold medal male athlete's unique IDs by number of gold medals for each apparatus, US athletes are present in multiple apparatuses but not many athletes are well decorated within each apparatus. But in vault there are two US athletes in the top 5 (Appendix: Image 12). Valuing individual apparatus events as

regular events of weight 1 would best suit both the male and female teams' success against their competitors. Weighing the team all-around as 3 points is viable because not only do both the men's and women's USA have the potential to win based on this simulation, but there is less reliance and pressure on one singular person. Weighing the individual all-around as 2 will hopefully benefit the women's team with Simone Biles as the potential representative for this event. These weights will in hope best accommodate the male and female athletes and give them the best chance at success against other countries in terms of the total number of gold medals.

### **Objective 3: All-Around vs Event Specialist vs Mixture**

In our metric of success, we chose the total count of gold medals and we decided to weigh team all-around events as greater than individual all-around events and individual all-around great than the individual apparatuses. For the women's team, we believe it is best to select a team of five female athletes who are a combination of all-around and event-specialist gymnasts. Since the US women's team has a strong shot at winning the individual all-around with multi-apparatus highly gold medal decorated athlete Simone Biles and team all-around with other multiple highly decorated gold medalists who specialize in their apparatus, focusing on both would be an optimal strategy (Appendix: Image 10). For the men's team, we believe it is best to select a team of five male athletes who are also a combination of both all-around gymnasts and specialists. In the simulation, since 3 of the top 10 most gold medal-decorated male gymnasts in parallel bars are from the US and 7 of the top 10 in vault are from the US, there is a good chance that a male athlete from the US may be successful in those apparatuses (Appendix: Image 11). Since the US does not seem to have very many strong gold medal specialists in the other apparatuses, the men's team should fill the remaining positions with all-around gymnasts.

### **Objective 4: Identifying 5 Athletes ...**

## **Discussion**

## **Appendix**

### **Work Cited**

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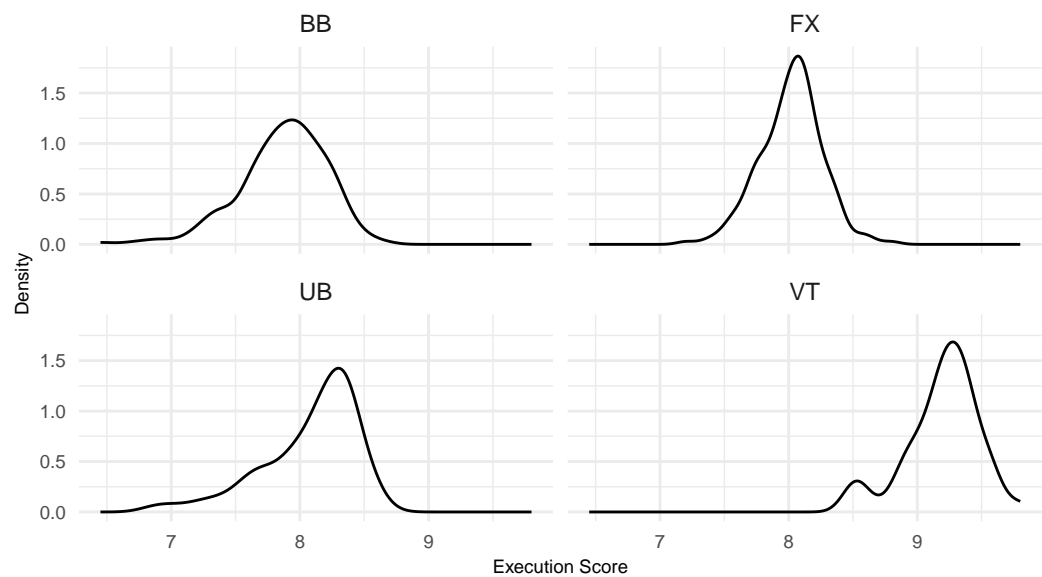
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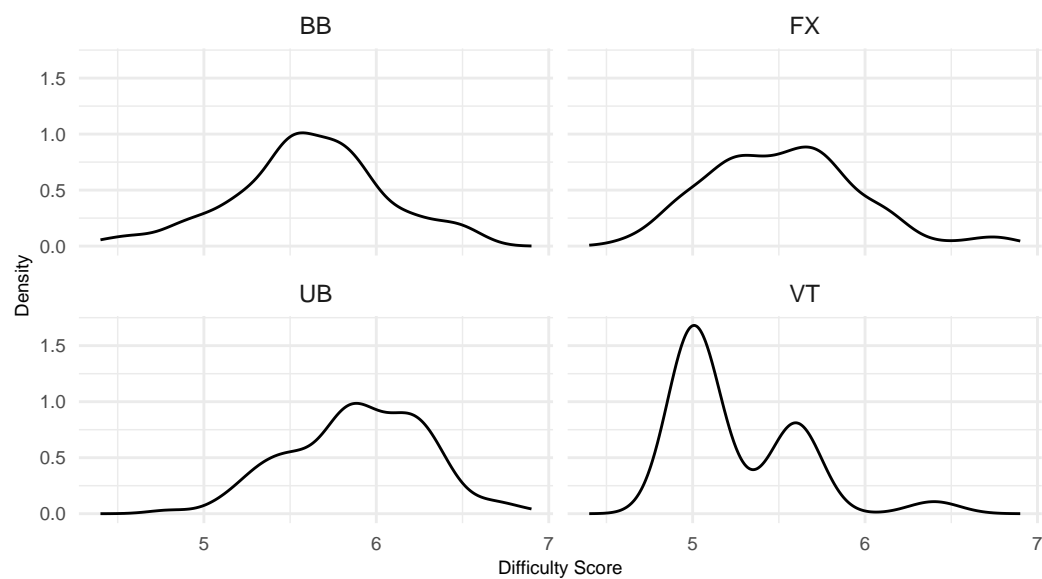
Yang, Tae Young, and Tim Swartz. "A Two-Stage Bayesian Model for Predicting Winners in Major League Baseball." *Journal of Data Science*, vol. 2, no. 1, Aug. 2022, pp. 61–73. [jds-online.org](http://jds-online.org), [https://doi.org/10.6339/JDS.2004.02\(1\).142](https://doi.org/10.6339/JDS.2004.02(1).142).

Extra Visualizations

Distribution of Female Gymnasts' Execution Scores  
By Apparatus



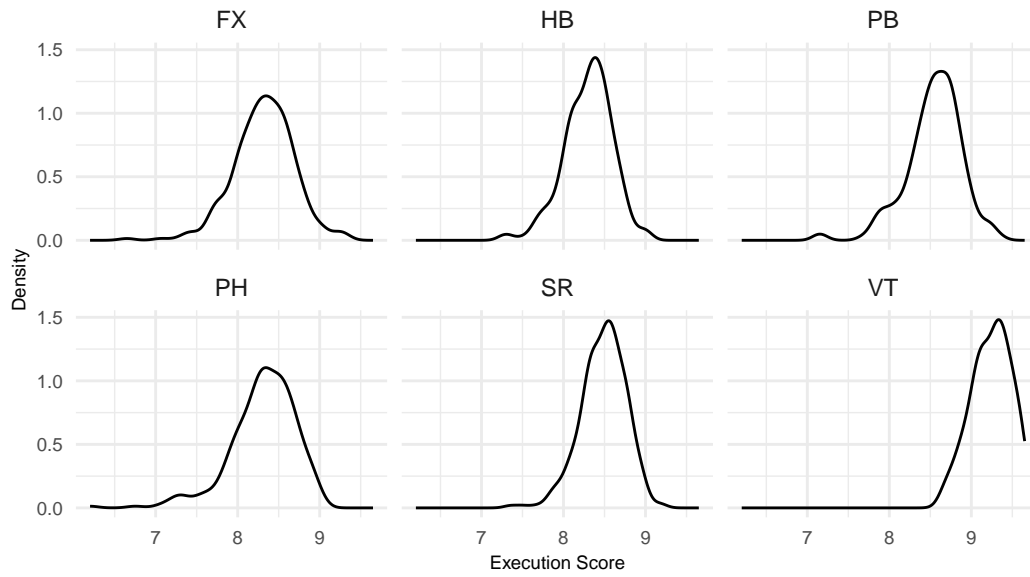
Distribution of Female Gymnasts' Difficulty Scores  
By Apparatus





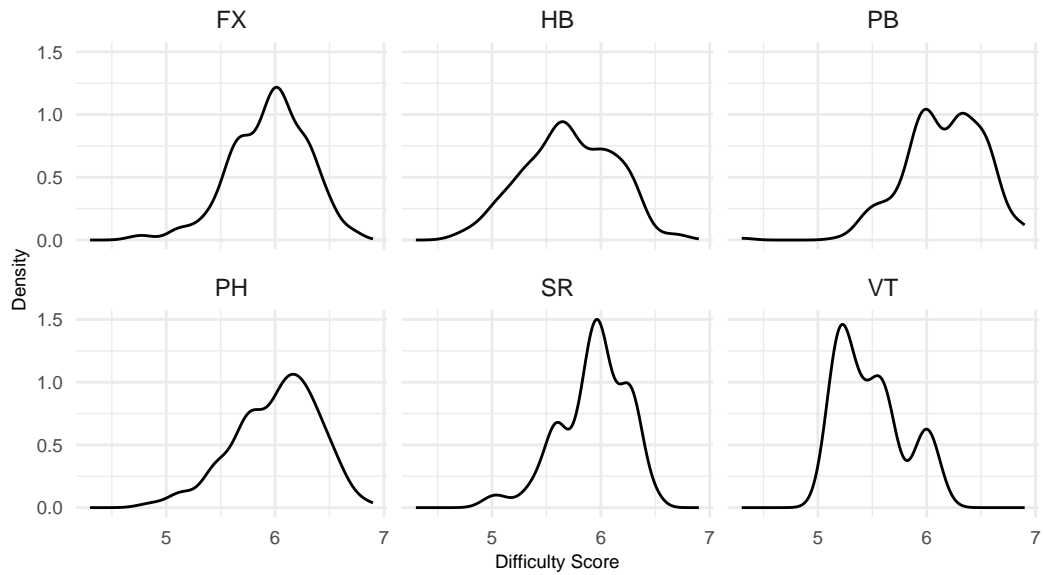
### Distribution of Male Gymnasts' Execution Scores

By Apparatus



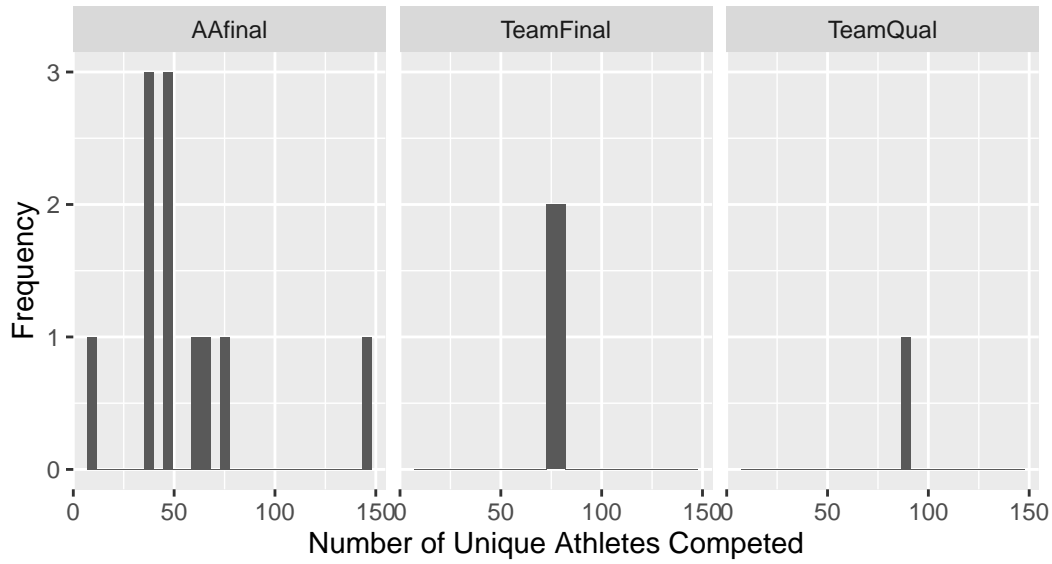
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By Apparatus

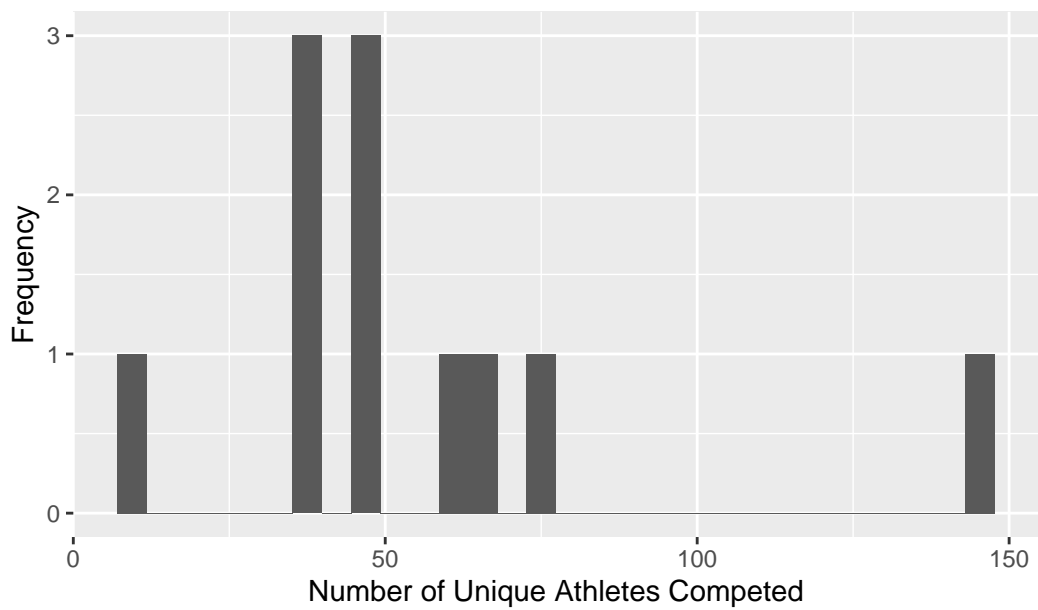


## 1) Distribution of Athletes Competed at Competition Rounds

All Around or Team All Arounds

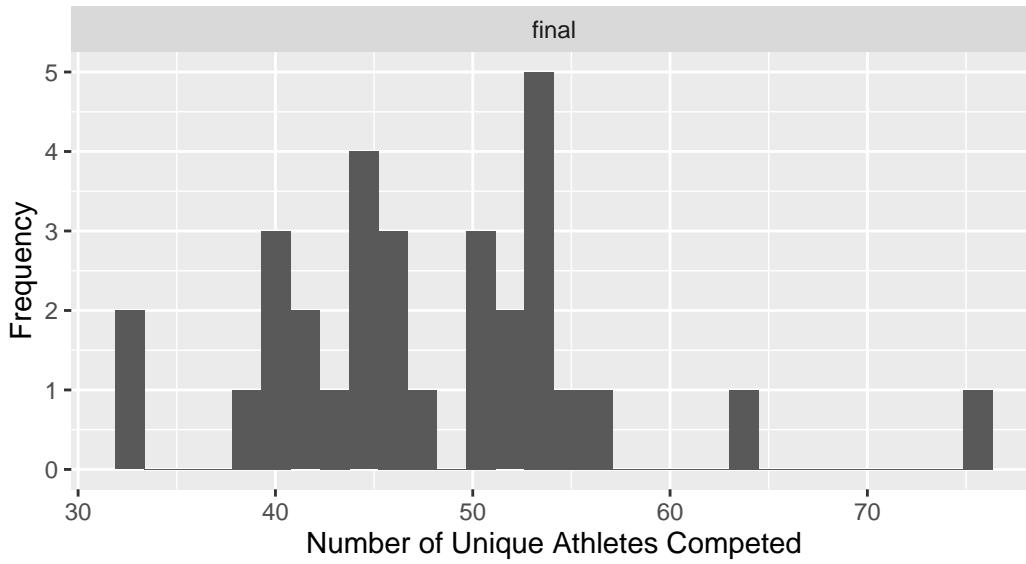


## 2) Distribution of Athletes Competed at AA Finals



### 3) Distribution of Athletes Competed at Final Rounds

Individual Apparatuses



### 4) Distribution of Athletes Competed at Competitions

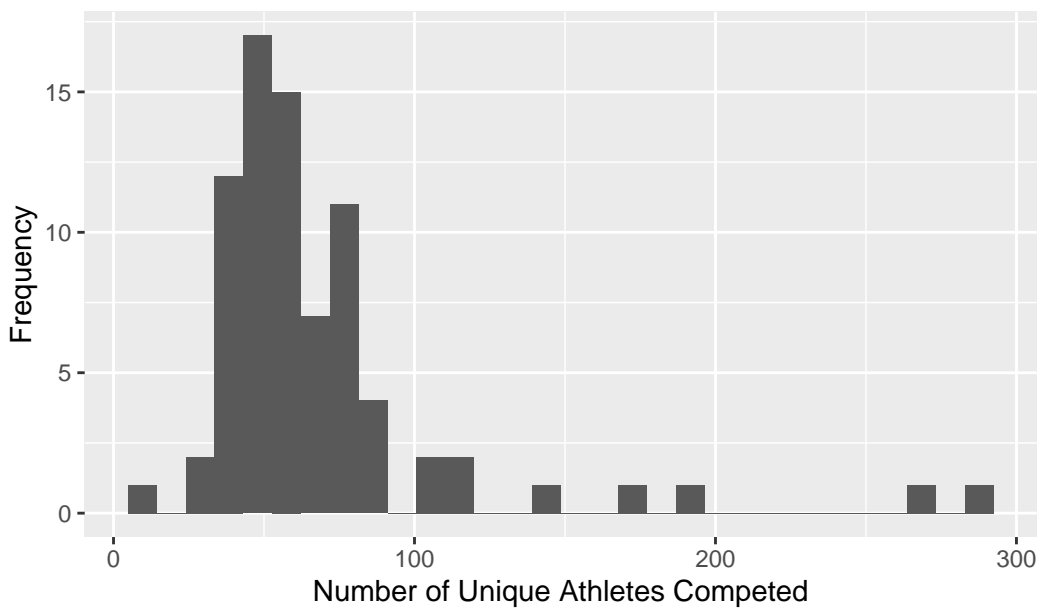
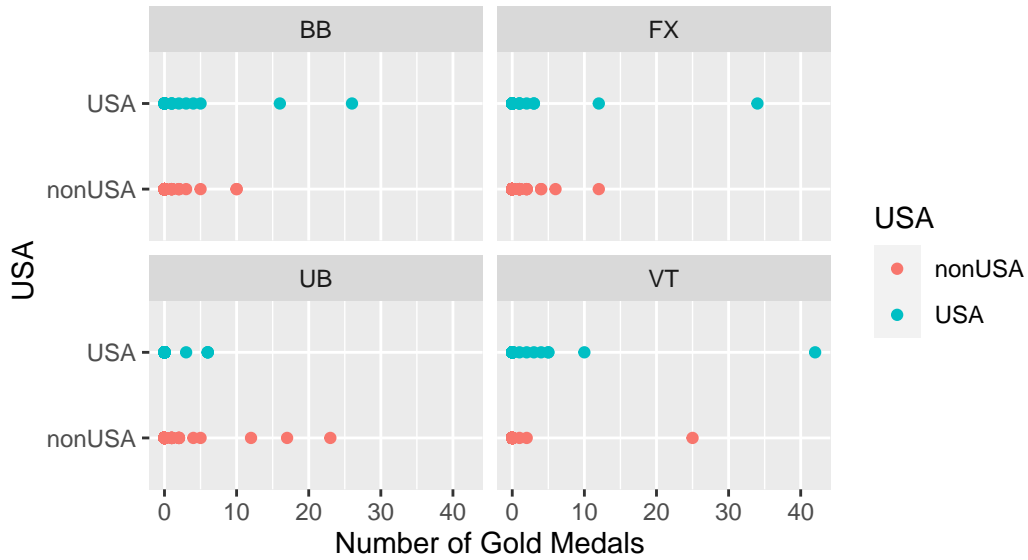
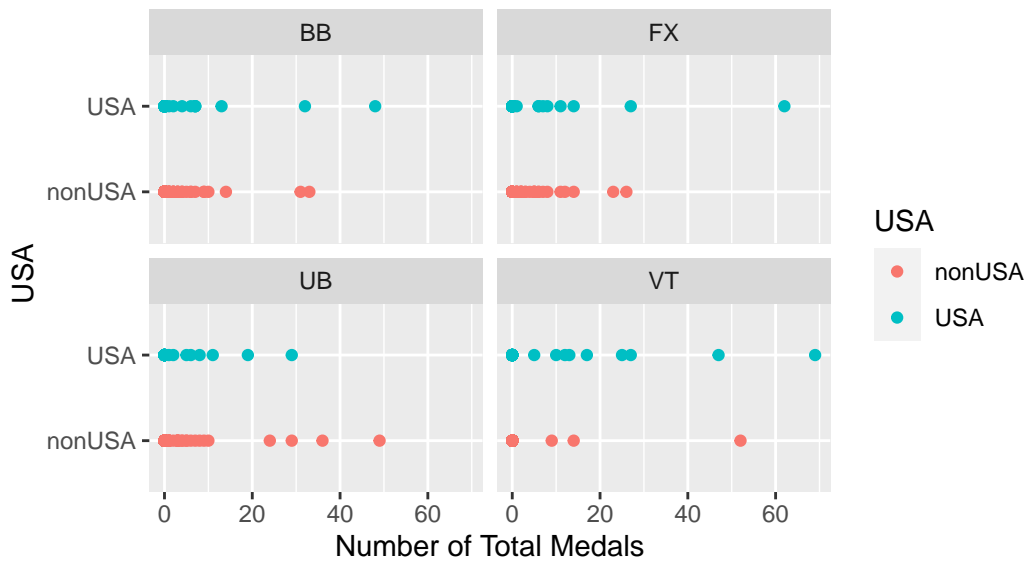


Image 5)

Individual Female Athlete's Number of Gold Medals  
by Country and by Apparatus



Individual Female Athlete's Number of Total Medals  
by Country and by Apparatus



Individual Female Athlete's Medal Weight  
by Country and by Apparatus

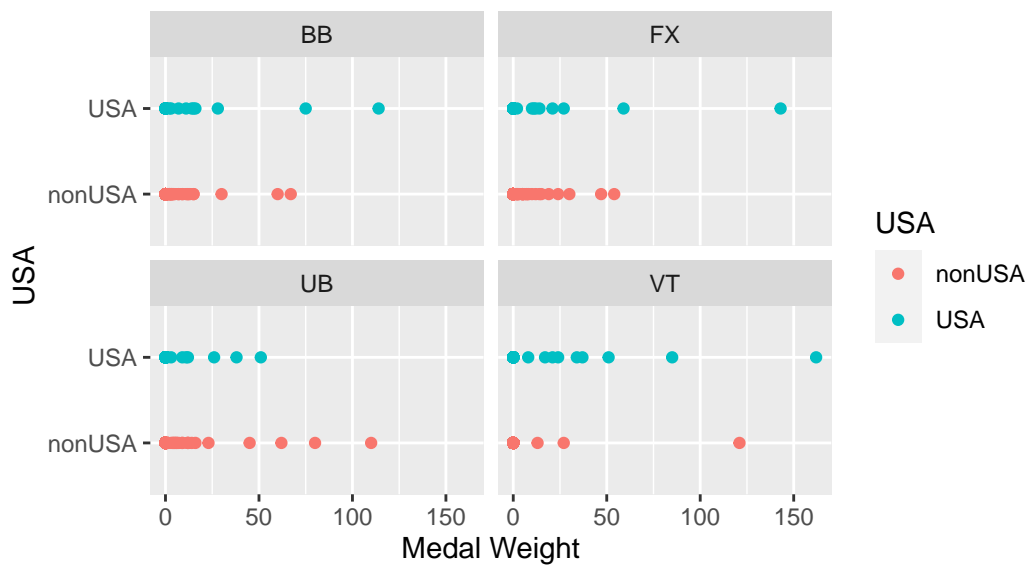
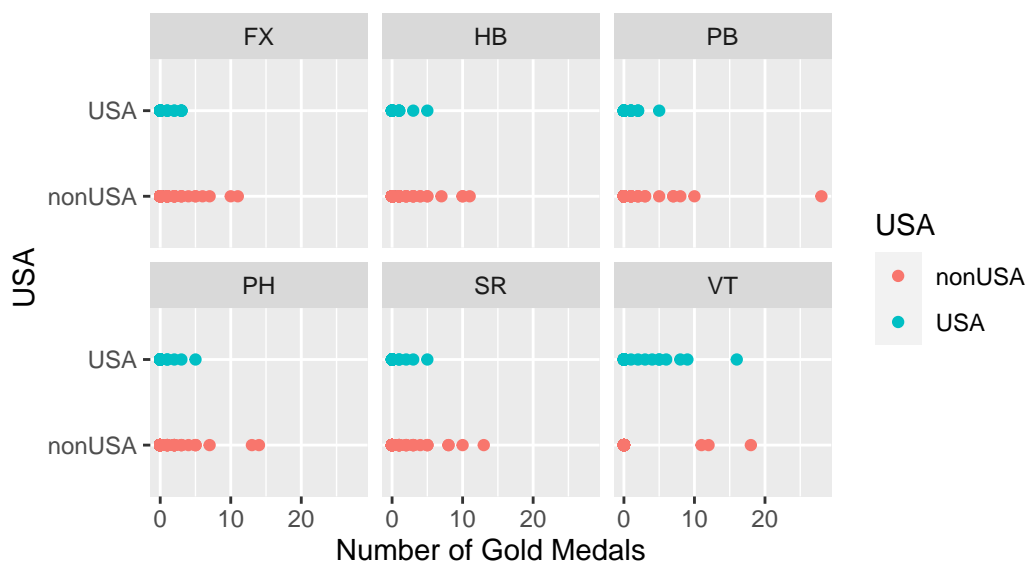
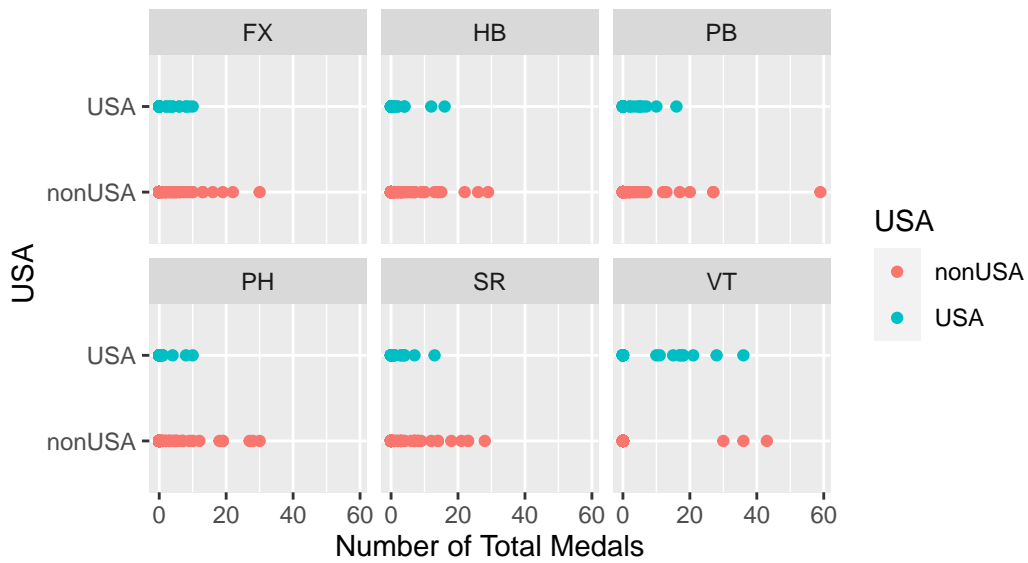


Image 6)

Individual Male Athlete's Number of Gold Medals  
by Country and by Apparatus



Individual Male Athlete's Number of Total Medals  
by Country and by Apparatus



Individual Male Athlete's Medal Weight  
by Country and by Apparatus

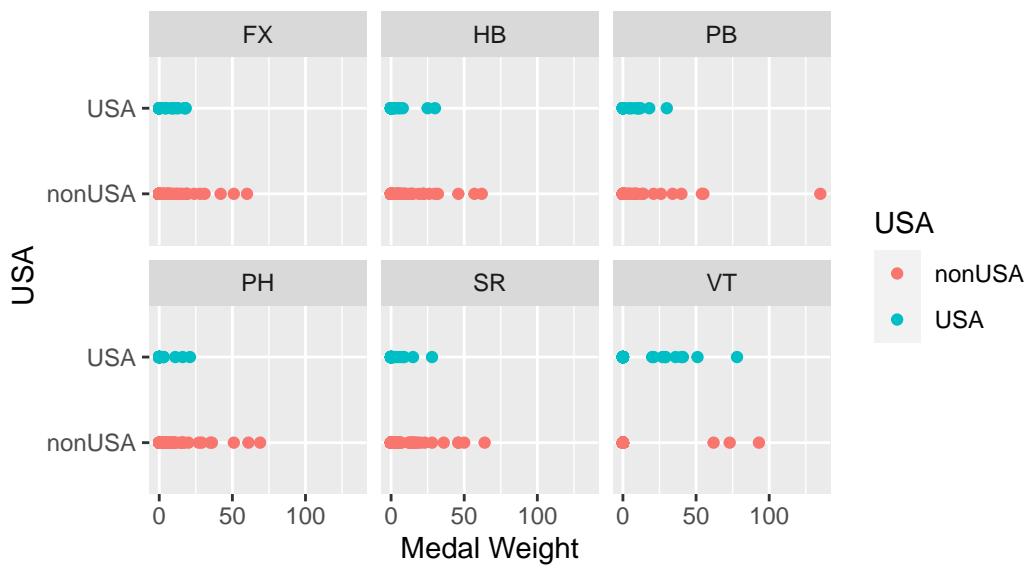


Image 7)

Women:

- Top 5 athletes by apparatus for each of the 3 success metrics
- Sum of each of the 3 metrics made by athletes from the US and non-US countries

| unique_id  | Golds | Silvers | Bronzes | Total_Medals | Country | Medal_Weight | Apparatus | USA    |
|------------|-------|---------|---------|--------------|---------|--------------|-----------|--------|
| SimBIL_USA | 26    | 14      | 8       | 48           | USA     | 114          | BB        | USA    |
| KonMCC_USA | 16    | 11      | 5       | 32           | USA     | 75           | BB        | USA    |
| YaqZHO_CHN | 10    | 14      | 9       | 33           | CHN     | 67           | BB        | nonUSA |
| QinZHA_CHN | 10    | 9       | 12      | 31           | CHN     | 60           | BB        | nonUSA |
| YusOU_CHN  | 5     | 6       | 3       | 14           | CHN     | 30           | BB        | nonUSA |
| SunLEE_USA | 5     | 5       | 3       | 13           | USA     | 28           | BB        | USA    |
| SimBIL_USA | 34    | 13      | 15      | 62           | USA     | 143          | FX        | USA    |
| KalLIN_USA | 12    | 8       | 7       | 27           | USA     | 59           | FX        | USA    |
| RebAND_BRA | 12    | 7       | 4       | 23           | BRA     | 54           | FX        | nonUSA |
| JesGAD_GBR | 6     | 9       | 11      | 26           | GBR     | 47           | FX        | nonUSA |
| FlaSAR_BRA | 4     | 8       | 2       | 14           | BRA     | 30           | FX        | nonUSA |
| MarMAG_ITA | 4     | 4       | 4       | 12           | ITA     | 24           | FX        | nonUSA |
| KayNEM_ALG | 23    | 15      | 11      | 49           | ALG     | 110          | UB        | nonUSA |
| QiyQIU_CHN | 17    | 10      | 9       | 36           | CHN     | 80           | UB        | nonUSA |
| XiaWEI_CHN | 12    | 9       | 8       | 29           | CHN     | 62           | UB        | nonUSA |
| ShiJON_USA | 6     | 10      | 13      | 29           | USA     | 51           | UB        | USA    |
| ZoeMIL_USA | 6     | 7       | 6       | 19           | USA     | 38           | UB        | USA    |
| SimBIL_USA | 6     | 3       | 2       | 11           | USA     | 26           | UB        | USA    |
| SimBIL_USA | 42    | 9       | 18      | 69           | USA     | 162          | VT        | USA    |
| RebAND_BRA | 25    | 19      | 8       | 52           | BRA     | 121          | VT        | nonUSA |
| JadCAR_USA | 10    | 18      | 19      | 47           | USA     | 85           | VT        | USA    |
| ShiJON_USA | 5     | 14      | 8       | 27           | USA     | 51           | VT        | USA    |
| KonMCC_USA | 5     | 7       | 5       | 17           | USA     | 34           | VT        | USA    |

| unique_id  | Golds | Silvers | Bronzes | Total_Medals | Country | Medal_Weight | Apparatus | USA    |
|------------|-------|---------|---------|--------------|---------|--------------|-----------|--------|
| SimBIL_USA | 26    | 14      | 8       | 48           | USA     | 114          | BB        | USA    |
| YaqZHO_CHN | 10    | 14      | 9       | 33           | CHN     | 67           | BB        | nonUSA |
| KonMCC_USA | 16    | 11      | 5       | 32           | USA     | 75           | BB        | USA    |
| QinZHA_CHN | 10    | 9       | 12      | 31           | CHN     | 60           | BB        | nonUSA |
| YusOU_CHN  | 5     | 6       | 3       | 14           | CHN     | 30           | BB        | nonUSA |
| SimBIL_USA | 34    | 13      | 15      | 62           | USA     | 143          | FX        | USA    |
| KalLIN_USA | 12    | 8       | 7       | 27           | USA     | 59           | FX        | USA    |
| JesGAD_GBR | 6     | 9       | 11      | 26           | GBR     | 47           | FX        | nonUSA |
| RebAND_BRA | 12    | 7       | 4       | 23           | BRA     | 54           | FX        | nonUSA |
| JadCAR_USA | 3     | 7       | 4       | 14           | USA     | 27           | FX        | USA    |
| FlaSAR_BRA | 4     | 8       | 2       | 14           | BRA     | 30           | FX        | nonUSA |
| KayNEM_ALG | 23    | 15      | 11      | 49           | ALG     | 110          | UB        | nonUSA |
| QiyQIU_CHN | 17    | 10      | 9       | 36           | CHN     | 80           | UB        | nonUSA |
| XiaWEI_CHN | 12    | 9       | 8       | 29           | CHN     | 62           | UB        | nonUSA |
| ShiJON_USA | 6     | 10      | 13      | 29           | USA     | 51           | UB        | USA    |
| AliD A_ITA | 4     | 13      | 7       | 24           | ITA     | 45           | UB        | nonUSA |
| SimBIL_USA | 42    | 9       | 18      | 69           | USA     | 162          | VT        | USA    |
| RebAND_BRA | 25    | 19      | 8       | 52           | BRA     | 121          | VT        | nonUSA |
| JadCAR_USA | 10    | 18      | 19      | 47           | USA     | 85           | VT        | USA    |
| ShiJON_USA | 5     | 14      | 8       | 27           | USA     | 51           | VT        | USA    |
| JorCHI_USA | 2     | 8       | 15      | 25           | USA     | 37           | VT        | USA    |

| unique_id  | Golds | Silvers | Bronzes | Total_Medals | Country | Medal_Weight | Apparatus | USA    |
|------------|-------|---------|---------|--------------|---------|--------------|-----------|--------|
| SimBIL_USA | 26    | 14      | 8       | 48           | USA     | 114          | BB        | USA    |
| KonMCC_USA | 16    | 11      | 5       | 32           | USA     | 75           | BB        | USA    |
| YaqZHO_CHN | 10    | 14      | 9       | 33           | CHN     | 67           | BB        | nonUSA |
| QinZHA_CHN | 10    | 9       | 12      | 31           | CHN     | 60           | BB        | nonUSA |
| YusOU_CHN  | 5     | 6       | 3       | 14           | CHN     | 30           | BB        | nonUSA |
| SimBIL_USA | 34    | 13      | 15      | 62           | USA     | 143          | FX        | USA    |
| KalLIN_USA | 12    | 8       | 7       | 27           | USA     | 59           | FX        | USA    |
| RebAND_BRA | 12    | 7       | 4       | 23           | BRA     | 54           | FX        | nonUSA |
| JesGAD_GBR | 6     | 9       | 11      | 26           | GBR     | 47           | FX        | nonUSA |
| FlaSAR_BRA | 4     | 8       | 2       | 14           | BRA     | 30           | FX        | nonUSA |
| KayNEM_ALG | 23    | 15      | 11      | 49           | ALG     | 110          | UB        | nonUSA |
| QiyQIU_CHN | 17    | 10      | 9       | 36           | CHN     | 80           | UB        | nonUSA |
| XiaWEI_CHN | 12    | 9       | 8       | 29           | CHN     | 62           | UB        | nonUSA |
| ShiJON_USA | 6     | 10      | 13      | 29           | USA     | 51           | UB        | USA    |
| AliD A_ITA | 4     | 13      | 7       | 24           | ITA     | 45           | UB        | nonUSA |
| SimBIL_USA | 42    | 9       | 18      | 69           | USA     | 162          | VT        | USA    |
| RebAND_BRA | 25    | 19      | 8       | 52           | BRA     | 121          | VT        | nonUSA |
| JadCAR_USA | 10    | 18      | 19      | 47           | USA     | 85           | VT        | USA    |
| ShiJON_USA | 5     | 14      | 8       | 27           | USA     | 51           | VT        | USA    |
| JorCHI_USA | 2     | 8       | 15      | 25           | USA     | 37           | VT        | USA    |

| USA    | sumGolds | sumTotal | sumWeighted |
|--------|----------|----------|-------------|
| nonUSA | 191      | 625      | 1226        |
| USA    | 209      | 575      | 1174        |

For the women's simulation when looking at the top 5 athletes by:

- *Gold Medal Count* for each apparatus there are 10 out of 20 from the US: balance beam (BB): 3, floor exercise (FX): 3, uneven bars (UB): 2, and vault (VT): 2
  - USA makes up 51% of the total women's gold medals in the simulation.
- *Total Medal Count* for each apparatus there are 12 out of 20 from the US: balance beam (BB): 3, floor exercise (FX): 4, uneven bars (UB): 1, vault (VT): 4
  - USA makes up 47% of the total women's medals in the simulation.
- *Weighted Medal Count* for each apparatus there are 10 out of 20 from the US: balance beam (BB): 3, floor exercise (FX): 2, uneven bars (UB): 1, vault (VT): 4
  - USA makes up 48% of the weight of women's medals in the simulation.

## Image 8)

Men:

- Top 5 athletes by apparatus for each of the 3 success metrics
- Sum of each of the 3 metrics made by athletes from the US and non-US countries



| unique_id  | Gold | Silver | Bronze | Total_Medals | Country | Medal_Weight | Apparatus | USA    |
|------------|------|--------|--------|--------------|---------|--------------|-----------|--------|
| RyoDOI_JPN | 11   | 7      | 4      | 22           | JPN     | 51           | FX        | nonUSA |
| CarYUL_PHI | 10   | 10     | 10     | 30           | PHI     | 60           | FX        | nonUSA |
| ArtDOL_ISR | 7    | 9      | 3      | 19           | ISR     | 42           | FX        | nonUSA |
| NicBAR_ITA | 6    | 3      | 4      | 13           | ITA     | 28           | FX        | nonUSA |
| BohZHA_CHN | 5    | 5      | 6      | 16           | CHN     | 31           | FX        | nonUSA |
| SunRYU_KOR | 5    | 2      | 0      | 7            | KOR     | 19           | FX        | nonUSA |
| BohZHA_CHN | 11   | 14     | 1      | 26           | CHN     | 62           | HB        | nonUSA |
| DaiHAS_JPN | 10   | 8      | 11     | 29           | JPN     | 57           | HB        | nonUSA |
| ConSHI_CHN | 10   | 4      | 8      | 22           | CHN     | 46           | HB        | nonUSA |
| ShoKAW_JPN | 7    | 2      | 5      | 14           | JPN     | 30           | HB        | nonUSA |
| BroMAL_USA | 5    | 4      | 7      | 16           | USA     | 30           | HB        | USA    |
| WeiSUN_CHN | 5    | 7      | 3      | 15           | CHN     | 32           | HB        | nonUSA |
| YuyKAM_JPN | 5    | 2      | 3      | 10           | JPN     | 22           | HB        | nonUSA |
| JinZOU_CHN | 28   | 20     | 11     | 59           | CHN     | 135          | PB        | nonUSA |
| BohZHA_CHN | 10   | 8      | 9      | 27           | CHN     | 55           | PB        | nonUSA |
| LukDAU_GER | 8    | 11     | 8      | 27           | GER     | 54           | PB        | nonUSA |
| CarYUL_PHI | 7    | 6      | 7      | 20           | PHI     | 40           | PB        | nonUSA |
| KaiSUG_JPN | 7    | 0      | 5      | 12           | JPN     | 26           | PB        | nonUSA |
| Mc_CLE_IRL | 14   | 5      | 9      | 28           | IRL     | 61           | PH        | nonUSA |
| MaxWHI_GBR | 13   | 13     | 4      | 30           | GBR     | 69           | PH        | nonUSA |
| ChiLEE_TPE | 7    | 10     | 10     | 27           | TPE     | 51           | PH        | nonUSA |
| RhyMCC_IRL | 5    | 6      | 8      | 19           | IRL     | 35           | PH        | nonUSA |
| NarKUR_KAZ | 5    | 8      | 5      | 18           | KAZ     | 36           | PH        | nonUSA |
| AhmSOU_JOR | 5    | 5      | 2      | 12           | JOR     | 27           | PH        | nonUSA |
| SteNED_USA | 5    | 1      | 4      | 10           | USA     | 21           | PH        | USA    |
| YanLIU_CHN | 13   | 10     | 5      | 28           | CHN     | 64           | SR        | nonUSA |
| JinZOU_CHN | 10   | 7      | 6      | 23           | CHN     | 50           | SR        | nonUSA |
| XinLAN_CHN | 8    | 7      | 8      | 23           | CHN     | 46           | SR        | nonUSA |
| ElePET_GRE | 8    | 9      | 4      | 21           | GRE     | 46           | SR        | nonUSA |
| AdeASI_TUR | 5    | 8      | 5      | 18           | TUR     | 36           | SR        | nonUSA |
| SalMAR_ITA | 5    | 4      | 5      | 14           | ITA     | 28           | SR        | nonUSA |
| DonWHI_USA | 5    | 5      | 3      | 13           | USA     | 28           | SR        | USA    |
| HaoYOU_CHN | 5    | 1      | 6      | 12           | CHN     | 23           | SR        | nonUSA |
| JakJAR_GBR | 18   | 14     | 11     | 43           | GBR     | 93           | VT        | nonUSA |
| AshHON_USA | 16   | 10     | 10     | 36           | USA     | 78           | VT        | USA    |
| BohZHA_CHN | 12   | 8      | 10     | 30           | CHN     | 62           | VT        | nonUSA |
| DaiHAS_JPN | 11   | 15     | 10     | 36           | JPN     | 73           | VT        | nonUSA |
| KhoYOU_USA | 9    | 4      | 5      | 18           | USA     | 40           | VT        | USA    |

| unique_id  | Golds | Silvers | Bronzes | Total_Medals | Country | Medal_Weight | Apparatus | USA    |
|------------|-------|---------|---------|--------------|---------|--------------|-----------|--------|
| CarYUL_PHI | 10    | 10      | 10      | 30           | PHI     | 60           | FX        | nonUSA |
| RyoDOI_JPN | 11    | 7       | 4       | 22           | JPN     | 51           | FX        | nonUSA |
| ArtDOL_ISR | 7     | 9       | 3       | 19           | ISR     | 42           | FX        | nonUSA |
| BohZHA_CHN | 5     | 5       | 6       | 16           | CHN     | 31           | FX        | nonUSA |
| DaiHAS_JPN | 3     | 5       | 5       | 13           | JPN     | 24           | FX        | nonUSA |
| NicBAR_ITA | 6     | 3       | 4       | 13           | ITA     | 28           | FX        | nonUSA |
| DaiHAS_JPN | 10    | 8       | 11      | 29           | JPN     | 57           | HB        | nonUSA |
| BohZHA_CHN | 11    | 14      | 1       | 26           | CHN     | 62           | HB        | nonUSA |
| ConSHI_CHN | 10    | 4       | 8       | 22           | CHN     | 46           | HB        | nonUSA |
| BroMAL_USA | 5     | 4       | 7       | 16           | USA     | 30           | HB        | USA    |
| WeiSUN_CHN | 5     | 7       | 3       | 15           | CHN     | 32           | HB        | nonUSA |
| JinZOU_CHN | 28    | 20      | 11      | 59           | CHN     | 135          | PB        | nonUSA |
| BohZHA_CHN | 10    | 8       | 9       | 27           | CHN     | 55           | PB        | nonUSA |
| LukDAU_GER | 8     | 11      | 8       | 27           | GER     | 54           | PB        | nonUSA |
| CarYUL_PHI | 7     | 6       | 7       | 20           | PHI     | 40           | PB        | nonUSA |
| IllKOV_UKR | 5     | 7       | 5       | 17           | UKR     | 34           | PB        | nonUSA |
| MaxWHI_GBR | 13    | 13      | 4       | 30           | GBR     | 69           | PH        | nonUSA |
| Mc_CLE_IRL | 14    | 5       | 9       | 28           | IRL     | 61           | PH        | nonUSA |
| ChiLEE_TPE | 7     | 10      | 10      | 27           | TPE     | 51           | PH        | nonUSA |
| RhyMCC_IRL | 5     | 6       | 8       | 19           | IRL     | 35           | PH        | nonUSA |
| AhmABU_JOR | 3     | 4       | 12      | 19           | JOR     | 29           | PH        | nonUSA |
| YanLIU_CHN | 13    | 10      | 5       | 28           | CHN     | 64           | SR        | nonUSA |
| XinLAN_CHN | 8     | 7       | 8       | 23           | CHN     | 46           | SR        | nonUSA |
| JinZOU_CHN | 10    | 7       | 6       | 23           | CHN     | 50           | SR        | nonUSA |
| ElePET_GRE | 8     | 9       | 4       | 21           | GRE     | 46           | SR        | nonUSA |
| AdeASI_TUR | 5     | 8       | 5       | 18           | TUR     | 36           | SR        | nonUSA |
| JakJAR_GBR | 18    | 14      | 11      | 43           | GBR     | 93           | VT        | nonUSA |
| AshHON_USA | 16    | 10      | 10      | 36           | USA     | 78           | VT        | USA    |
| DaiHAS_JPN | 11    | 15      | 10      | 36           | JPN     | 73           | VT        | nonUSA |
| BohZHA_CHN | 12    | 8       | 10      | 30           | CHN     | 62           | VT        | nonUSA |
| DalHAL_USA | 6     | 11      | 11      | 28           | USA     | 51           | VT        | USA    |

| unique_id  | Golds | Silvers | Bronzes | Total_Medals | Country | Medal_Weight | Apparatus | USA    |
|------------|-------|---------|---------|--------------|---------|--------------|-----------|--------|
| CarYUL_PHI | 10    | 10      | 10      | 30           | PHI     | 60           | FX        | nonUSA |
| RyoDOI_JPN | 11    | 7       | 4       | 22           | JPN     | 51           | FX        | nonUSA |
| ArtDOL_ISR | 7     | 9       | 3       | 19           | ISR     | 42           | FX        | nonUSA |
| BohZHA_CHN | 5     | 5       | 6       | 16           | CHN     | 31           | FX        | nonUSA |
| NicBAR_ITA | 6     | 3       | 4       | 13           | ITA     | 28           | FX        | nonUSA |
| BohZHA_CHN | 11    | 14      | 1       | 26           | CHN     | 62           | HB        | nonUSA |
| DaiHAS_JPN | 10    | 8       | 11      | 29           | JPN     | 57           | HB        | nonUSA |
| ConSHI_CHN | 10    | 4       | 8       | 22           | CHN     | 46           | HB        | nonUSA |
| WeiSUN_CHN | 5     | 7       | 3       | 15           | CHN     | 32           | HB        | nonUSA |
| BroMAL_USA | 5     | 4       | 7       | 16           | USA     | 30           | HB        | USA    |
| ShoKAW_JPN | 7     | 2       | 5       | 14           | JPN     | 30           | HB        | nonUSA |
| JinZOU_CHN | 28    | 20      | 11      | 59           | CHN     | 135          | PB        | nonUSA |
| BohZHA_CHN | 10    | 8       | 9       | 27           | CHN     | 55           | PB        | nonUSA |
| LukDAU_GER | 8     | 11      | 8       | 27           | GER     | 54           | PB        | nonUSA |
| CarYUL_PHI | 7     | 6       | 7       | 20           | PHI     | 40           | PB        | nonUSA |
| IllKOV_UKR | 5     | 7       | 5       | 17           | UKR     | 34           | PB        | nonUSA |
| MaxWHI_GBR | 13    | 13      | 4       | 30           | GBR     | 69           | PH        | nonUSA |
| Mc CLE_IRL | 14    | 5       | 9       | 28           | IRL     | 61           | PH        | nonUSA |
| ChiLEE_TPE | 7     | 10      | 10      | 27           | TPE     | 51           | PH        | nonUSA |
| NarKUR_KAZ | 5     | 8       | 5       | 18           | KAZ     | 36           | PH        | nonUSA |
| RhyMCC_IRL | 5     | 6       | 8       | 19           | IRL     | 35           | PH        | nonUSA |
| YanLIU_CHN | 13    | 10      | 5       | 28           | CHN     | 64           | SR        | nonUSA |
| JinZOU_CHN | 10    | 7       | 6       | 23           | CHN     | 50           | SR        | nonUSA |
| XinLAN_CHN | 8     | 7       | 8       | 23           | CHN     | 46           | SR        | nonUSA |
| ElePET_GRE | 8     | 9       | 4       | 21           | GRE     | 46           | SR        | nonUSA |
| AdeASI_TUR | 5     | 8       | 5       | 18           | TUR     | 36           | SR        | nonUSA |
| JakJAR_GBR | 18    | 14      | 11      | 43           | GBR     | 93           | VT        | nonUSA |
| AshHON_USA | 16    | 10      | 10      | 36           | USA     | 78           | VT        | USA    |
| DaiHAS_JPN | 11    | 15      | 10      | 36           | JPN     | 73           | VT        | nonUSA |
| BohZHA_CHN | 12    | 8       | 10      | 30           | CHN     | 62           | VT        | nonUSA |
| DalHAL_USA | 6     | 11      | 11      | 28           | USA     | 51           | VT        | USA    |

| USA    | sumGolds | sumTot | sumWeighted |
|--------|----------|--------|-------------|
| nonUSA | 470      | 1374   | 2762        |
| USA    | 130      | 426    | 838         |

For the men's simulation when looking at the top 5 athletes by:

- *Gold Medal Count* for each apparatus there are 5 out of 30 from the US: floor exercise (FX): 1, high bar (HB): 1, parallel bars (PB): 1 pommel horse (PH): 0, still rings (SR): 0, vault (VT): 2
  - USA makes up 21% of the total men's gold medals in the simulation.
- *Total Medal Count* for each apparatus there are 4 out of 30 from the US: floor exercise (FX): 1, high bar (HB): 1, parallel bars (PB): 0, pommel horse (PH): 0, still rings (SR): 0, vault (VT): 2
  - USA makes up 24% of the total men's medals in the simulation.
- *Weighted Medal Count* for each apparatus there are 4 out of 30 from the US: floor exercise (FX): 1, high bar (HB): 1, parallel bars (PB): 0, pommel horse (PH): 0, still rings (SR): 0, vault (VT): 2
  - USA makes up 23% of the weight of men's medals in the simulation.

Image 9)

```
# A tibble: 51 x 5
# Groups:   Apparatus [4]
  unique_id  Golds Country Apparatus USA
  <chr>      <dbl> <fct>   <chr>   <fct>
1 SimBIL_USA    26 USA      BB      USA
2 KonMCC_USA    16 USA      BB      USA
3 YaqZHO_CHN    10 CHN      BB    nonUSA
4 QinZHA_CHN    10 CHN      BB    nonUSA
5 YusOU__CHN     5 CHN      BB    nonUSA
6 SunLEE_USA     5 USA      BB      USA
7 ShiJON_USA     4 USA      BB      USA
8 TiaSUM_USA     3 USA      BB      USA
9 QiyQIU_CHN     3 CHN      BB    nonUSA
10 LeaWON_USA     2 USA      BB      USA
# i 41 more rows
```

Image 10)

10) Women's Unique ID by Number of Gold Medals  
by Apparatus

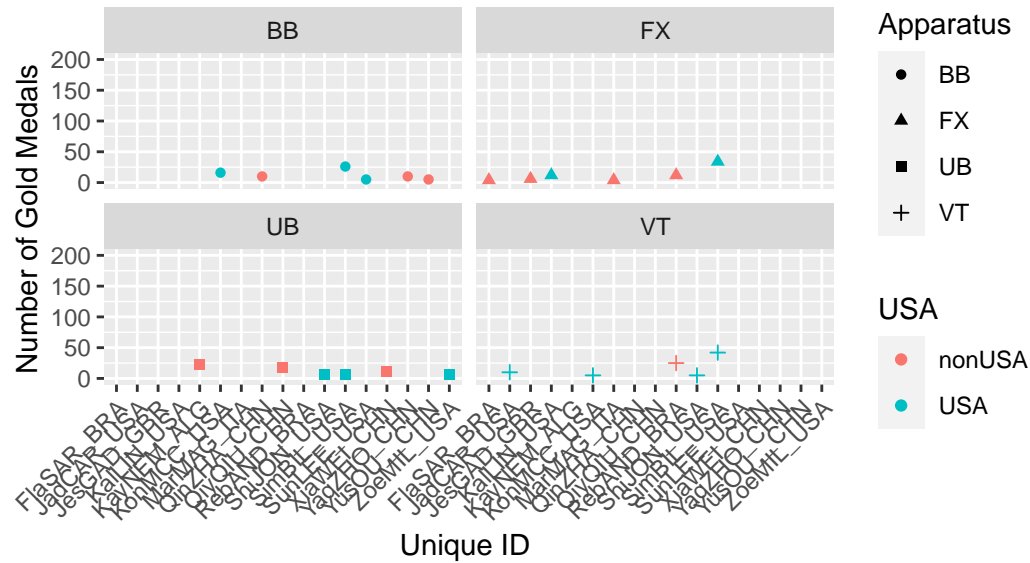
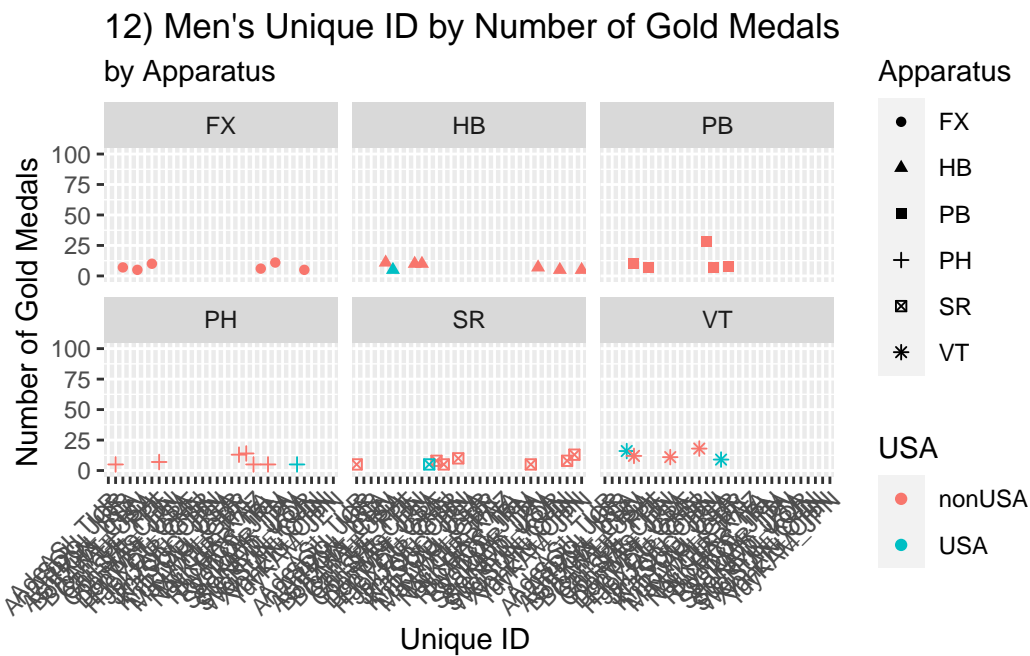


Image 11)

```
# A tibble: 79 x 5
# Groups:   Apparatus [6]
  unique_id  Golds Country Apparatus USA
  <chr>      <dbl> <fct>   <chr>   <fct>
1 RyoDOI_JPN    11 JPN      FX    nonUSA
2 CarYUL_PHI    10 PHI      FX    nonUSA
3 ArtDOL_ISR     7 ISR      FX    nonUSA
4 NicBAR_ITA     6 ITA      FX    nonUSA
5 BohZHA_CHN     5 CHN      FX    nonUSA
6 SunRYU_KOR     5 KOR      FX    nonUSA
```

```
7 HarHEP_GBR      4 GBR      FX      nonUSA
8 DaiHAS_JPN      3 JPN      FX      nonUSA
9 PauJUD_USA      3 USA      FX      USA
10 YulMOL_USA      3 USA      FX      USA
# i 69 more rows
```

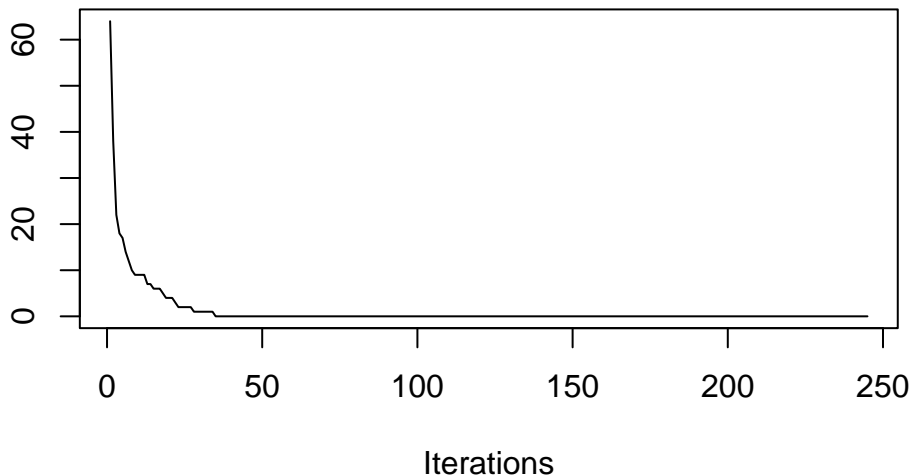
Image 12)



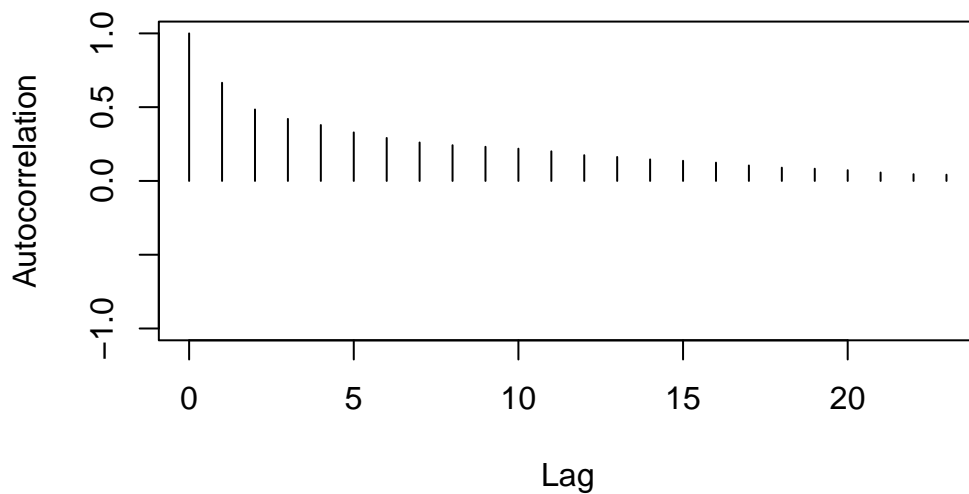
**Note:** The excessive unique ids display that there is not much overlap in the top 5 most gold medal decorated athletes on the men's team and therefore the lack of well-rounded gymnasts.

Diagnostics

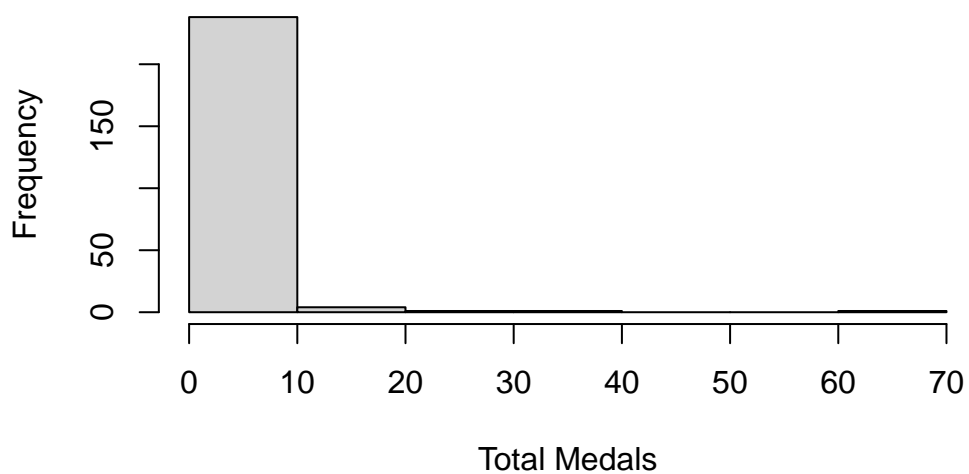
Trace Plot of Total Medals



var1  
32.15503



### Histogram of Total Medals



Iterations = 1:980  
Thinning interval = 1  
Number of chains = 1  
Sample size per chain = 980

1. Empirical mean and standard deviation for each variable,  
plus standard error of the mean:

| Mean   | SD     | Naive SE | Time-series SE |
|--------|--------|----------|----------------|
| 1.2245 | 5.6408 | 0.1802   | 0.5361         |

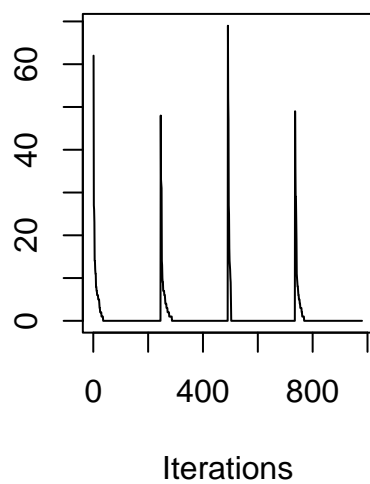
2. Quantiles for each variable:

| 2.5% | 25% | 50% | 75% | 97.5% |
|------|-----|-----|-----|-------|
| 0    | 0   | 0   | 0   | 13    |

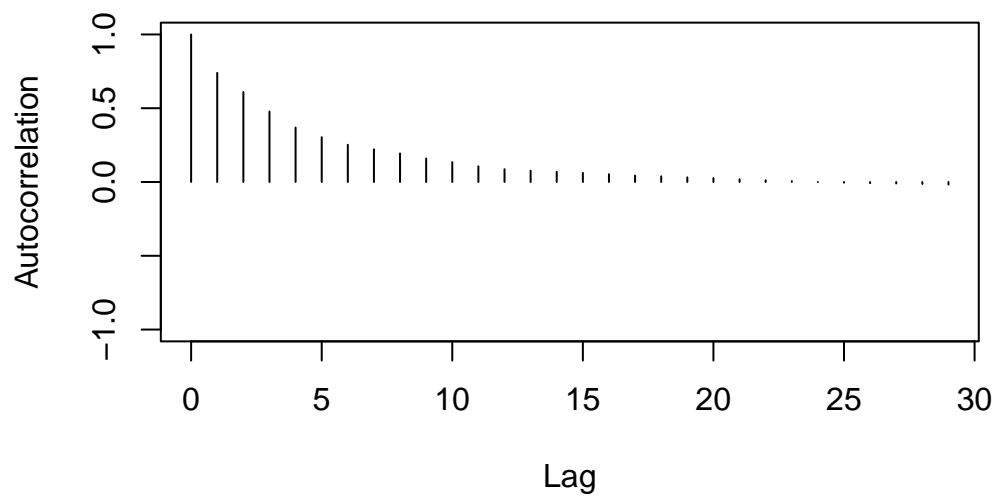
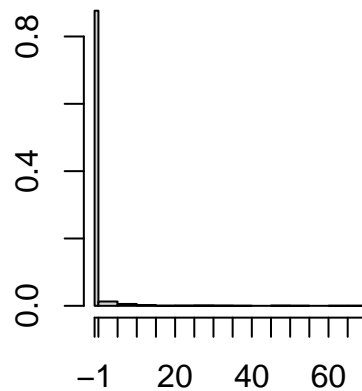
```
var1  
0.06230848
```

```
var1  
110.6978
```

**Trace of var1**



**Density of var1**



```

Iterations = 1:1470
Thinning interval = 1
Number of chains = 1
Sample size per chain = 1470

```

1. Empirical mean and standard deviation for each variable,  
plus standard error of the mean:

| Mean   | SD     | Naive SE | Time-series SE |
|--------|--------|----------|----------------|
| 1.2245 | 4.4256 | 0.1154   | 0.4285         |

2. Quantiles for each variable:

| 2.5% | 25%  | 50%  | 75%  | 97.5% |
|------|------|------|------|-------|
| 0.00 | 0.00 | 0.00 | 0.00 | 14.27 |

```

var1
0.06330837

```

```

var1
106.6612

```

