US Gymnastics Analysis

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Introduction

Context and Background

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)

These are our main 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 Nederoscik, 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.

The Data

The UConn Sports Analytics Symposium provisioned a clean data set 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. These competitions took place in the 2022 and 2023 gymnastics seasons. The UConn Sports Analytics Symposium also provides a clean data set of the results of all the women's artistic gymnastics teams that participated in the 2020 Tokyo Summer Olympics qualifying and final events. Both datasets are at the individual athlete, competition, apparatus, and round level. The data of the recorded results for each competition for both men and women gymnasts were collected and manually input from the official corresponding competitions' website results after the judging of each competition.

The columns for both datasets include LastName, Firstname, Gender, Country, Data, Competition, Round ("TeamQual": team all-around qualifiers, "TeamFinal": team all-around finals, "AAqual": individual all-around qualifiers, "AAfinal": individual all-around finals, "qual": individual apparatus qualifiers, "final": individual apparatus finals), Location, 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), Rank, D_Score (difficulty score), E_Score (execution score), Penalty (score deduction for breaking event criteria), and Score (D_Score + E_Score - Penalty).

We decided to not proceed in using the data set of results from the 2020 Tokyo Summer Olympics since the data consisted only of female athletes and one competition (the Olympic Games). Also 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).

EDA ...

Methodology

Simulations

Female Athletes' Results

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14.0574616  0.5891628  0.6657795 79.5576545
```

Table 1: Women's Floor Exercise Simulation Results

Athlete	Golds	Silvers	Bronzes	Total Medals
SimBIL_USA	211	99	47	357
RebAND_BRA	56	64	49	169
KalLIN_USA	31	33	32	96
JesGAD_GBR	26	27	42	95
FlaSAR_BRA	25	28	28	81
JorCHI_USA	22	27	27	76
JadCAR_USA	24	20	26	70
ShiJON_USA	14	28	19	61
JosROB_USA	16	24	18	58
MarMAG_ITA	13	21	13	47

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```

Table 2: Women's Balance Beam Simulation Results

Athlete	Golds	Silvers	Bronzes	Total Medals
SimBIL_USA	24	11	10	45
YaqZHO_CHN	17	14	12	43
KonMCC_USA	13	9	11	33
YusOU___CHN	7	7	5	19
QinZHA_CHN	7	9	3	19
HuaLUO_CHN	2	3	5	10
LeaWON_USA	4	5	1	10
SunLEE_USA	2	2	6	10
SanWEV_NED	1	4	4	9
SkyBLA_USA	2	4	3	9

```
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```

Table 3: Women's Vault Simulation Results

Athlete	Golds	Silvers	Bronzes	Total Medals
SimBIL_USA	32	20	14	66
RebAND_BRA	18	16	16	50
JadCAR_USA	13	9	8	30
ShiJON_USA	11	6	10	27
SkyBLA_USA	3	8	9	20
OndACH_GBR	4	7	9	20
KonMCC_USA	2	10	7	19
ShoMIY_JPN	4	9	5	18
JorCHI_USA	4	4	10	18
JosROB_USA	5	6	5	16

```
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```

Table 4: Women's Uneven Bars Simulation Results

Athlete	Golds	Silvers	Bronzes	Total Medals
KayNEM_ALG	16	14	7	37
ShiJON_USA	10	8	9	27
QiyQIU_CHN	13	6	6	25
ZoeMIL_USA	6	8	8	22
RebAND_BRA	5	8	7	20
XijTAN_CHN	9	3	7	19
XiaWEI_CHN	4	8	3	15
AliD A_ITA	5	4	5	14
EliSEI_GER	2	7	4	13
YunLEE_KOR	4	3	4	11

Male Athletes' Results

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14.0574616  0.5891628  0.6657795 79.5576545
```

Table 5: Men's Floor Exercise Simulation Results

Athlete	Golds	Silvers	Bronzes	Total Medals
CarYUL_PHI	12	11	4	27
ArtDOL_ISR	11	6	4	21
DaiHAS_JPN	4	5	8	17
RyoDOI_JPN	6	4	3	13
PauJUD_USA	3	6	3	12
ConMCC_USA	3	1	6	10
FreRIC_USA	2	4	4	10
NicBAR_ITA	6	3	0	9
ChiTAN_TPE	2	3	4	9
GiaREG_GBR	5	2	2	9

```
       m_0      sig_0        k_0        v_0
14.0574616  0.5891628  0.6657795 79.5576545
```

Table 6: Men's Vault Simulation Results

Athlete	Golds	Silvers	Bronzes	Total Medals
JakJAR_GBR	19	15	8	42
AshHON_USA	17	7	8	32
DaiHAS_JPN	8	12	10	30
KhoYOU_USA	7	11	11	29
BohZHA_CHN	10	11	7	28
DonWHI_USA	9	11	5	25
CurPHI_USA	5	7	9	21
TayBUR_USA	4	5	10	19
DalHAL_USA	5	6	7	18
KamNEL_USA	2	6	8	16

```
       m_0      sig_0        k_0        v_0
14.0574616  0.5891628  0.6657795 79.5576545
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Table 7: Men's Pommel Horse Simulation Results

Athlete	Golds	Silvers	Bronzes	Total Medals
MaxWHI_GBR	13	11	12	36
ChiLEE_TPE	15	9	5	29
RhyMCC_IRL	8	8	7	23
NarKUR_KAZ	12	5	4	21
AhmSOU_JOR	4	8	8	20
Mc CLE_IRL	8	8	4	20
AhmABU_JOR	5	1	6	12
LorDE _NED	3	2	6	11
SteNED_USA	5	2	4	11
RhyMC _IRL	2	3	5	10

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       m_0      sig_0        k_0        v_0
14.0574616  0.5891628  0.6657795 79.5576545
```

Table 8: Men's High Bar Simulation Results

Athlete	Golds	Silvers	Bronzes	Total Medals
DaiHAS_JPN	9	9	9	27
BohZHA_CHN	12	6	7	25
WeiSUN_CHN	8	5	6	19
ConSHI_CHN	9	3	3	15
YuyKAM_JPN	5	7	2	14
BroMAL_USA	4	4	4	12
ArtMAR_BRA	4	5	3	12
WeiSU___CHN	1	4	7	12
JoeFRA_GBR	3	5	3	11
ShoKAW_JPN	4	3	3	10

```
       m_0       sig_0         k_0         v_0
14.0574616  0.5891628  0.6657795 79.5576545
```

Table 9: Men's Still Rings Simulation Results

Athlete	Golds	Silvers	Bronzes	Total Medals
XinLAN_CHN	15	10	11	36
YanLIU_CHN	14	12	6	32
ElePET_GRE	15	8	6	29
JinZOU_CHN	5	7	9	21
HaoYOU_CHN	6	6	0	12
BohZHA_CHN	2	6	4	12
AdeASI_TUR	5	5	2	12
NikSIM_AZE	1	3	8	12
IbrCOL_TUR	4	2	4	10
SalMAR_ITA	4	4	2	10

```
       m_0       sig_0         k_0         v_0
14.0574616  0.5891628  0.6657795 79.5576545
```

Table 10: Men's Parallel Bars Simulation Results

Athlete	Golds	Silvers	Bronzes	Total Medals
JinZOU_CHN	32	17	11	60
LukDAU_GER	12	7	5	24
BohZHA_CHN	4	6	8	18
JoeFRA_GBR	4	6	6	16
IllKOV_UKR	3	4	9	16
CurPHI_USA	4	4	7	15
BlaSUN_USA	4	7	3	14
ColWAL_USA	6	2	5	13
CarYUL_PHI	2	7	2	11
ConSHI_CHN	4	2	3	9

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

From the 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 58% of the total women's gold medals in the simulation which is a higher proportion than the 49% of the total medal count

and 52% of the weighted medals (Appendix: Image 7). From the 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 25% of the total medal count in the simulation which is a higher proportion than the 23% of the total gold medal count and 24% 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 tends to be 0-3 (mostly 0) male athletes present (Appendix: Image 8).

Considering that female USA athletes 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. 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 number of gold medals. In this case valuing the team 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 balance beam as first, in floor exercise as first, in uneven bars tied at eighth highest, and vault as first. Valuing individual all-around higher also may help team USA increase in our metric of success. Also, 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, China, and Great Britain make multiple appearances. The only countries that have an athlete in each apparatus for the top 10, are the USA and Great Britain (Appendix: Image 11). Since Great Britain has 1-2 (mostly 1) highly decorated gold medalist in the top 10 rankings for each apparatus and the US tends to have more, it could be slightly beneficial to the men's team to value the team 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 athlete's 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, the US athletes are only present in vault and parallel bars (Appendix: Image 12). Valuing individual apparatus events as a regular event of weight 1 would best suite both the male and female team's success against their competitors. Weighing the team-all around as 3 points is viable because not only do both the men and women's USA have the potential to win based on this simulation, but there is less of a 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 hopefully 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 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 that 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 own 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 atheletes are also a combination of both all-around gymnasts and specialists. In the simulatiom, since 4 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.

Discussion

Appendix

Work Cited

- "Paris 2024 Olympic Games: How Do Athletes Qualify?" Olympics, 8 Aug. 2021, olympics.com/en/news/paris-2024-olympic-games-how-do-athletes-qualify. Accessed 20 Nov. 2023.
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- "UCSAS 2024 USOPC DATA CHALLENGE." UConn Sports Analytics Symposium (UCSAS), statds.org/events/ucsas2024/challenge.html. Accessed 20 Nov. 2023.
- Camenker, Jacob. "How Old Is Simone Biles? Why Elite Olympic Gymnasts Typically Retire at a Young Age." Sporting News, 18 Sept. 2021, www.sportingnews.com/us/athletics/news/simone-biles-retire-age-olympics/1laom4i4u4wh1thcgta4nun2x. Accessed 20 Nov. 2023.
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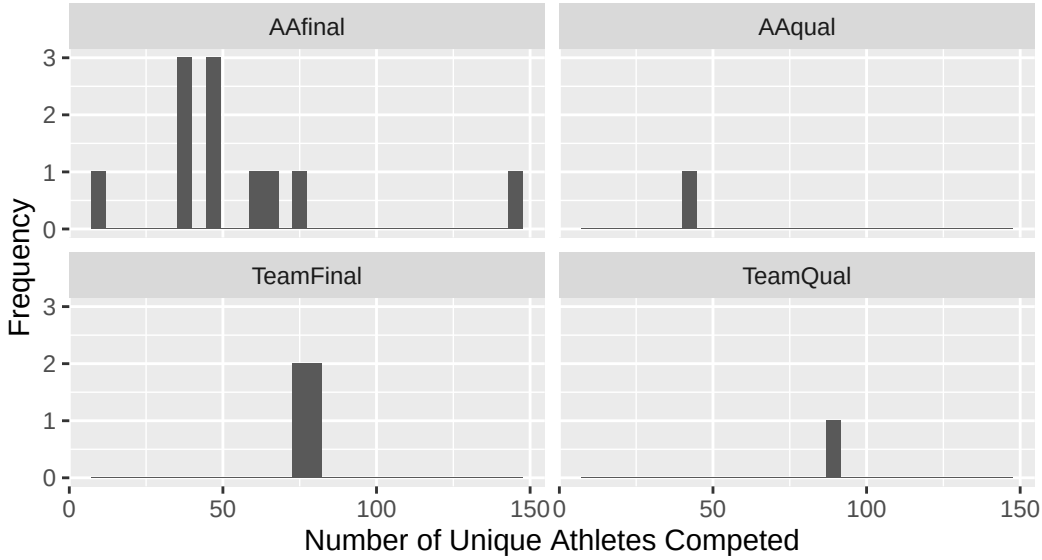
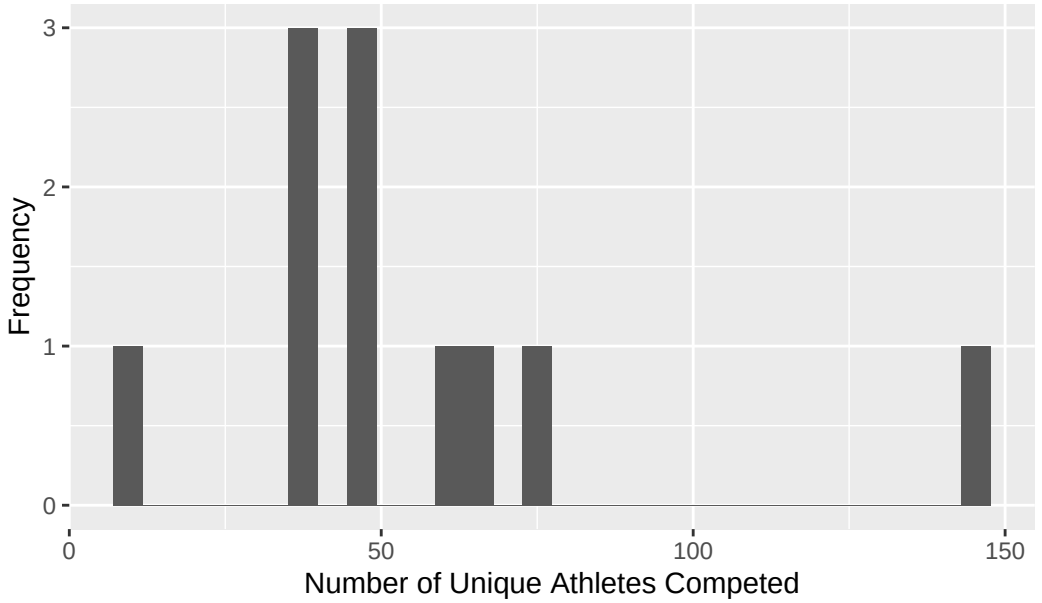
Visualizations

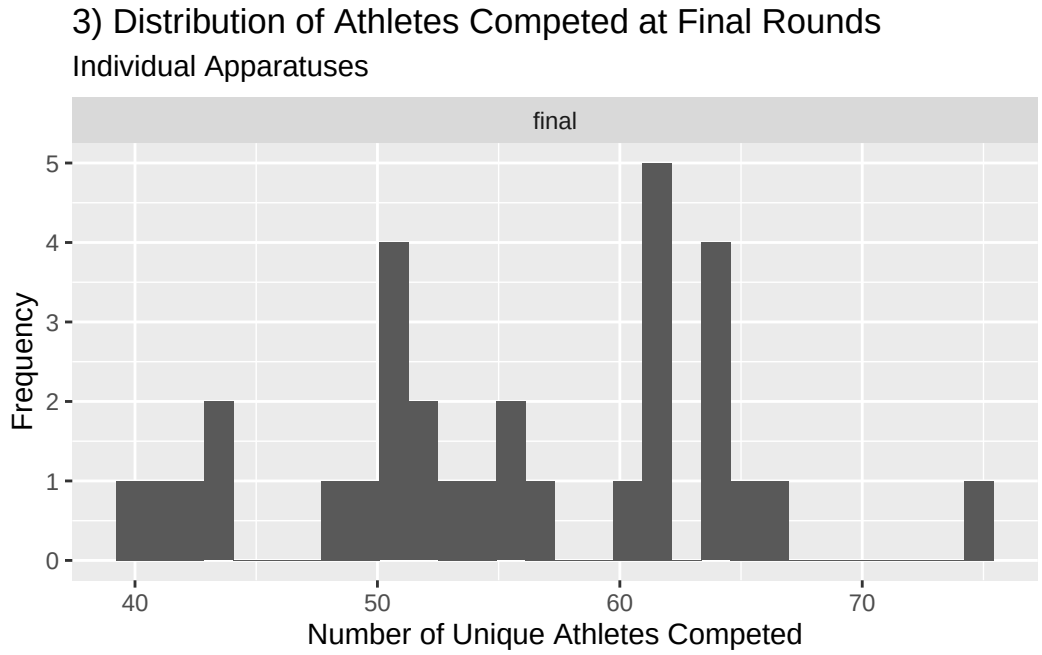
1) Distribution of Athletes Competed at Competition Rounds

All Around or Team All Arounds



2) Distribution of Athletes Competed at AA Finals




3) Distribution of Athletes Competed at Final Rounds
Individual Apparatuses
final
Frequency
0
1
2
3
4
5
40
50
60
70
Number of Unique Athletes Competed

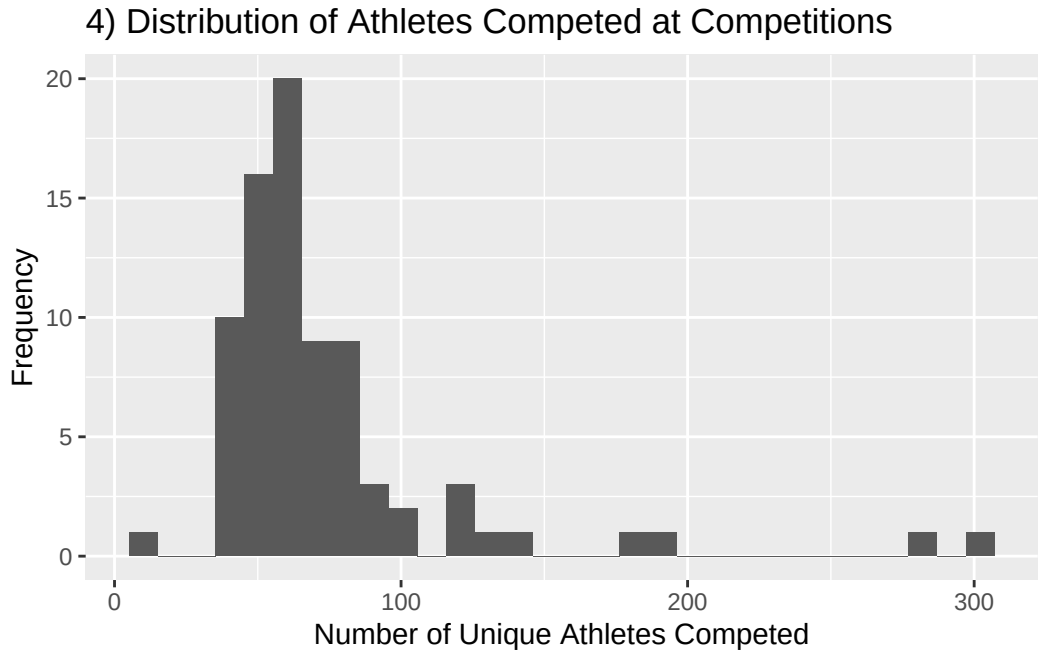
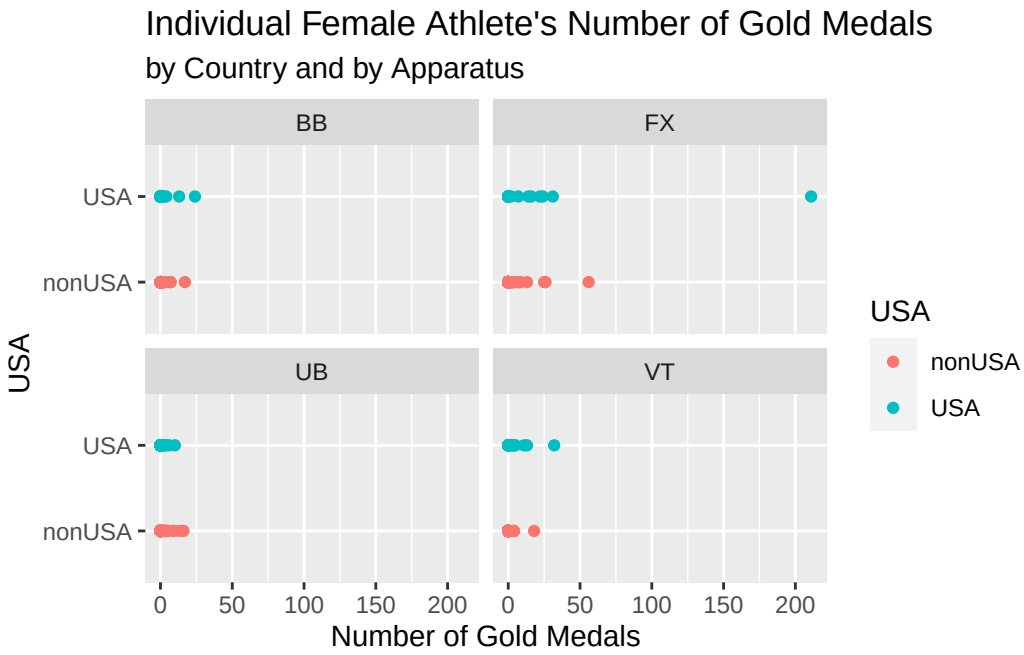

4) Distribution of Athletes Competed at Competitions
Frequency
0
5
10
15
20
0
100
200
300
Number of Unique Athletes Competed

Image 5)


Individual Female Athlete's Number of Gold Medals
by Country and by Apparatus
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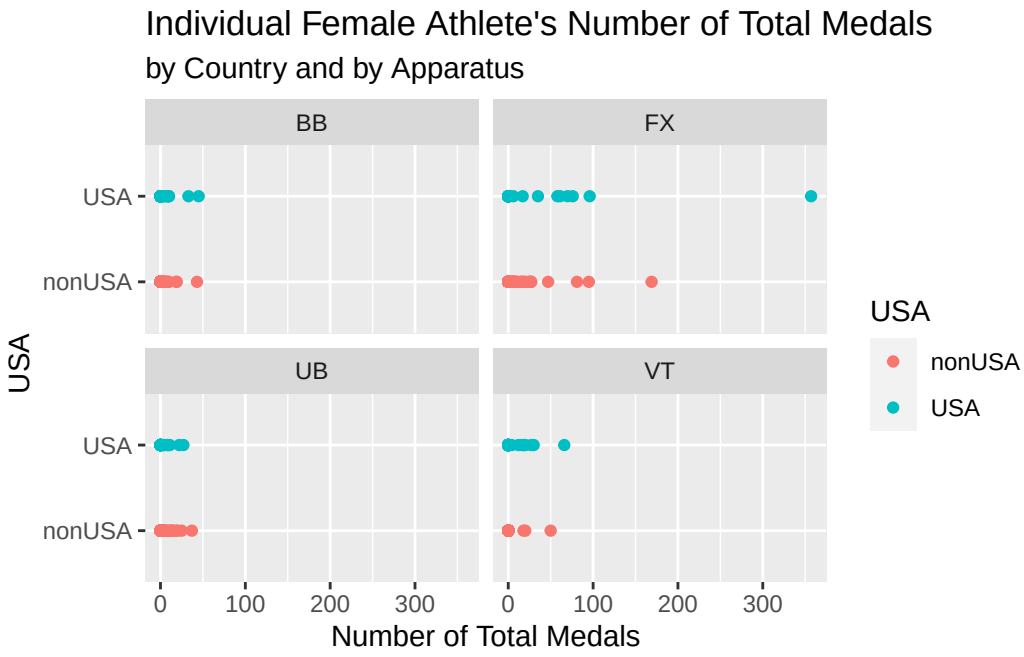
FX
UB
VT
USA
nonUSA
USA
0
50
100
150
200
Number of Gold Medals
USA
nonUSA
USA


Individual Female Athlete's Number of Total Medals
by Country and by Apparatus
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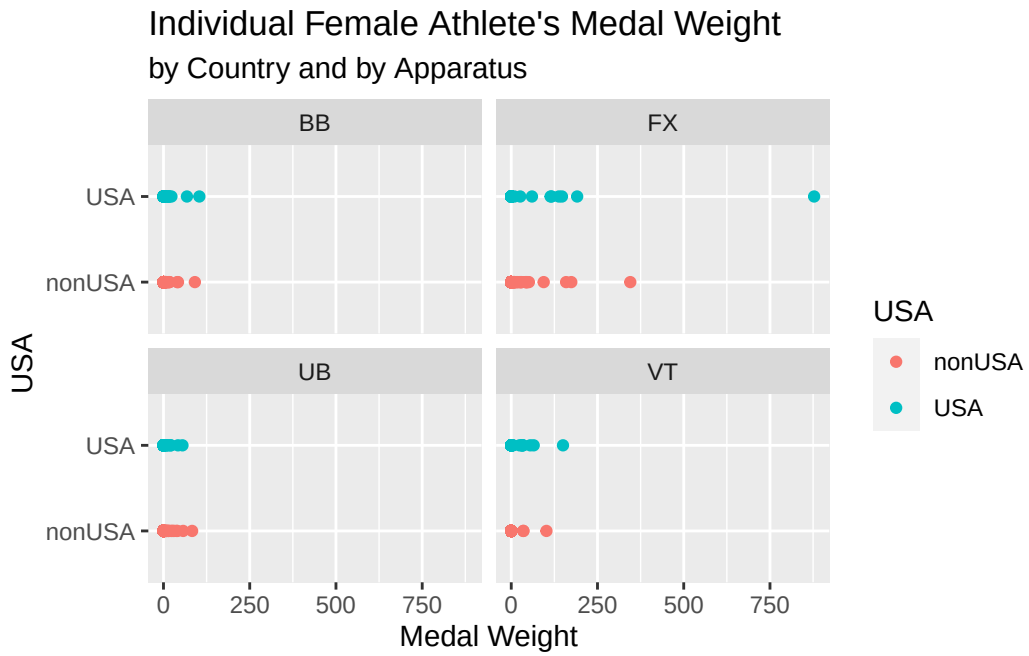
FX
UB
VT
USA
nonUSA
USA
0
100
200
300
Number of Total Medals
USA
nonUSA
USA


Individual Female Athlete's Medal Weight
by Country and by Apparatus
BB
FX
UB
VT
USA
nonUSA
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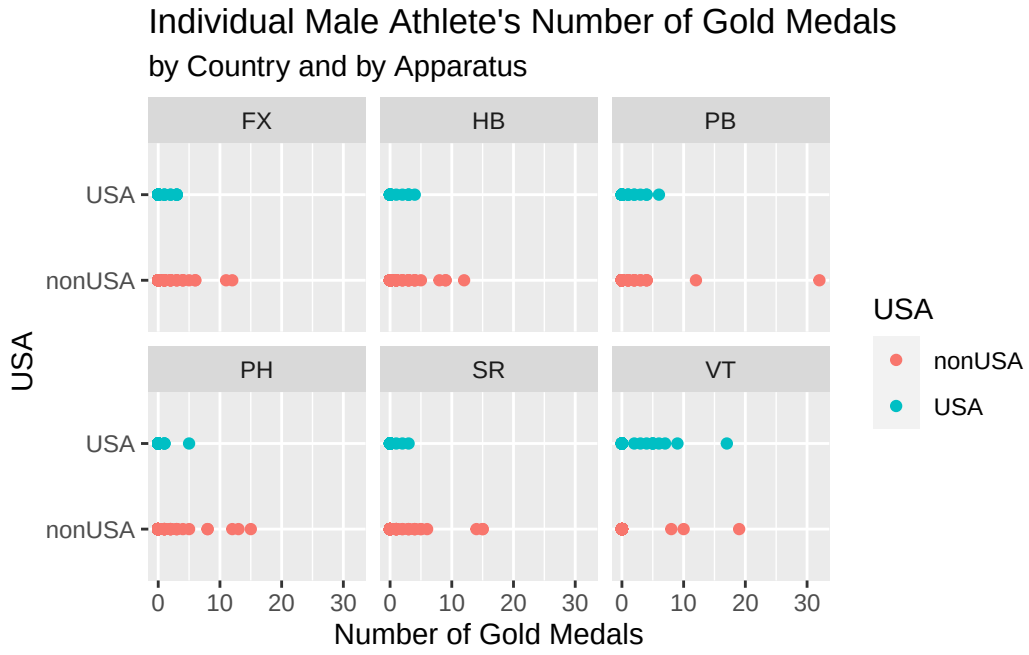
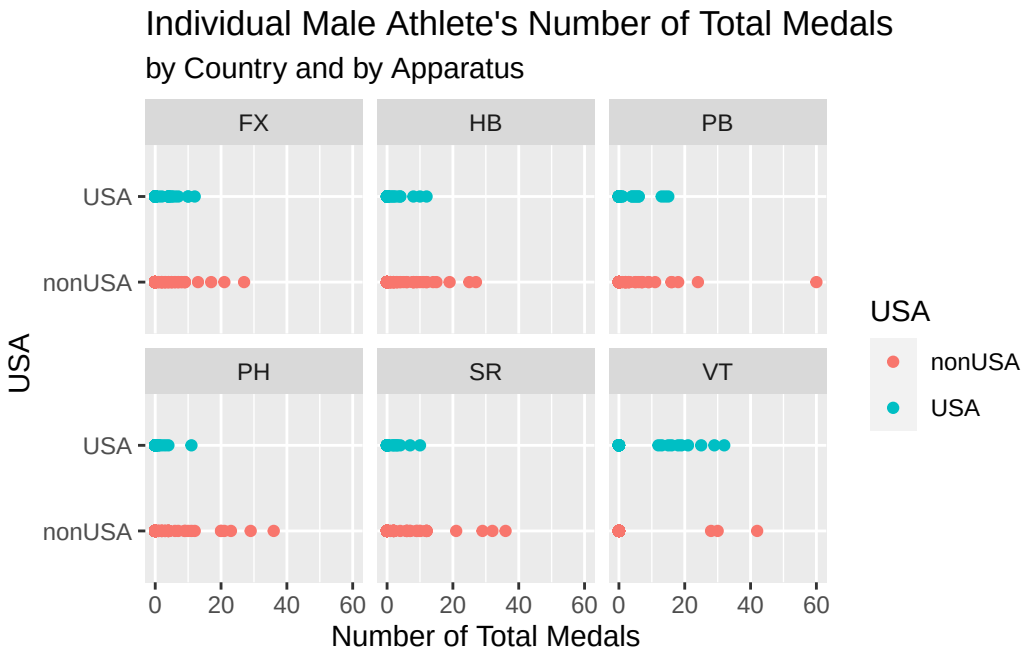
250
500
750
Medal Weight
USA
nonUSA
USA

Image 6)


Individual Male Athlete's Number of Gold Medals
by Country and by Apparatus
FX
HB
PB
PH
SR
VT
USA
nonUSA
0
10
20
30
Number of Gold Medals
USA
nonUSA
USA


Individual Male Athlete's Number of Total Medals
by Country and by Apparatus
FX
HB
PB
PH
SR
VT
USA
nonUSA
0
20
40
60
Number of Total Medals
USA
nonUSA

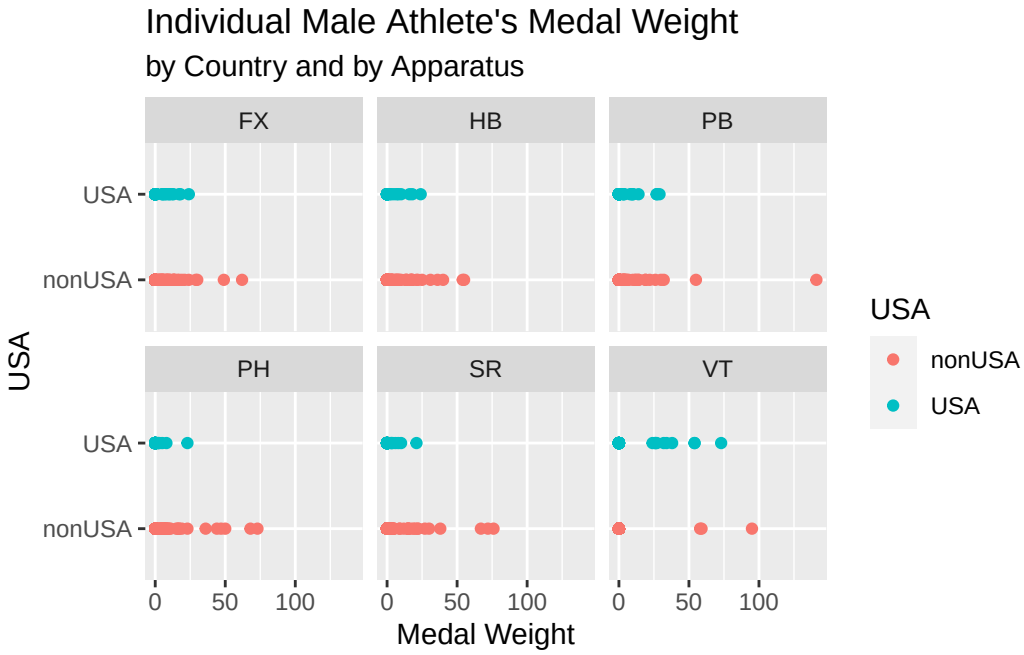

Individual Male Athlete's Medal Weight
by Country and by Apparatus
FX
HB
PB
PH
SR
VT
USA
nonUSA
0
50
100
Medal Weight
USA
nonUSA

Image 7)

unique_id	Golds	Silvers	Bronzes	Total_Medals	Country	Medal_Weight	Apparatus	USA
SimBIL_USA	24	11	10	45	USA	104	BB	USA
YaqZHO_CHN	17	14	12	43	CHN	91	BB	nonUSA
KonMCC_USA	13	9	11	33	USA	68	BB	USA
YusOU___CHN	7	7	5	19	CHN	40	BB	nonUSA
QinZHA_CHN	7	9	3	19	CHN	42	BB	nonUSA
SimBIL_USA	211	99	47	357	USA	878	FX	USA
RebAND_BRA	56	64	49	169	BRA	345	FX	nonUSA
KalLIN_USA	31	33	32	96	USA	191	FX	USA
JesGAD_GBR	26	27	42	95	GBR	174	FX	nonUSA
FlaSAR_BRA	25	28	28	81	BRA	159	FX	nonUSA
KayNEM_ALG	16	14	7	37	ALG	83	UB	nonUSA
QiyQIU_CHN	13	6	6	25	CHN	57	UB	nonUSA
ShiJON_USA	10	8	9	27	USA	55	UB	USA
XijTAN_CHN	9	3	7	19	CHN	40	UB	nonUSA
ZoeMIL_USA	6	8	8	22	USA	42	UB	USA
SimBIL_USA	32	20	14	66	USA	150	VT	USA
RebAND_BRA	18	16	16	50	BRA	102	VT	nonUSA
JadCAR_USA	13	9	8	30	USA	65	VT	USA
ShiJON_USA	11	6	10	27	USA	55	VT	USA
JosROB_USA	5	6	5	16	USA	32	VT	USA

unique_id	Golds	Silvers	Bronzes	Total_Medals	Country	Medal_Weight	Apparatus	USA
SimBIL_USA	24	11	10	45	USA	104	BB	USA
YaqZHO_CHN	17	14	12	43	CHN	91	BB	nonUSA
KonMCC_USA	13	9	11	33	USA	68	BB	USA
YusOU___CHN	7	7	5	19	CHN	40	BB	nonUSA
QinZHA_CHN	7	9	3	19	CHN	42	BB	nonUSA
SimBIL_USA	211	99	47	357	USA	878	FX	USA
RebAND_BRA	56	64	49	169	BRA	345	FX	nonUSA
KalLIN_USA	31	33	32	96	USA	191	FX	USA
JesGAD_GBR	26	27	42	95	GBR	174	FX	nonUSA
FlaSAR_BRA	25	28	28	81	BRA	159	FX	nonUSA
KayNEM_ALG	16	14	7	37	ALG	83	UB	nonUSA
ShiJON_USA	10	8	9	27	USA	55	UB	USA
QiyQIU_CHN	13	6	6	25	CHN	57	UB	nonUSA
ZoeMIL_USA	6	8	8	22	USA	42	UB	USA
RebAND_BRA	5	8	7	20	BRA	38	UB	nonUSA
SimBIL_USA	32	20	14	66	USA	150	VT	USA
RebAND_BRA	18	16	16	50	BRA	102	VT	nonUSA
JadCAR_USA	13	9	8	30	USA	65	VT	USA
ShiJON_USA	11	6	10	27	USA	55	VT	USA
SkyBLA_USA	3	8	9	20	USA	34	VT	USA
OndACH_GBR	4	7	9	20	GBR	35	VT	nonUSA

unique_id	Golds	Silvers	Bronzes	Total_Medals	Country	Medal_Weight	Apparatus	USA
SimBIL_USA	24	11	10	45	USA	104	BB	USA
YaqZHO_CHN	17	14	12	43	CHN	91	BB	nonUSA
KonMCC_USA	13	9	11	33	USA	68	BB	USA
QinZHA_CHN	7	9	3	19	CHN	42	BB	nonUSA
YusOU___CHN	7	7	5	19	CHN	40	BB	nonUSA
SimBIL_USA	211	99	47	357	USA	878	FX	USA
RebAND_BRA	56	64	49	169	BRA	345	FX	nonUSA
KalLIN_USA	31	33	32	96	USA	191	FX	USA
JesGAD_GBR	26	27	42	95	GBR	174	FX	nonUSA
FlaSAR_BRA	25	28	28	81	BRA	159	FX	nonUSA
KayNEM_ALG	16	14	7	37	ALG	83	UB	nonUSA
QiyQIU_CHN	13	6	6	25	CHN	57	UB	nonUSA
ShiJON_USA	10	8	9	27	USA	55	UB	USA
ZoeMIL_USA	6	8	8	22	USA	42	UB	USA
XijTAN_CHN	9	3	7	19	CHN	40	UB	nonUSA
SimBIL_USA	32	20	14	66	USA	150	VT	USA
RebAND_BRA	18	16	16	50	BRA	102	VT	nonUSA
JadCAR_USA	13	9	8	30	USA	65	VT	USA
ShiJON_USA	11	6	10	27	USA	55	VT	USA
OndACH_GBR	4	7	9	20	GBR	35	VT	nonUSA
ShoMIY_JPN	4	9	5	18	JPN	35	VT	nonUSA

USA	sumGolds	sumTot	sumWeighted
nonUSA	324	1195	2250
USA	476	1205	2550

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

Gold Medal Count for each apparatus there are 11 out of 20 from the US: balance beam (BB): 2, floor exercise (FX): 3, uneven bars (UB): 2, and vault (VT): 4

USA makes up 58% of the total women's gold medals in the simulation.

Total Medal Count for each apparatus there are 10 out of 20 from the US: balance beam (BB): 2, floor exercise (FX): 2, uneven bars (UB): 2, vault (VT): 4

USA makes up 49% of the total women's medals in the simulation.

Weighted Medal Count for each apparatus there are 9 out of 20 from the US: balance beam (BB): 2, floor exercise (FX): 2, uneven bars (UB): 2, vault (VT): 3

USA makes up 52% of the weight of women's medals in the simulation.

Image 8)

unique_id	Golds	Silvers	Bronzes	Total_Medals	Country	Medal_Weight	Apparatus	USA
CarYUL_PHI	12	11	4	27	PHI	62	FX	nonUSA
ArtDOL_ISR	11	6	4	21	ISR	49	FX	nonUSA
RyoDOI_JPN	6	4	3	13	JPN	29	FX	nonUSA
NicBAR_ITA	6	3	0	9	ITA	24	FX	nonUSA
GiaREG_GBR	5	2	2	9	GBR	21	FX	nonUSA
BohZHA_CHN	12	6	7	25	CHN	55	HB	nonUSA
DaiHAS_JPN	9	9	9	27	JPN	54	HB	nonUSA
ConSHI_CHN	9	3	3	15	CHN	36	HB	nonUSA
WeiSUN_CHN	8	5	6	19	CHN	40	HB	nonUSA
YuyKAM_JPN	5	7	2	14	JPN	31	HB	nonUSA
JinZOU_CHN	32	17	11	60	CHN	141	PB	nonUSA
LukDAU_GER	12	7	5	24	GER	55	PB	nonUSA
ColWAL_USA	6	2	5	13	USA	27	PB	USA
BohZHA_CHN	4	6	8	18	CHN	32	PB	nonUSA
JoeFRA_GBR	4	6	6	16	GBR	30	PB	nonUSA
CurPHI_USA	4	4	7	15	USA	27	PB	USA
BlaSUN_USA	4	7	3	14	USA	29	PB	USA
ConSHI_CHN	4	2	3	9	CHN	19	PB	nonUSA
ChiLEE_TPE	15	9	5	29	TPE	68	PH	nonUSA
MaxWHI_GBR	13	11	12	36	GBR	73	PH	nonUSA
NarKUR_KAZ	12	5	4	21	KAZ	50	PH	nonUSA
RhyMCC_IRL	8	8	7	23	IRL	47	PH	nonUSA
Mc CLE_IRL	8	8	4	20	IRL	44	PH	nonUSA
XinLAN_CHN	15	10	11	36	CHN	76	SR	nonUSA
ElePET_GRE	15	8	6	29	GRE	67	SR	nonUSA
YanLIU_CHN	14	12	6	32	CHN	72	SR	nonUSA
HaoYOU_CHN	6	6	0	12	CHN	30	SR	nonUSA
JinZOU_CHN	5	7	9	21	CHN	38	SR	nonUSA
AdeASI_TUR	5	5	2	12	TUR	27	SR	nonUSA
JakJAR_GBR	19	15	8	42	GBR	95	VT	nonUSA
AshHON_USA	17	7	8	32	USA	73	VT	USA
BohZHA_CHN	10	11	7	28	CHN	59	VT	nonUSA
DonWHI_USA	9	11	5	25	USA	54	VT	USA
DaiHAS_JPN	8	12	10	30	JPN	58	VT	nonUSA

unique_id	Golds	Silvers	Bronzes	Total_Medals	Country	Medal_Weight	Apparatus	USA
CarYUL_PHI	12	11	4	27	PHI	62	FX	nonUSA
ArtDOL_ISR	11	6	4	21	ISR	49	FX	nonUSA
DaiHAS_JPN	4	5	8	17	JPN	30	FX	nonUSA
RyoDOI_JPN	6	4	3	13	JPN	29	FX	nonUSA
PauJUD_USA	3	6	3	12	USA	24	FX	USA
DaiHAS_JPN	9	9	9	27	JPN	54	HB	nonUSA
BohZHA_CHN	12	6	7	25	CHN	55	HB	nonUSA
WeiSUN_CHN	8	5	6	19	CHN	40	HB	nonUSA
ConSHI_CHN	9	3	3	15	CHN	36	HB	nonUSA
YuyKAM_JPN	5	7	2	14	JPN	31	HB	nonUSA
JinZOU_CHN	32	17	11	60	CHN	141	PB	nonUSA
LukDAU_GER	12	7	5	24	GER	55	PB	nonUSA
BohZHA_CHN	4	6	8	18	CHN	32	PB	nonUSA
JoeFRA_GBR	4	6	6	16	GBR	30	PB	nonUSA
IllKOV_UKR	3	4	9	16	UKR	26	PB	nonUSA
MaxWHI_GBR	13	11	12	36	GBR	73	PH	nonUSA
ChiLEE_TPE	15	9	5	29	TPE	68	PH	nonUSA
RhyMCC_IRL	8	8	7	23	IRL	47	PH	nonUSA
NarKUR_KAZ	12	5	4	21	KAZ	50	PH	nonUSA
AhmSOU_JOR	4	8	8	20	JOR	36	PH	nonUSA
Mc CLE_IRL	8	8	4	20	IRL	44	PH	nonUSA
XinLAN_CHN	15	10	11	36	CHN	76	SR	nonUSA
YanLIU_CHN	14	12	6	32	CHN	72	SR	nonUSA
ElePET_GRE	15	8	6	29	GRE	67	SR	nonUSA
JinZOU_CHN	5	7	9	21	CHN	38	SR	nonUSA
HaoYOU_CHN	6	6	0	12	CHN	30	SR	nonUSA
BohZHA_CHN	2	6	4	12	CHN	22	SR	nonUSA
AdeASI_TUR	5	5	2	12	TUR	27	SR	nonUSA
NikSIM_AZE	1	3	8	12	AZE	17	SR	nonUSA
JakJAR_GBR	19	15	8	42	GBR	95	VT	nonUSA
AshHON_USA	17	7	8	32	USA	73	VT	USA
DaiHAS_JPN	8	12	10	30	JPN	58	VT	nonUSA
KhoYOU_USA	7	11	11	29	USA	54	VT	USA
BohZHA_CHN	10	11	7	28	CHN	59	VT	nonUSA

unique_id	Golds	Silvers	Bronzes	Total_Medals	Country	Medal_Weight	Apparatus	USA
CarYUL_PHI	12	11	4	27	PHI	62	FX	nonUSA
ArtDOL_ISR	11	6	4	21	ISR	49	FX	nonUSA
DaiHAS_JPN	4	5	8	17	JPN	30	FX	nonUSA
RyoDOI_JPN	6	4	3	13	JPN	29	FX	nonUSA
PauJUD_USA	3	6	3	12	USA	24	FX	USA
NicBAR_ITA	6	3	0	9	ITA	24	FX	nonUSA
BohZHA_CHN	12	6	7	25	CHN	55	HB	nonUSA
DaiHAS_JPN	9	9	9	27	JPN	54	HB	nonUSA
WeiSUN_CHN	8	5	6	19	CHN	40	HB	nonUSA
ConSHI_CHN	9	3	3	15	CHN	36	HB	nonUSA
YuyKAM_JPN	5	7	2	14	JPN	31	HB	nonUSA
JinZOU_CHN	32	17	11	60	CHN	141	PB	nonUSA
LukDAU_GER	12	7	5	24	GER	55	PB	nonUSA
BohZHA_CHN	4	6	8	18	CHN	32	PB	nonUSA
JoeFRA_GBR	4	6	6	16	GBR	30	PB	nonUSA
BlaSUN_USA	4	7	3	14	USA	29	PB	USA
MaxWHI_GBR	13	11	12	36	GBR	73	PH	nonUSA
ChiLEE_TPE	15	9	5	29	TPE	68	PH	nonUSA
NarKUR_KAZ	12	5	4	21	KAZ	50	PH	nonUSA
RhyMCC_IRL	8	8	7	23	IRL	47	PH	nonUSA
Mc CLE_IRL	8	8	4	20	IRL	44	PH	nonUSA
XinLAN_CHN	15	10	11	36	CHN	76	SR	nonUSA
YanLIU_CHN	14	12	6	32	CHN	72	SR	nonUSA
ElePET_GRE	15	8	6	29	GRE	67	SR	nonUSA
JinZOU_CHN	5	7	9	21	CHN	38	SR	nonUSA
HaoYOU_CHN	6	6	0	12	CHN	30	SR	nonUSA
JakJAR_GBR	19	15	8	42	GBR	95	VT	nonUSA
AshHON_USA	17	7	8	32	USA	73	VT	USA
BohZHA_CHN	10	11	7	28	CHN	59	VT	nonUSA
DaiHAS_JPN	8	12	10	30	JPN	58	VT	nonUSA
KhoYOU_USA	7	11	11	29	USA	54	VT	USA
DonWHI_USA	9	11	5	25	USA	54	VT	USA

USA	sumGolds	sumTot	sumWeighted
nonUSA	464	1350	2738
USA	136	450	862

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): 0, high bar (HB): 0,parallel bars (PB): 3 pommel horse (PH): 0, still rings (SR): 0, vault (VT): 2

USA makes up 23% of the total men's gold medals in the simulation.

Total Medal Count for each apparatus there are 3 out of 30 from the US: floor exercise (FX): 1, high bar (HB): 0, parallel bars (PB): 0, pommel horse (PH): 0, still rings (SR): 0, vault (VT): 2

USA makes up 25% of the total men's medals in the simulation.

Weighted Medal Count for each apparatus there are 5 out of 30 from the US: floor exercise (FX): 1, high bar (HB): 0, parallel bars (PB): 1, pommel horse (PH): 0, still rings (SR): 0, vault (VT): 3

USA makes up 24% of the weight of men's medals in the simulation.

Image 9)

unique_id	Golds	Country	Apparatus	USA
SimBIL_USA	24	USA	BB	USA
YaqZHO_CHN	17	CHN	BB	nonUSA
KonMCC_USA	13	USA	BB	USA
YusOU___CHN	7	CHN	BB	nonUSA
QinZHA_CHN	7	CHN	BB	nonUSA
LeaWON_USA	4	USA	BB	USA
AnaBAR_ROU	3	ROU	BB	nonUSA
GeoGOD_AUS	3	AUS	BB	nonUSA
HuaLUO_CHN	2	CHN	BB	nonUSA
SunLEE_USA	2	USA	BB	USA
SkyBLA_USA	2	USA	BB	USA
EmmMAL_GER	2	GER	BB	nonUSA
GioVIL_ITA	2	ITA	BB	nonUSA
SimBIL_USA	211	USA	FX	USA
RebAND_BRA	56	BRA	FX	nonUSA
KalLIN_USA	31	USA	FX	USA
JesGAD_GBR	26	GBR	FX	nonUSA
FlaSAR_BRA	25	BRA	FX	nonUSA
JadCAR_USA	24	USA	FX	USA
JorCHI_USA	22	USA	FX	USA
JosROB_USA	16	USA	FX	USA
ShiJON_USA	14	USA	FX	USA
MarMAG_ITA	13	ITA	FX	nonUSA
KayNEM_ALG	16	ALG	UB	nonUSA
QiyQIU_CHN	13	CHN	UB	nonUSA
ShiJON_USA	10	USA	UB	USA
XijTAN_CHN	9	CHN	UB	nonUSA
ZoeMIL_USA	6	USA	UB	USA
RebAND_BRA	5	BRA	UB	nonUSA
AliD A_ITA	5	ITA	UB	nonUSA
XiaWEI_CHN	4	CHN	UB	nonUSA
YunLEE_KOR	4	KOR	UB	nonUSA
SimBIL_USA	4	USA	UB	USA
SimBIL_USA	32	USA	VT	USA
RebAND_BRA	18	BRA	VT	nonUSA
JadCAR_USA	13	USA	VT	USA
ShiJON_USA	11	USA	VT	USA
JosROB_USA	5	USA	VT	USA
OndACH_GBR	4	GBR	VT	nonUSA
ShoMIY_JPN	4	JPN	VT	nonUSA
JorCHI_USA	4	USA	VT	USA
TiaSUM_USA	4	USA	VT	USA
SkyBLA_USA	3	USA	VT	USA

Image 10)

```
Warning: Removed 1 rows containing missing values (`geom_point()`).
```

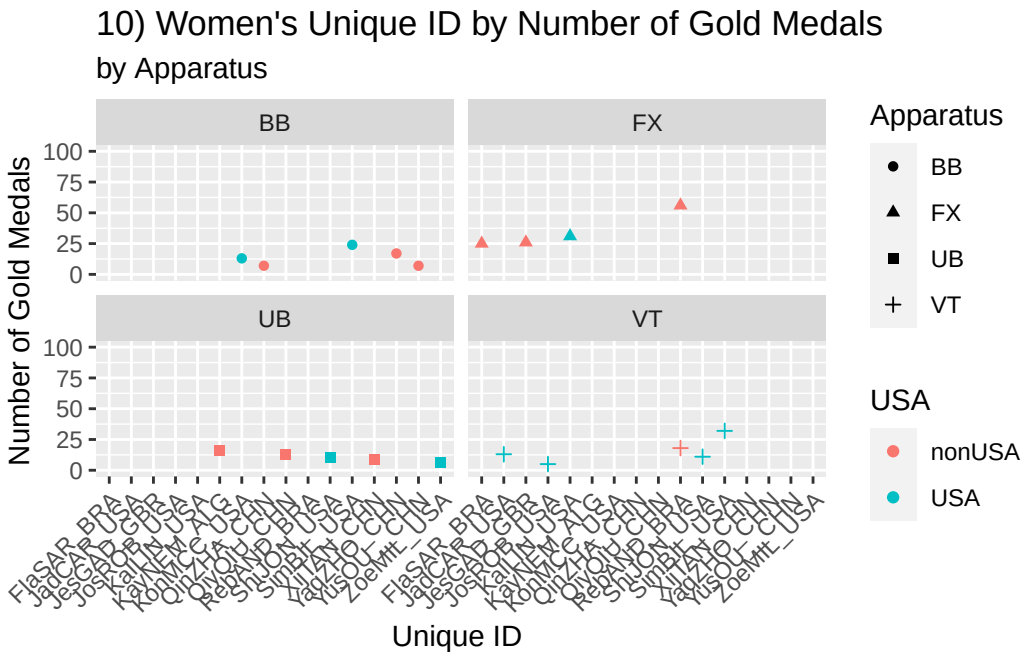
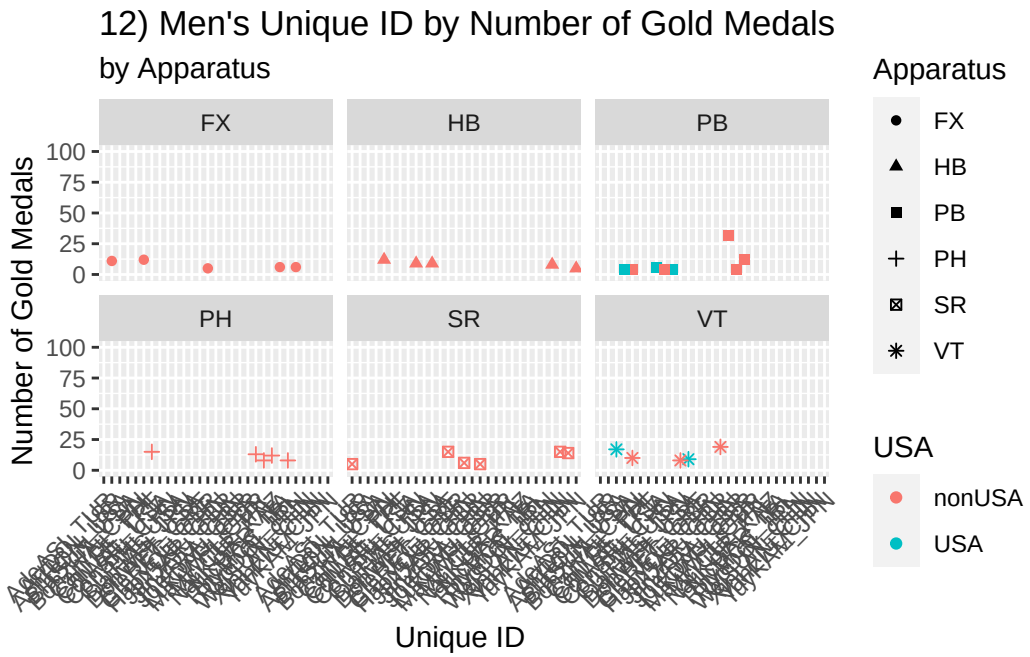

10) Women's Unique ID by Number of Gold Medals
by Apparatus
BB
FX
UB
VT
Number of Gold Medals
100
75
50
25
0
Unique ID
Apparatus
BB
FX
UB
VT
USA
nonUSA
USA

Image 11)

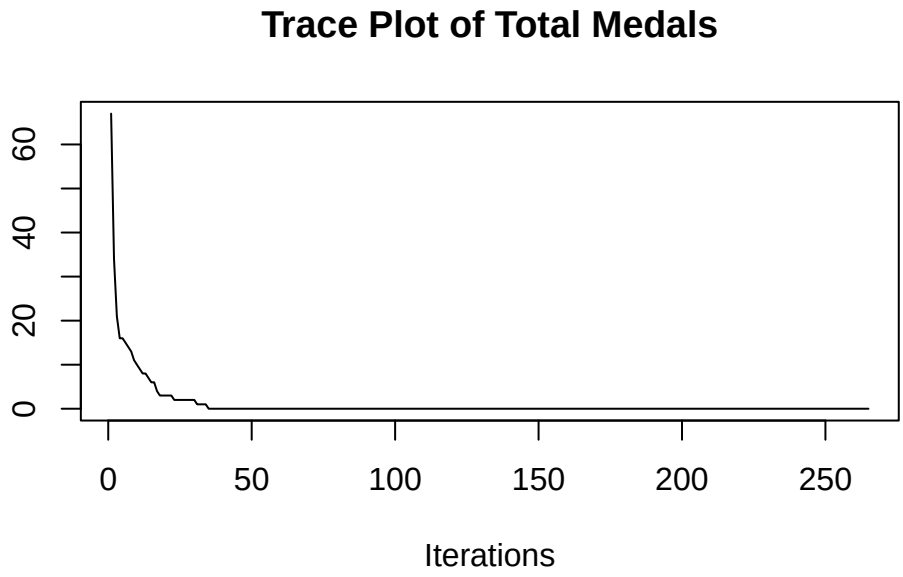
unique_id	Golds	Country	Apparatus	USA
CarYUL_PHI	12	PHI	FX	nonUSA
ArtDOL_ISR	11	ISR	FX	nonUSA
RyoDOI_JPN	6	JPN	FX	nonUSA
NicBAR_ITA	6	ITA	FX	nonUSA
GiaREG_GBR	5	GBR	FX	nonUSA
DaiHAS_JPN	4	JPN	FX	nonUSA
KakTAN_JPN	4	JPN	FX	nonUSA
SunRYU_KOR	4	KOR	FX	nonUSA
PauJUD_USA	3	USA	FX	USA
ConMCC_USA	3	USA	FX	USA
HanKIM_KOR	3	KOR	FX	nonUSA
LeaSAU_CAN	3	CAN	FX	nonUSA
ColWAL_USA	3	USA	FX	USA
AshHON_USA	3	USA	FX	USA
JakJAR_ENG	3	ENG	FX	nonUSA
BohZHA_CHN	12	CHN	HB	nonUSA
DaiHAS_JPN	9	JPN	HB	nonUSA
ConSHI_CHN	9	CHN	HB	nonUSA
WeiSUN_CHN	8	CHN	HB	nonUSA
YuyKAM_JPN	5	JPN	HB	nonUSA
BroMAL_USA	4	USA	HB	USA
ArtMAR_BRA	4	BRA	HB	nonUSA
ShoKAW_JPN	4	JPN	HB	nonUSA
MarGEO_CYP	4	CYP	HB	nonUSA
JoeFRA_GBR	3	GBR	HB	nonUSA
FreRIC_USA	3	USA	HB	USA
MilKAR_KAZ	3	KAZ	HB	nonUSA
PauJUD_USA	3	USA	HB	USA
AhmOND_TUR	3	TUR	HB	nonUSA
TinSRB_CRO	3	CRO	HB	nonUSA
MatCOR_USA	3	USA	HB	USA
JinZOU_CHN	32	CHN	PB	nonUSA
LukDAU_GER	12	GER	PB	nonUSA
ColWAL_USA	6	USA	PB	USA
BohZHA_CHN	4	CHN	PB	nonUSA
JoeFRA_GBR	4	GBR	PB	nonUSA
CurPHI_USA	4	USA	PB	USA
BlaSUN_USA	4	USA	PB	USA
ConSHI_CHN	4	CHN	PB	nonUSA
IllKOV_UKR	3	UKR	PB	nonUSA
KazKAY_JPN	3	JPN	PB	nonUSA
BroMAL_USA	3	USA	PB	USA
ChiLEE_TPE	15	TPE	PH	nonUSA
MaxWHI_GBR	13	GBR	PH	nonUSA
NarKUR_KAZ	12	KAZ	PH	nonUSA
RhyMCC_IRL	8	IRL	PH	nonUSA
Mc CLE_IRL	8	IRL	PH	nonUSA
AhmABU_JOR	5	JOR	PH	nonUSA
SteNED_USA	5	USA	PH	USA
AhmSOU_JOR	4	JOR	PH	nonUSA
LorDE _NED	3	NED	PH	nonUSA
HarMER_ARM	3	ARM	PH	nonUSA
JamLEW_GBR	3	GBR	PH	nonUSA

Image 12)



Note: The excessive overlap in unique ids displays 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




```
    var1
29.54697
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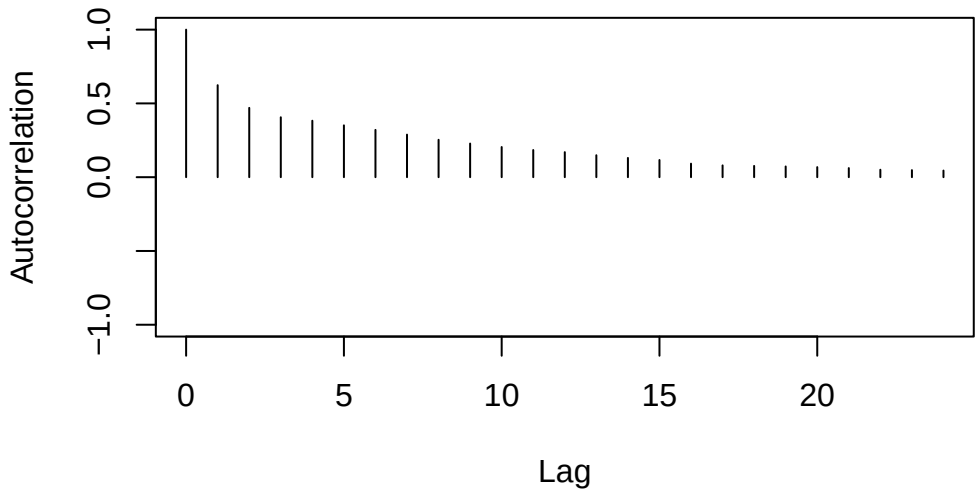
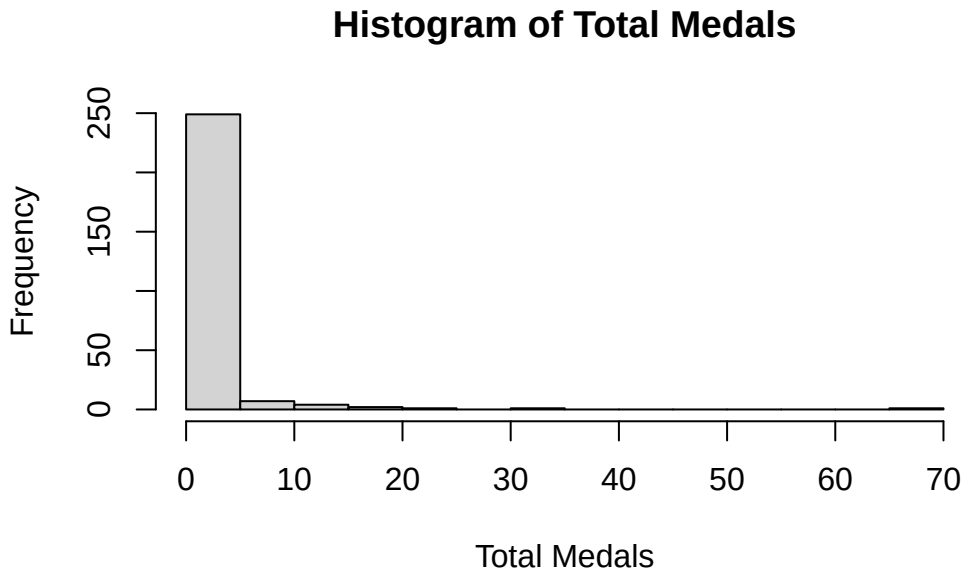


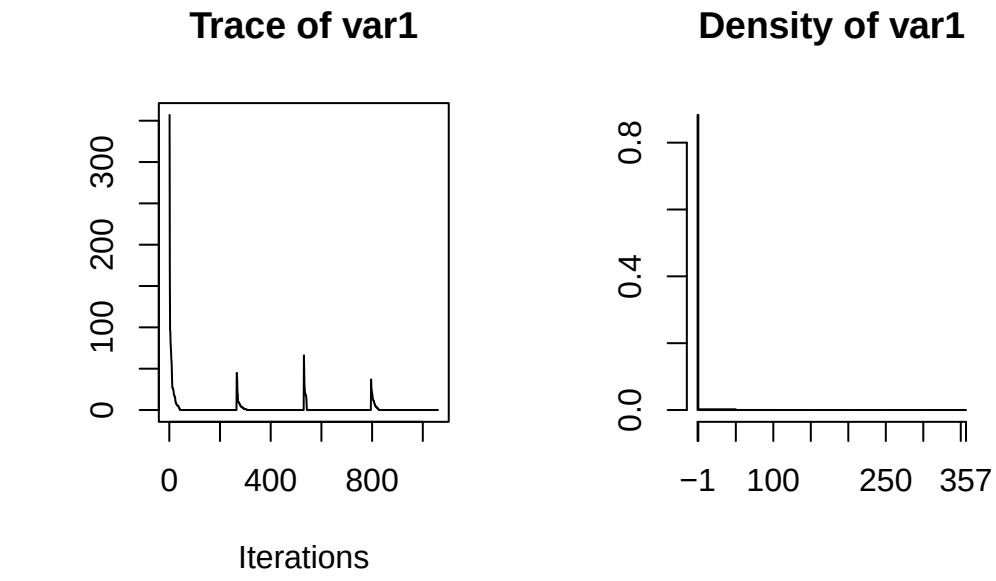


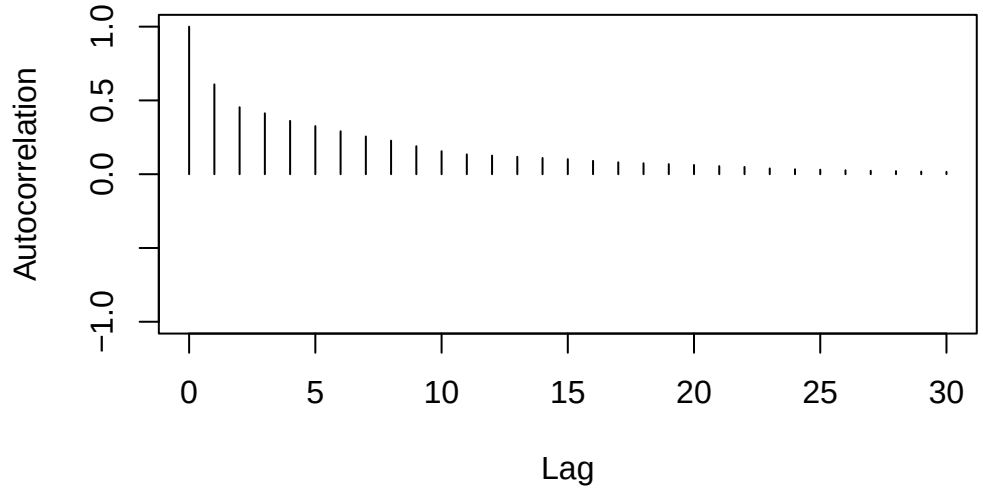

```
Iterations = 1:1060
Thinning interval = 1
Number of chains = 1
Sample size per chain = 1060

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

          Mean             SD       Naive SE Time-series SE
        2.2642        14.5906          0.4481         1.3603

2. Quantiles for each variable:
```

```
 2.5%   25%   50%   75% 97.5%
    0     0     0     0    22
```

```
      var1
0.06893296
```

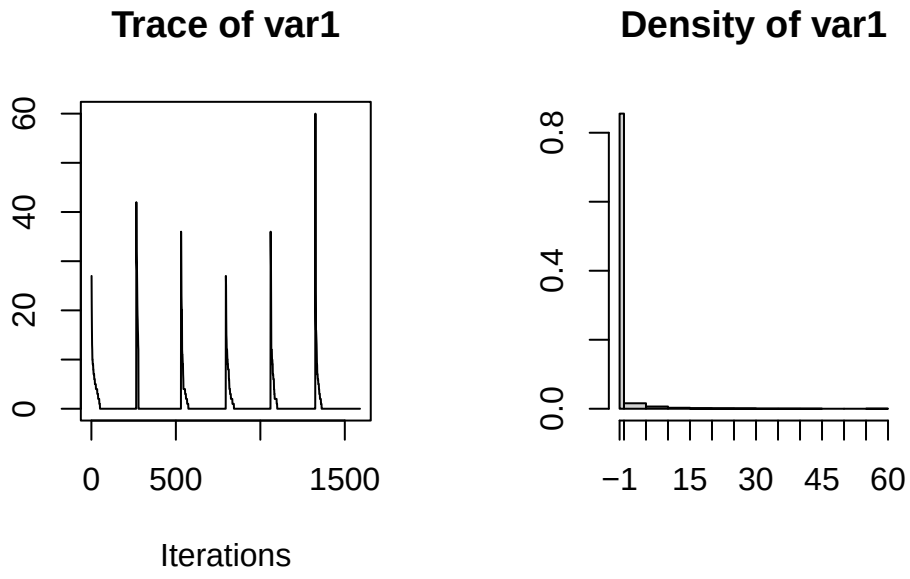
```
    var1
115.0435
```

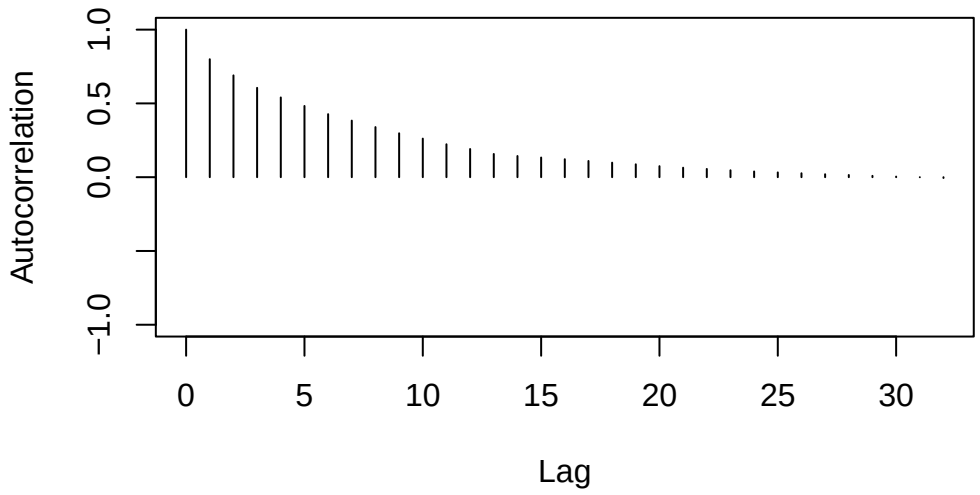





```
Iterations = 1:1590
Thinning interval = 1
Number of chains = 1
```

```
Sample size per chain = 1590

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

          Mean             SD       Naive SE Time-series SE
        1.1321         4.2520         0.1066         0.4052

2. Quantiles for each variable:

 2.5%   25%   50%   75% 97.5%
    0     0     0     0    12


      var1
0.05852738


    var1
110.1097
```




Autocorrelation
1.0
0.5
0.0
−1.0
0
5
10
15
20
25
30
Lag