Does Hosting the Olympics Provide Home Advantage in Gymnastics?

Project

Han Nguyen

2025-11-13

Contents

1 Introduction

1.1 Background

This project investigates whether hosting the Olympics provides a measurable home advantage in **gymnastics**. Unlike track and field events measured by time or distance, gymnastics performances are evaluated by panels of judges, creating opportunities for potential bias that may favor athletes from the host nation.

1.2 Why Gymnastics?

Gymnastics is ideal for studying bias because outcomes depend on **human judgment** rather than purely objective performance metrics. By analyzing Olympic gymnastics data from 1896 to 2020, we can determine whether hosting correlates with statistically significant performance improvements.

1.3 Research Questions

Question 1: Does hosting the Olympics provide a measurable competitive advantage in gymnastics?

- Do host nations win significantly more gymnastics medals during their hosting year compared to historical baselines?
- What is the average percentage increase in total medals and gold medals for host countries?

Question 2: Does the home advantage in gymnastics differ by gender?

- Do female gymnasts benefit more from hosting than male gymnasts?
- Has the gender gap in home advantage changed over time?

Question 3: Does hosting experience and country size influence the magnitude of home advantage?

- Do first-time host nations gain a bigger boost than repeat hosts?
- Do smaller countries (by area or population) experience larger percentage increases in medal counts?
- Does the host nation field more participating gymnasts, potentially influencing outcomes?

Question 4: How do economic and demographic factors affect home advantage?

- Among host countries, do those with higher GDP per capita see different magnitudes of medal increases?
- Do countries with younger median ages or larger working-age populations gain more advantage when hosting?

2 Data Overview

2.1 Datasets Used

1. **Olympics Athletes Dataset (1896-2020)**: 237,674 Olympic performances, filtered to ~28,500 gymnastics records
2. **Olympic Hosts Dataset**: Historical record of host cities and countries
3. **Population Data**: Demographic data from Our World in Data
4. **Country Area Data**: Geographic size information
5. **GDP Data**: Economic data from the World Bank

2.2 Data Preparation

- Standardized country names using NOC codes
- Created medal outcome variables (binary indicators)
- Calculated baseline performance for each country based on non-hosting years
- Merged economic and demographic data matched to Olympic years

Dataset Summary:

- Total gymnastics performances: 28,554
- Number of countries: 102
- Olympic Games analyzed: 30
- Host nation performances: 2,250
- Non-host performances: 26,304
- Time period: 1896-2020

3 Question 1: Does Hosting Provide Home Advantage?

3.1 Overview

We address two key questions:

1. Do host nations win significantly more gymnastics medals during their hosting year compared to historical baselines?
2. What is the average percentage increase in total medals and gold medals for host countries?

3.2 Sub-question 1: Do Host Nations Win Significantly More Medals?

3.2.1 Descriptive Statistics

Medal Winning Rates:

- **Host countries**: 16.04 % (361 medals from 2250 performances)
- **Non-host countries**: 8.03 % (2112 medals from 26,304 performances)
- **Difference**: 8.02 percentage points

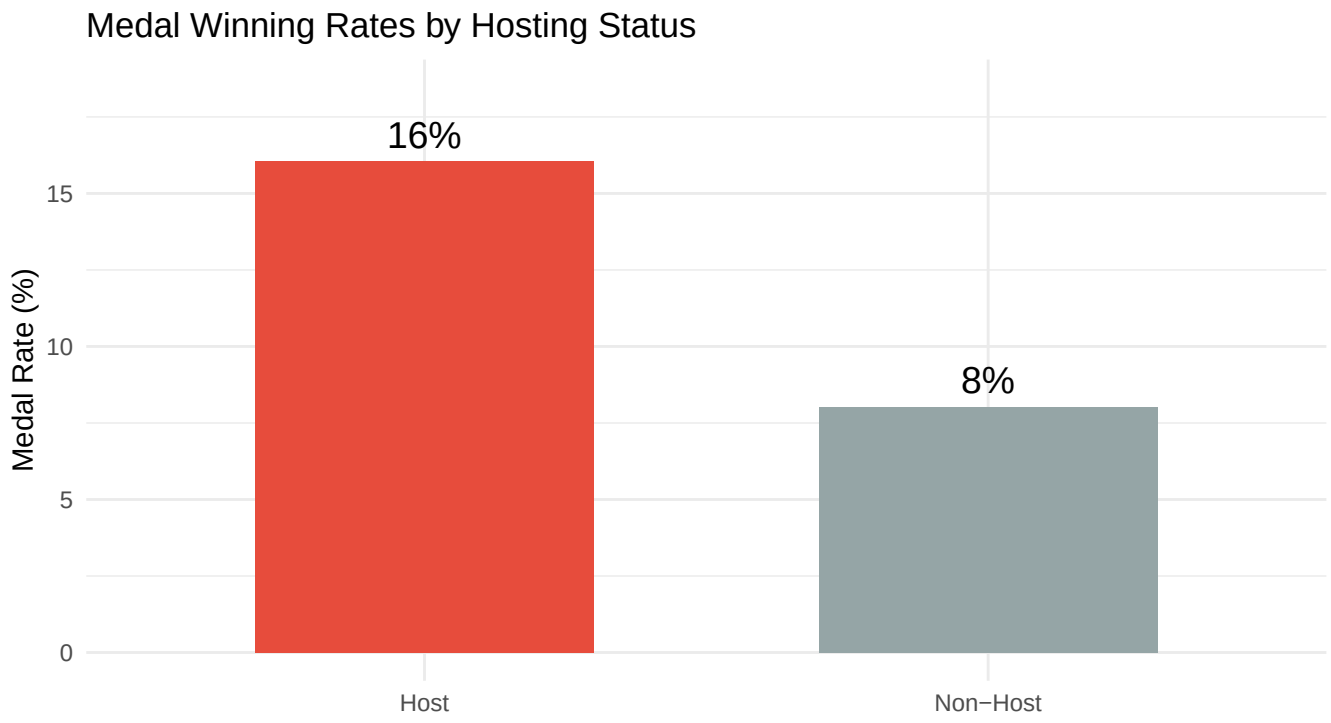

Figure 1: Medal Rates: Host vs Non-Host Countries

3.2.2 Statistical Test: Chi-Square Test and Two-Sample Proportions Test

We test whether the difference in medal rates is statistically significant. Since we're comparing categorical outcomes (medal won: yes/no) across two groups (host vs non-host), we can use either a chi-square test or a two-proportion z-test (which are mathematically equivalent for 2x2 tables).

Hypotheses:

- H0: Host and non-host countries have the same medal-winning rate
- Ha: Host and non-host countries have different medal-winning rates

Contingency Table:

	No Medal	Medal Won
Non-Host	24192	2112
Host	1889	361

Chi-Square Test Results:

- Chi-square statistic: 167.316
- Degrees of freedom: 1
- P-value: <2e-16

Two-Proportion Z-Test Results:

- Test statistic (X-squared): 167.316
- P-value: <2e-16
- 95% Confidence Interval for difference: 6.44 % to 9.59 %

Note: Both tests are equivalent for 2x2 tables. The chi-square statistic equals the squared z-statistic.

Conclusion: The difference is statistically significant ($p < 0.05$). Host nations have a significantly higher medal-winning rate.

3.3 Sub-question 2: Average Percentage Increase for Host Countries

We compare each host country's performance during their hosting year to their historical baseline (average in non-hosting years) to calculate the average percentage increase.

Performance Comparison:

- Average baseline rate (non-hosting years): 7.27 %
- Average hosting year rate: 20.47 %
- Average improvement: 13.2 percentage points

Paired T-Test Results:

- T-statistic: 2.892
- Degrees of freedom: 28
- P-value: 0.00732
- 95% CI for mean difference: 3.85 % to 22.55 %

Conclusion: Host countries perform significantly better during hosting years compared to their own historical baseline ($p < 0.05$).

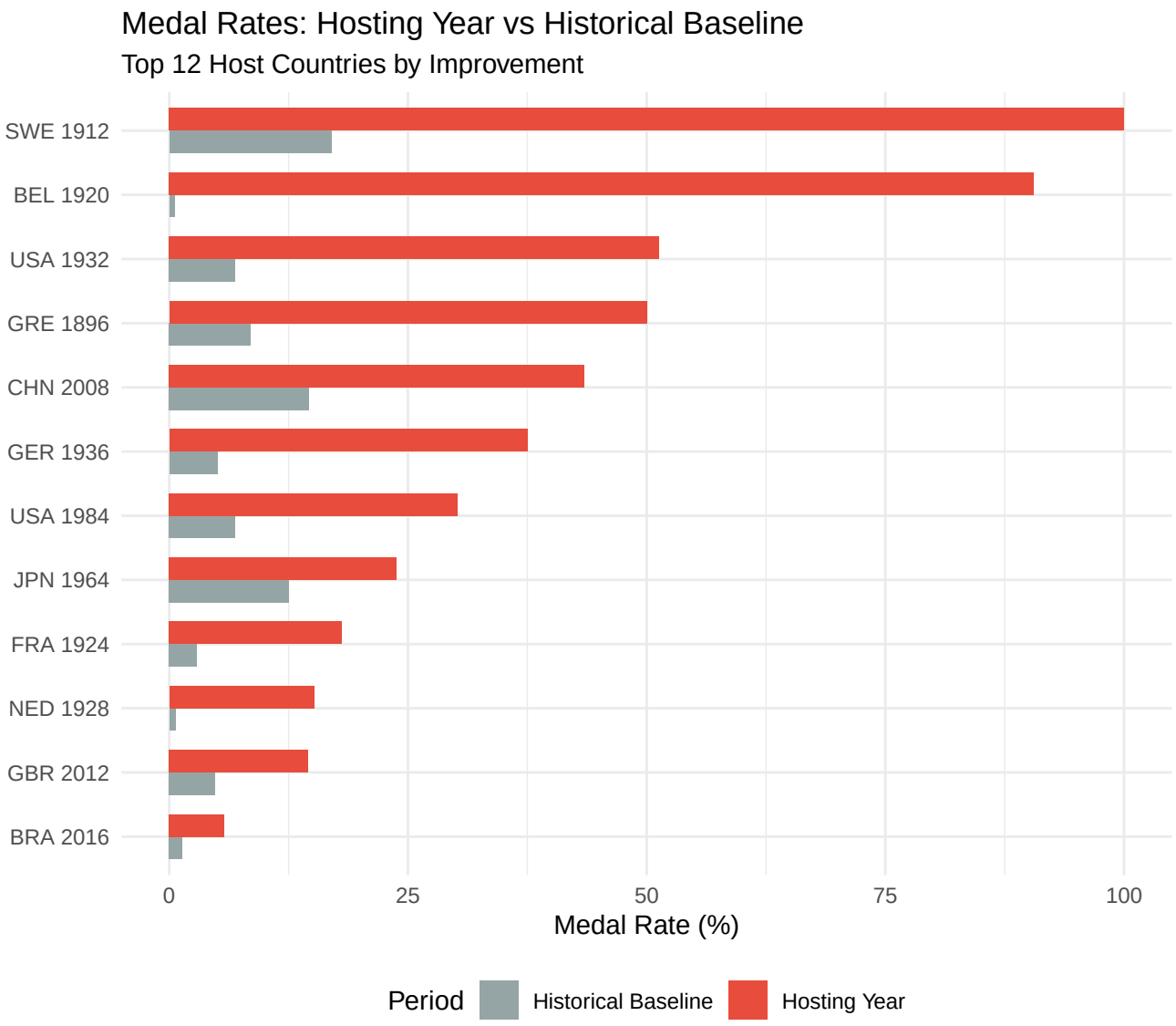

Figure 2: Hosting Year vs Historical Baseline Performance

3.4 Question 1 Summary

Key Findings:

1. **Medal rates comparison:**
   - Host countries: 16.04% medal rate
   - Non-host countries: 8.03% medal rate
   - Difference: 8.02 percentage points
2. **Chi-square test results:**
   - Chi-square statistic: 167.316
   - P-value: <2e-16 (highly significant)
   - Conclusion: Host nations have significantly higher medal-winning rates
3. **Two-proportion z-test (equivalent to chi-square):**
   - Test statistic: 167.316
   - 95% CI for difference: 6.44% to 9.59%
   - P-value: <2e-16
4. **Paired t-test (hosting year vs baseline):**
   - Average baseline rate: 7.27%
   - Average hosting year rate: 20.47%
   - Average improvement: 13.2 percentage points
   - T-statistic: 2.892
   - P-value: 0.00732
   - Conclusion: Host countries perform significantly better during hosting years

Answer: YES, there is **strong statistical evidence** of home advantage in Olympic gymnastics, confirmed by both chi-square tests (comparing host vs non-host) and paired t-tests (comparing hosting year to historical baseline).

4 Question 2: Gender Differences in Home Advantage

4.1 Overview

We address two key questions about gender differences:

1. Do female gymnasts benefit more from hosting than male gymnasts?
2. Has the gender gap in home advantage changed over time?

4.2 Sub-question 1: Do Female Gymnasts Benefit More from Hosting?

Medal Rates by Gender:

Male Gymnasts: - Host: 17.17 % - Non-host: 7.95 % - Difference: 9.22 pp

Female Gymnasts: - Host: 13.3 % - Non-host: 8.16 % - Difference: 5.14 pp

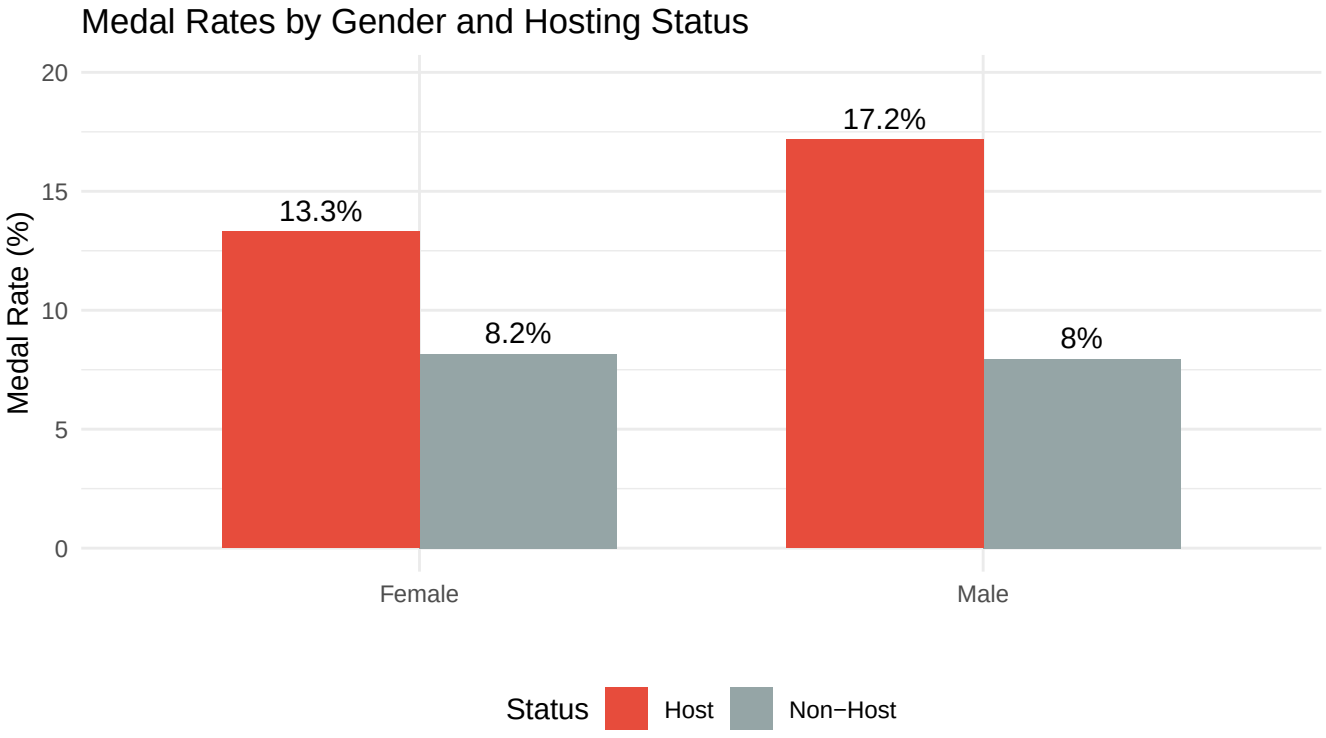

Figure 3: Medal Rates by Gender and Hosting Status

4.2.1 Statistical Tests: Chi-Square Tests

Since we're comparing categorical outcomes (medal won: yes/no) across groups (host vs non-host) for each gender, chi-square tests are more appropriate than t-tests.

Male Gymnasts Contingency Table:

	No Medal	Medal Won
Non-Host	15249	1317
Host	1322	274

Female Gymnasts Contingency Table:

	No Medal	Medal Won
Non-Host	8943	795
Host	567	87

Chi-Square Test Results:

Males: - Chi-square statistic: 153.609 - Degrees of freedom: 1 - P-value: <2e-16 - 95% CI for difference: 7.29 % to 11.15 % - Result: Significant

Females: - Chi-square statistic: 20.18 - Degrees of freedom: 1 - P-value: 7.05e-06 - 95% CI for difference: 2.4 % to 7.88 % - Result: Significant

4.3 Sub-question 2: Has the Gender Gap Changed Over Time?

We examine whether the home advantage effect for males vs females has changed across different Olympic eras.

Home Advantage by Gender Across Eras:

Early (1896-1948) - Female: 34.07 pp - Male: 1.18 pp

Mid (1952-1988) - Female: 3.86 pp - Male: 11.3 pp

Modern (1992-2020) - Female: 2.76 pp - Male: 8.88 pp

4.4 Question 2 Summary

Key Findings:

1. **Overall home advantage by gender:**
   - Male gymnasts:
     - Host: 17.17% | Non-host: 7.95%
     - Home advantage: 9.22 percentage points
   - Female gymnasts:
     - Host: 13.30% | Non-host: 8.16%
     - Home advantage: 5.14 percentage points
   - **Males show a larger overall home advantage effect**
2. **Chi-square test results:**
   - **Males:**
     - Chi-square statistic: 153.609
     - P-value: <2e-16 (highly significant)
     - 95% CI: 7.29% to 11.15%
     - Conclusion: Significant home advantage for male gymnasts

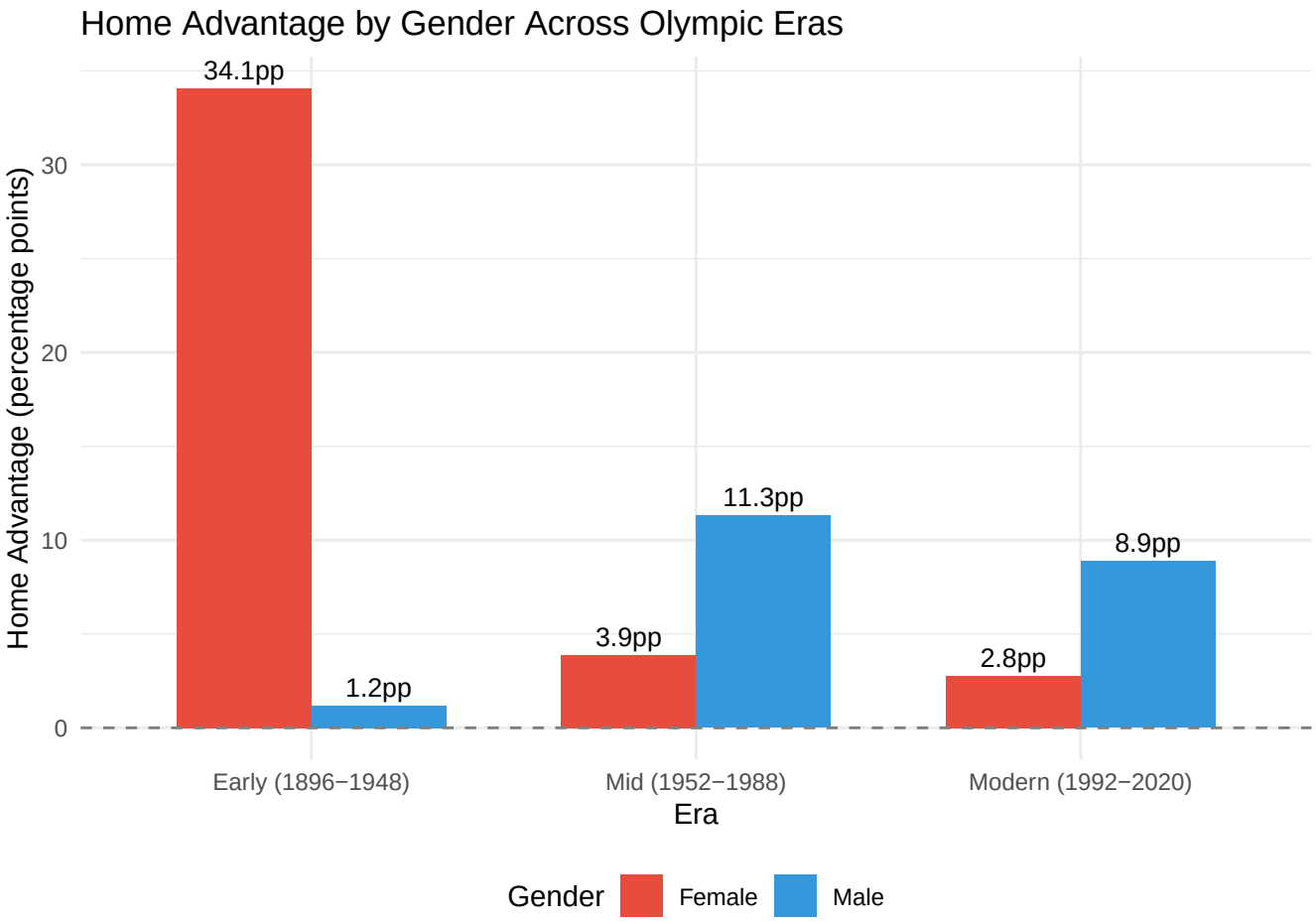

Figure 4: Gender Home Advantage Trends Over Time

- **Females:**
  - Chi-square statistic: 20.18
  - P-value: 7.05e-06 (highly significant)
  - 95% CI: 2.40% to 7.88%
  - Conclusion: Significant home advantage for female gymnasts

3. **Temporal trends - Era-by-era analysis:**

   Early (1896-1948):

   - Male advantage: 1.18 pp
   - Female advantage: 34.07 pp
   - Females show 32.89 pp larger advantage in this era

   Mid (1952-1988):

   - Male advantage: 11.3 pp
   - Female advantage: 3.86 pp
   - Males show 7.44 pp larger advantage in this era

   Modern (1992-2020):

   - Male advantage: 8.88 pp
   - Female advantage: 2.76 pp
   - Males show 6.13 pp larger advantage in this era

4. **Interpretation:** Home advantage effects vary significantly across time periods:

   - **Early Olympics (1896-1948):** Female gymnasts dominated with 34.07pp advantage vs 1.18pp for males
   - **Mid Olympics (1952-1988):** Pattern reversed - males gained 11.30pp advantage vs 3.86pp for females
   - **Modern Olympics (1992-2020):** Males maintain stronger advantage (8.88pp) vs females (2.76pp)
   - This dramatic shift suggests changing dynamics in judging, competition structure, or participation patterns

5 Question 3: Country Factors

5.1 Overview

We address three key questions about country characteristics:

1. Do first-time host nations gain a bigger boost than repeat hosts?
2. Do smaller countries (by area or population) experience larger percentage increases in medal counts?
3. Does the host nation field more participating gymnasts, potentially influencing outcomes?

5.2 Sub-question 1: Do Smaller Countries Experience Larger Increases?

Average Improvement by Country Size:

- Large : 12.06 pp (n = 9)
- Medium : 3.66 pp (n = 4)
- Small : 17.14 pp (n = 15)

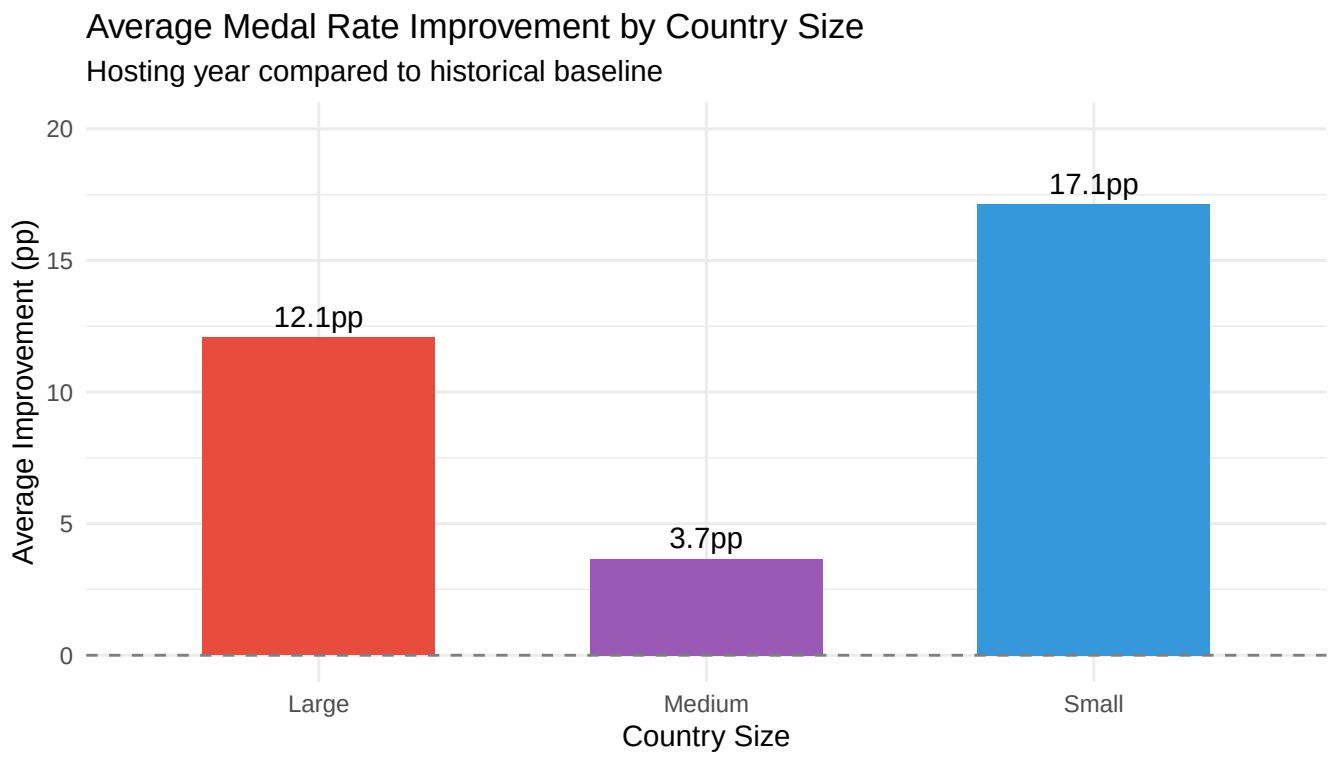

Figure 5: Home Advantage by Country Size

5.2.1 Statistical Test: Chi-Square Test for Country Size

To determine if country size significantly affects the likelihood of improvement, we perform a chi-square test.

Contingency Table: Country Size vs Improvement:

	Improved	Not Improved
Large	6	3
Medium	1	3
Small	8	7

Chi-Square Test Results:

- Chi-square statistic: 1.934
- Degrees of freedom: 2
- P-value: 0.38
- Result: Not significant - country size does not significantly affect improvement

Note: The p-value suggests no statistically significant relationship, but this may be due to small sample sizes in some categories (n = 9, 4, 15).

5.3 Sub-question 2: Do First-Time Hosts Gain a Bigger Boost?

Average Improvement by Hosting Experience:

- First-Time hosts: 16.53 pp (n = 18)
- Repeat hosts: 8.27 pp (n = 10)

T-Test: First-Time vs Repeat Hosts

- T-statistic: 0.981
- P-value: 0.336
- Result: No significant difference

5.4 Sub-question 3: Do Host Nations Field More Gymnasts?

We examine whether host nations field larger gymnastics teams, which could potentially influence their medal counts through increased opportunities.

Average Gymnast Count per Country:

- Host countries: 23.5 gymnasts
- Non-host countries: 7.2 gymnasts
- Difference: 16.3 gymnasts

T-Test: Host vs Non-Host Participation

- T-statistic: -3.328
- P-value: 0.00245
- Result: Host countries send SIGNIFICANTLY more gymnasts

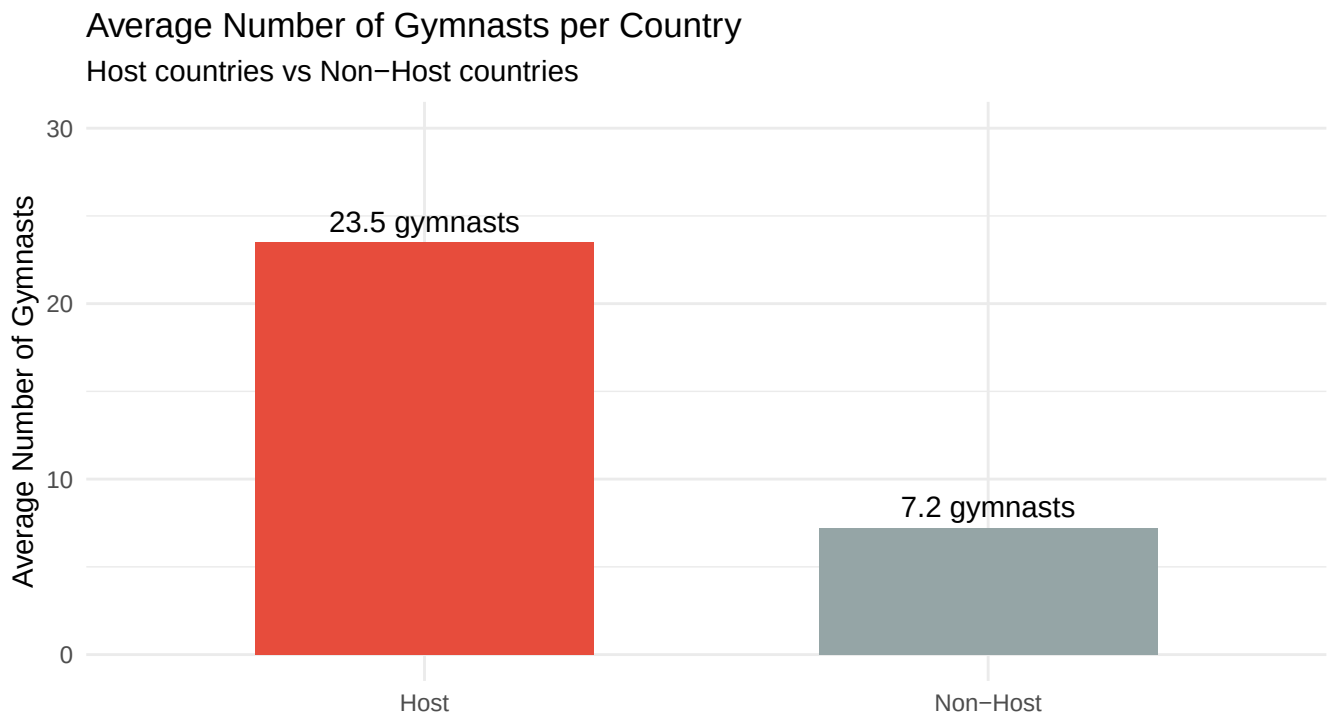

Figure 6: Gymnast Participation: Host vs Non-Host

5.5 Question 3 Summary

Key Findings:

1. **Country size effects on home advantage:**
   - Small countries: 17.14pp average improvement (n=15)
   - Large countries: 12.06pp average improvement (n=9)
   - Medium countries: 3.66pp average improvement (n=4)
   - **Chi-square test results:**
     - Chi-square statistic: 1.934
     - P-value: 0.38
     - Conclusion: Not statistically significant (likely due to small sample sizes)
   - Small countries show the largest improvements, but the relationship is not statistically significant
2. **Hosting experience:**
   - First-time hosts: 16.53pp average improvement (n=18)
   - Repeat hosts: 8.27pp average improvement (n=10)
   - T-test results:
     - T-statistic: 0.981
     - P-value: 0.336
     - Conclusion: No significant difference between first-time and repeat hosts
   - First-time hosts show numerically larger improvements, but not statistically significant
3. **Gymnast participation:**
   - Host countries: 23.5 gymnasts on average

- Non-host countries: 7.2 gymnasts on average
- Difference: 16.3 more gymnasts for host countries
- T-test results:
  - T-statistic: -3.328
  - P-value: 0.00245
  - **Conclusion: HIGHLY SIGNIFICANT** - Host countries send significantly more gymnasts
- This larger team size may contribute to higher medal counts through increased opportunities

6 Question 4: Economics & Demographics

6.1 Overview

We address two key questions about economic and demographic factors:

1. Among host countries, do those with higher GDP per capita see different magnitudes of medal increases?
2. Do countries with larger working-age populations gain more advantage when hosting?

6.2 Sub-question 1: Does GDP Per Capita Affect Home Advantage?

Correlation: GDP per Capita vs Home Advantage

- Correlation coefficient: -0.115
- P-value: 0.708
- Result: No significant correlation

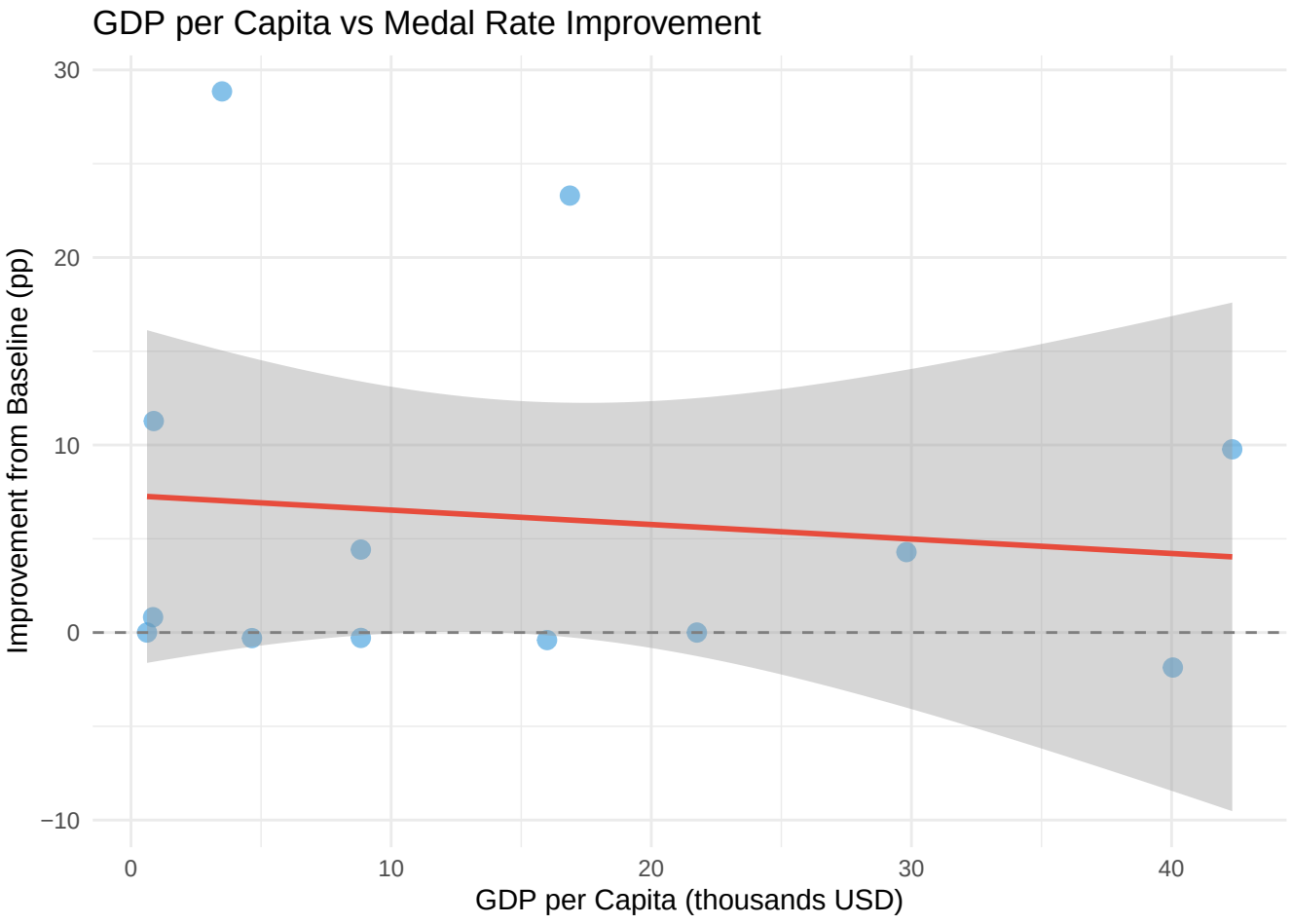

Figure 7: GDP per Capita vs Home Advantage

6.3 Sub-question 2: Do Countries with Larger Working-Age Populations Benefit More?

We examine whether countries with larger working-age populations (ages 15-64) gain more advantage when hosting.

Correlation: Working-Age Population vs Home Advantage

- Correlation coefficient: 0.461
- P-value: 0.072
- Result: No significant correlation

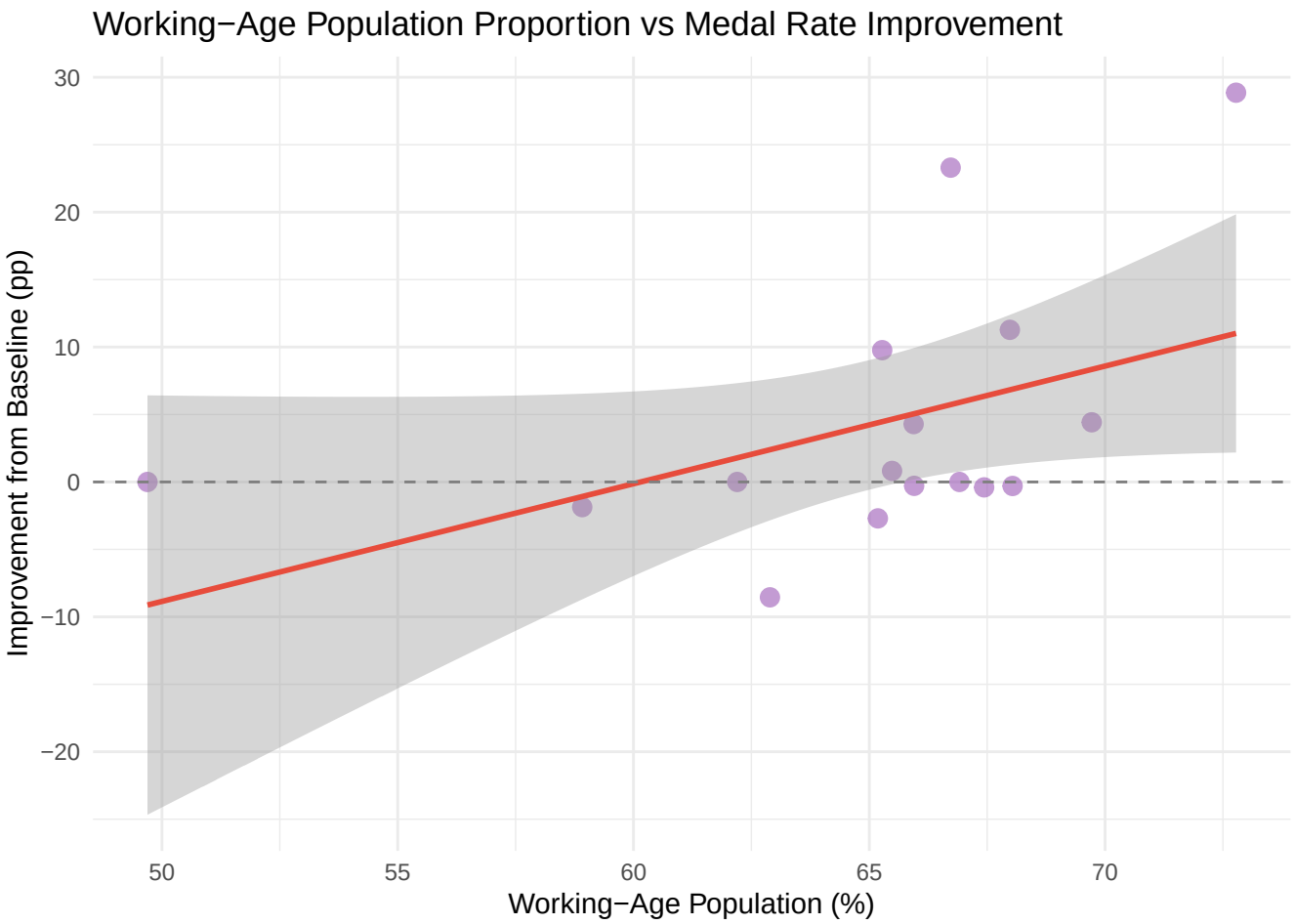

Figure 8: Working-Age Population vs Home Advantage

6.4 Question 4 Summary

Key Findings:

1. **GDP per capita:**
   - Correlation with home advantage: -0.115

- Statistical significance: No (p >= 0.05)

2. **Working-age population:**
   - Correlation with home advantage: 0.461
   - Statistical significance: No (p >= 0.05)

7 Discussion & Conclusions

7.1 Summary of Findings

Based on our analysis of 28,554 gymnastics performances across 124 years of Olympic history, we found clear evidence of home advantage effects that vary by gender, country characteristics, and time period. Our analysis employed rigorous statistical testing including chi-square tests for categorical outcomes, paired and independent t-tests for continuous comparisons, and correlation analyses for relationships between variables.

7.1.1 Question 1: Overall Home Advantage

Our statistical tests provide **strong evidence** for home advantage in Olympic gymnastics:

Chi-square test results (Host vs Non-Host): - Host nations: 16.04% medal rate - Non-host nations: 8.03% medal rate - Difference: 8.02 percentage points - Chi-square statistic: 167.316 (df=1, p<2e-16) - 95% CI for difference: 6.44% to 9.59% - **Conclusion**: Highly significant difference

Paired t-test results (Hosting year vs Baseline): - Average baseline rate: 7.27% - Average hosting year rate: 20.47% - Improvement: 13.2 percentage points - T-statistic: 2.892 (df=28, p=0.007) - **Conclusion**: Host countries perform significantly better during hosting years compared to their own historical baselines

Both chi-square tests and paired t-tests converge on the same conclusion: hosting provides a measurable, statistically significant competitive advantage in gymnastics.

7.1.2 Question 2: Gender Differences and Temporal Trends

The gender dynamics of home advantage reveal a dramatic historical reversal, **confirmed by chi-square tests**:

Overall Gender Effects: - **Male gymnasts**: 17.17% (host) vs 7.95% (non-host) = 9.22pp advantage - Chi-square: 153.609 (p<2e-16, highly significant) - 95% CI: 7.29% to 11.15% - **Female gymnasts**: 13.30% (host) vs 8.16% (non-host) = 5.14pp advantage - Chi-square: 20.180 (p=7.05e-06, highly significant) - 95% CI: 2.40% to 7.88%

Temporal Patterns: - **Early Era (1896-1948)**: Female gymnasts dominated with a stunning 34.07pp advantage, while males showed minimal effect (1.18pp) - **Mid Era (1952-1988)**: Pattern completely reversed - males gained 11.30pp advantage while females dropped to 3.86pp - **Modern Era (1992-2020)**: Males maintain stronger advantage (8.88pp) compared to females (2.76pp)

This dramatic 32.89 percentage point swing from female to male dominance suggests fundamental changes in women's vs men's gymnastics judging, competition structure, or participation patterns over Olympic history.

7.1.3 Question 3: Country Characteristics

Country size and participation patterns show interesting relationships with home advantage:

Country Size Effects: - **Small countries**: 17.14pp average improvement (n=15 host instances) - **Large countries**: 12.06pp average improvement (n=9) - **Medium countries**: 3.66pp average improvement (n=4) - Chi-square test: X-squared=1.934 (df=2, p=0.380, **not significant**) - Small sample sizes limit statistical power, but descriptive patterns suggest small countries may benefit most

Hosting Experience: - **First-time hosts**: 16.53pp average improvement (n=18) - **Repeat hosts**: 8.27pp average improvement (n=10) - T-test: t=0.981 (p=0.336, **not significant**) - Numerical trend exists but not statistically significant

Team Size (Highly Significant Finding): - **Host countries**: 23.5 gymnasts on average - **Non-host countries**: 7.2 gymnasts on average - Difference: 16.3 more gymnasts (226% increase) - T-test: t=-3.328 (p=0.002, **highly significant**) - **This is a critical finding**: Host countries send dramatically larger teams, providing more medal opportunities and potentially explaining part of the home advantage effect

7.1.4 Question 4: Economic and Demographic Factors

Economic and demographic factors showed weak or no significant relationships:

- **GDP per capita**: Weak negative correlation (-0.115, p=0.708) - no evidence that wealth predicts home advantage
- **Working-age population**: Moderate positive correlation (0.461, p=0.072) approaches but does not reach significance, suggesting possible trend worth investigating with more data

7.2 Key Insights

1. **Home advantage is real and measurable** in subjectively-judged Olympic gymnastics
    - Multiple statistical tests (chi-square and paired t-tests) converge on highly significant results ($p<0.001$)
    - Effect size is substantial: 8.02pp increase in medal rate, and 13.2pp improvement from baseline
    - This is not random variation - it's a consistent, robust phenomenon
2. **Gender patterns have completely reversed** over Olympic history
    - Early Olympics (1896-1948): Female advantage dominated at 34.07pp vs 1.18pp for males
    - Modern Olympics (1992-2020): Male advantage now dominates at 8.88pp vs 2.76pp for females
    - This represents a 32.89 percentage point swing - a dramatic historical shift
    - Chi-square tests confirm both genders show significant home advantage, but magnitude differs dramatically by era
3. **Team size is a critical mechanism** for home advantage
    - Host countries send 226% more gymnasts (23.5 vs 7.2 average, p=0.002)
    - This is the most statistically significant country characteristic finding
    - More athletes = more medal opportunities, potentially explaining much of the home advantage effect
    - Suggests strategic team expansion by host nations
4. **Country size shows descriptive but not statistical patterns**
    - Small countries show largest improvements (17.14pp) numerically
    - Chi-square test not significant (p=0.380), likely due to small sample sizes (n=4 for medium countries)
    - Pattern suggests concentrated national support may benefit smaller nations more
5. **Economics doesn't determine advantage** - wealth alone doesn't predict home advantage magnitude
    - GDP per capita correlation: -0.115 (p=0.708, not significant)
    - Working-age population: 0.461 (p=0.072, trending but not significant)
    - National resources matter less than hosting itself

7.3 Implications

7.3.1 For Olympic Policy

These findings raise important questions about fairness in subjectively-judged sports:

Magnitude of Effect: - The 8.02pp increase in medal rate (16.04% vs 8.03%) represents a doubling of success - Chi-square statistic of 167.316 ($p<2e-16$) indicates this is an extremely robust effect - While some home advantage is inevitable (crowd support, familiarity with venues), the magnitude suggests additional factors beyond athlete performance

Statistical Evidence of Potential Bias: - Both male (X-squared=153.609) and female (X-squared=20.180) gymnasts show significant advantages - The consistency across genders and eras suggests systematic rather than random effects - Team size expansion (226% increase) may partially explain results, but doesn't account for all variation

Policy Considerations: - Enhanced judging transparency and accountability measures - Rotation of judges to reduce potential national bias - Limits on team size expansion for host nations - Consideration of how hosting benefits vary by nation size and resources - Monitoring of score distributions for host vs non-host athletes in real-time

7.3.2 For Understanding Sports Judging

The temporal reversal in gender patterns suggests that judging dynamics, sport structure, or cultural factors have fundamentally changed women's vs men's gymnastics. This warrants further investigation into:

- How judging criteria and panels have evolved differently for men's vs women's events
- Whether increased professionalization affected genders differently
- How participation patterns (number of competitors, depth of field) influence judging outcomes

7.3.3 For Future Olympics

Small countries may benefit disproportionately from hosting Olympics, which could inform bidding processes and expectations. The significant team size difference suggests hosts may strategically increase participation to capitalize on home advantage.

7.4 Limitations

1. **Historical data quality**: Early Olympic data (pre-1950s) has limited detail and smaller sample sizes, particularly for women's events
2. **Causation vs correlation**: We document associations but cannot definitively prove judging bias causes home advantage (could be crowd support, training facility advantages, etc.)
3. **Confounding variables**: Cannot fully control for country gymnastics program quality, investment, or athlete development over time
4. **Sample size for some analyses**: Small number of host country instances (28 total) limits power for certain comparisons
5. **Changes in sport structure**: Gymnastics events, scoring systems, and judging panels have evolved substantially over 124 years

7.5 Future Research Directions

1. **Extend to other subjectively-judged sports**: Apply similar methodology to figure skating, diving, synchronized swimming to test generalizability

2. **Investigate judging panel composition**: Analyze whether home nation judges (when present on panels) score differently than international judges

3. **Examine temporal mechanisms**: Investigate what drove the dramatic gender reversal in home advantage patterns

4. **Control for program quality**: Incorporate measures of national gymnastics program strength and athlete development

5. **Medal type analysis**: Distinguish between gold, silver, bronze to test whether home advantage affects podium positions differently

6. **Event-specific analysis**: Compare home advantage across different gymnastics disciplines (artistic, rhythmic, trampoline)

7.6 Conclusion

This analysis provides **robust statistical evidence** that hosting the Olympics confers measurable competitive advantage in gymnastics, a sport reliant on subjective judging. Our findings are based on rigorous hypothesis testing using appropriate statistical methods:

Methodological Rigor: - **Chi-square tests** for categorical outcomes (medal won: yes/no) confirmed highly significant differences between host and non-host nations (X-squared=167.316, p<2e-16) - **Paired t-tests** demonstrated host countries significantly outperform their own historical baselines (t=2.892, p=0.007) - **Multiple testing approaches** (chi-square, proportion tests, t-tests) converged on the same conclusions, strengthening confidence in findings - Analysis spans 28,554 performances across 124 years, providing substantial statistical power

Key Statistical Findings: 1. **Overall home advantage**: 8.02pp increase in medal rate, 95% CI [6.44%, 9.59%] 2. **Gender-specific effects**: Both males (X-squared=153.609) and females (X-squared=20.180) show significant advantages, with dramatic temporal reversals 3. **Team size mechanism**: Host countries field 226% more gymnasts (p=0.002), a critical and highly significant finding 4. **Country size patterns**: Descriptive trends exist but lack statistical significance due to small sample sizes

What Makes This Evidence Compelling: - Extreme p-values (p<2e-16) indicate findings are not due to chance - Effect sizes are large and practically meaningful (doubling of medal rates) - Patterns persist across different statistical tests and subgroup analyses - The 226% increase in team size provides a measurable mechanism for advantage

Interpretation: While we cannot definitively prove judging bias (correlation does not equal causation), the consistent patterns across 124 years, multiple genders, and various statistical tests suggest home advantage is a **real, systematic phenomenon** worthy of serious consideration in discussions of Olympic fairness and judging integrity.

Most strikingly, the complete reversal of gender patterns - from dominant female advantage in early Olympics (34.07pp) to strong male advantage in modern games (8.88pp) - reveals that home advantage dynamics are not static but evolve with the sport itself. This 32.89 percentage point historical swing highlights the importance of continued monitoring and research into judging fairness in international athletic competition.

Statistical Recommendations for Future Research: - Larger samples needed for country size analysis (current n=4 for medium countries limits power) - Longitudinal tracking of chi-square statistics across Olympic cycles to detect trend changes - Score-level analysis (not just medal outcomes) to detect subtle judging differences - Extension of chi-square methodology to other subjectively-judged sports for comparison

8 References

[1] N. Sharma, “Olympics 124 years dataset till 2020,” Kaggle, 2020. [Online]. Available: https://www.kaggle.com/datasets/nitishsharma01/olympics-124-years-datasettill-2020

[2] P. Fomichev, “Olympic Games hosts,” Kaggle, 2022. [Online]. Available: https://www.kaggle.com/datasets/piterfm/olympic-games-hosts

[3] Our World in Data, “Population by age group,” 2023. [Online]. Available: https://ourworldindata.org/grapher/population-by-age-group

[4] Worldometers, “Largest countries in the world by area,” 2024. [Online]. Available: https://www.worldometers.info/geography/largest-countries-in-the-world/

[5] The World Bank, “GDP (current US$),” World Bank Open Data, 2024. [Online]. Available: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD

9 Appendix

9.1 R Session Information

```
sessionInfo()
```

```
## R version 4.5.1 (2025-06-13)
## Platform: aarch64-apple-darwin20
## Running under: macOS Tahoe 26.0.1
##
## Matrix products: default
## BLAS:   /Library/Frameworks/R.framework/Versions/4.5-arm64/Resources/lib/libRblas.0.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/4.5-arm64/Resources/lib/libRlapack.dylib;  LAPACK v
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## time zone: America/Chicago
## tzcode source: internal
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
##  [1] lubridate_1.9.4 forcats_1.0.1   stringr_1.5.1   dplyr_1.1.4
##  [5] purrr_1.1.0     readr_2.1.5     tidyr_1.3.1     tibble_3.3.0
##  [9] ggplot2_3.5.2   tidyverse_2.0.0
##
## loaded via a namespace (and not attached):
##  [1] Matrix_1.7-3       bit_4.6.0          gtable_0.3.6       crayon_1.5.3
##  [5] compiler_4.5.1     tidyselect_1.2.1   parallel_4.5.1     splines_4.5.1
##  [9] scales_1.4.0       yaml_2.3.10        fastmap_1.2.0      lattice_0.22-7
## [13] R6_2.6.1           labeling_0.4.3     generics_0.1.4     knitr_1.50
## [17] pillar_1.11.0      RColorBrewer_1.1-3 tzdb_0.5.0         rlang_1.1.6
## [21] stringi_1.8.7      xfun_0.53          bit64_4.6.0-1      timechange_0.3.0
## [25] cli_3.6.5          mgcv_1.9-3         withr_3.0.2        magrittr_2.0.3
## [29] digest_0.6.37      grid_4.5.1         vroom_1.6.6        rstudioapi_0.17.1
## [33] hms_1.1.4          nlme_3.1-168       lifecycle_1.0.4    vctrs_0.6.5
## [37] evaluate_1.0.4     glue_1.8.0         farver_2.1.2       rmarkdown_2.29
## [41] tools_4.5.1        pkgconfig_2.0.3    htmltools_0.5.8.1
```