

Research on Intercontinental Competitive Athletics Characteristics and Evolution Trend of Track and Field in Olympic Games

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Abstract: Track and field were the first event to enter the Olympics and has the largest number of gold medals. Understanding its more than one hundred years of Olympic history is strategically significant for the future sports development of all continents. Using statistical data from 27 Olympic Games between 1896 and 2021, an analysis was conducted using the Boston matrix method from economics. The results indicate that Europe and North America have reached saturation, Africa has made the fastest progress, Asia has rebounded after a 40-year trough, Oceania still has a long way to go, and South America is struggling. Global track and field sports have reached a state of "convergence," characterized by "the strong becoming stronger, the weak remaining weak, and a clear disparity between the strong and weak." In the future, the overall competitive structure is expected to maintain a stable dynamic balance cycle under the dominance of Europe, North America, and Africa.

Keywords: Summer Olympic Games; Track and Field; Medals; Intercontinental; Athletics Characteristic; Distribution Situation.

1. Introduction

The Olympic Games, the world's largest comprehensive sports event, have been held 32 times to date. Approximately 30,000 athletes from over 200 countries or regions have participated in the athletics events. Hosted by member countries of the International Olympic Committee every four years, the Olympics represent a continually evolving competitive system. The number of gold medals and the medal table are used as indicators to measure the athletic strength of regions and countries, with a reliability coefficient of 0.986 [1]. The number of gold medals primarily reflects the number of top-level athletes in each country, emphasizing "quality," while the total number of medals reflects the overall competitive strength and depth of the participating countries, focusing on "quantity" [2]. This study utilizes a combination of metrics, including medal share and growth rate across

different continents in athletics events from past Olympic Games, to analyze the distribution and evolution patterns of competitive strength. Based on the development status and competitive levels of different continents, corresponding development strategies are proposed.

2. Methods

Based on the "Olympic Athletics Data Handbook 2021 Edition" published by World Athletics and with reference to the stages of modern Olympic history as classified by Kanin [3], the century-long Olympic Games can be divided into four stages: (1st-5th, 7th-11th, 14th-21st, and 24th to present). The 6th, 12th, and 13th Olympic Games were not held due to wars, and the 22nd and 23rd Olympic Games were boycotted by many countries due to political issues between the Soviet Union and the United States. Therefore, this study does not include these five Olympic Games.

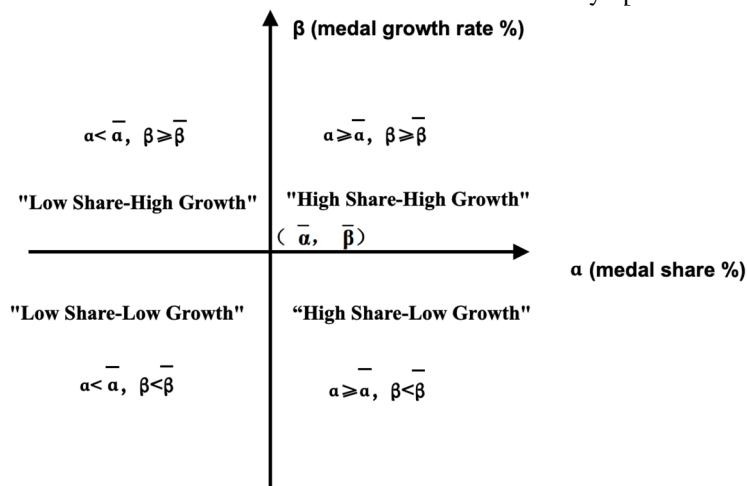


Figure 1. The Basis and Significance of Quadrant Division of BCG Matrix

Using one of the common Olympic medal scoring method, gold, silver, and bronze medals are assigned scores of 5, 3,

and 2 points respectively [4]. The total medal scores for each country or region in the Olympics are then calculated and summarized by continent (Central American countries are included in North America, and Antarctica is excluded). Let Δ represent the Olympic athletics system, and c represent a continent, thus dividing the system by continent $\Delta/c = \{\Delta_1, \Delta_2, \dots, \Delta_i\}$. Let X_t^i be the total medal score of continent i in year t , and define the medal share (α_i) and the medal growth rate (β_i) as follows:

$$\alpha_i = \frac{X_t^i}{\sum X_t^i} \times 100\% \quad \beta_i = \frac{X_t^i - X_{t-1}^i}{X_{t-1}^i} \times 100\%$$

When calculating β_i , if $X_{t-1}^i = 0$, indicating that the continent did not win any medals in the previous Olympics, then use $X_{t-2}^i = 0$ instead. If $X_{t-2}^i = 0$, continue substituting

with X_{t-3}^i , and so on until a non-zero value is found.

Using the Boston Matrix method commonly applied in economics, the average values of the medal share (α) and growth rate (β) are taken as the origin ($\bar{\alpha}, \bar{\beta}$). Based on the positions of $\Delta_i(\alpha_i, \beta_i)$ and ($\bar{\alpha}, \bar{\beta}$) in the matrix diagram, the competitive strength distribution types are classified into four categories: "High Share-High Growth" "High Share-Low Growth" "Low Share-High Growth" and "Low Share-Low Growth". After obtaining the relevant data, initial statistical analysis is performed using Excel, followed by plotting and further analysis with SPSS 26.0.

3. Results

Table 1. Medals and Scores of Participating Continent in the First Stage (1896-1912)

| Continent | North America | | | | Europe | | | | Africa | | | | Oceania | | | |
|-----------|---------------|--------|--------|-----|--------|--------|--------|-----|--------|--------|--------|----|---------|--------|--------|----|
| | Gold | Silver | Bronze | TS | Gold | Silver | Bronze | TS | Gold | Silver | Bronze | TS | Gold | Silver | Bronze | TS |
| 1st(1896) | 9 | 6 | 1 | 65 | 1 | 7 | 10 | 46 | | | | | 2 | 0 | 0 | 10 |
| 2nd(1900) | 17 | 13 | 11 | 146 | 6 | 10 | 8 | 76 | | | | | 0 | 0 | 3 | 6 |
| 3rd(1904) | 23 | 22 | 22 | 223 | 1 | 2 | 2 | 15 | | | | | | | | |
| 4th(1908) | 17 | 11 | 12 | 142 | 9 | 15 | 12 | 114 | 1 | 1 | 0 | 8 | 0 | 0 | 1 | 2 |
| 5th(1912) | 17 | 16 | 12 | 157 | 14 | 14 | 16 | 144 | 1 | 1 | 0 | 8 | | | | |

TS = Total Scores

Table 2. Medals and Scores of Participating Continent in the Second Stage (1920-1936)

| Continent | North America | | | TS | Europe | | | TS | Africa | | | TS | Oceania | | | TS | Asia | | | TS | South America | | | TS |
|------------|---------------|--------|--------|-----|--------|--------|--------|-----|--------|--------|--------|----|---------|--------|--------|----|------|--------|--------|----|---------------|--------|--------|----|
| | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | |
| 7th(1920) | 10 | 12 | 8 | 102 | 18 | 15 | 20 | 175 | 1 | 1 | 1 | 10 | 0 | 1 | 0 | 3 | | | | | | | | |
| 8th(1924) | 12 | 10 | 10 | 110 | 14 | 15 | 15 | 145 | 0 | 1 | 1 | 5 | 1 | 0 | 1 | 7 | | | | | 0 | 1 | 0 | 3 |
| 9th(1928) | 13 | 11 | 10 | 118 | 12 | 14 | 17 | 136 | 0 | 0 | 1 | 2 | | | | | 1 | 1 | 0 | 8 | 0 | 1 | 0 | 3 |
| 10th(1932) | 17 | 16 | 11 | 155 | 10 | 12 | 14 | 114 | | | | | | | | | 1 | 1 | 3 | 14 | 1 | 0 | 0 | 5 |
| 11th(1936) | 14 | 8 | 7 | 108 | 12 | 19 | 17 | 151 | | | | | 1 | 0 | 1 | 7 | 2 | 2 | 4 | 24 | | | | |

TS = Total Scores

Table 3. Medals and Scores of Participating Continent in the Third Stage (1948-1976)

| Continent | North America | | | TS | Europe | | | TS | Africa | | | TS | Oceania | | | TS | Asia | | | TS | South America | | | TS |
|------------|---------------|--------|--------|-----|--------|--------|--------|-----|--------|--------|--------|----|---------|--------|--------|----|------|--------|--------|----|---------------|--------|--------|----|
| | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | |
| 14th(1948) | 13 | 7 | 13 | 112 | 18 | 21 | 17 | 187 | | | | | 1 | 3 | 2 | 18 | 0 | 1 | 1 | 5 | 1 | 1 | 0 | 8 |
| 15th(1952) | 17 | 13 | 6 | 136 | 10 | 18 | 23 | 150 | 1 | 1 | 0 | 8 | 4 | 0 | 2 | 24 | | | | | 1 | 1 | 2 | 12 |
| 16th(1956) | 16 | 10 | 5 | 120 | 11 | 21 | 22 | 162 | | | | | 5 | 2 | 6 | 43 | | | | | 1 | 1 | 0 | 8 |
| 17th(1960) | 12 | 8 | 8 | 100 | 18 | 23 | 22 | 203 | 1 | 1 | 1 | 10 | 3 | 2 | 2 | 25 | 0 | 1 | 0 | 3 | | | | |
| 18th(1964) | 14 | 10 | 6 | 112 | 18 | 24 | 22 | 206 | 1 | 1 | 1 | 10 | 3 | 1 | 6 | 30 | 0 | 0 | 1 | 2 | | | | |
| 19th(1968) | 15 | 10 | 7 | 119 | 14 | 16 | 24 | 166 | 5 | 5 | 2 | 44 | 2 | 3 | 2 | 23 | 0 | 1 | 1 | 5 | 0 | 1 | 0 | 3 |
| 20th(1972) | 6 | 8 | 11 | 76 | 29 | 25 | 21 | 262 | 3 | 3 | 4 | 32 | 0 | 2 | 1 | 8 | | | | | 0 | 0 | 1 | 2 |
| 21th(1976) | 11 | 11 | 8 | 104 | 25 | 24 | 28 | 253 | | | | | 1 | 1 | 0 | 8 | | | | | 0 | 1 | 1 | 5 |

TS = Total Scores

Table 4. Medals and Scores of Participating Continent in the Fourth Stage (1988-2020)

| Continent | North America | | | TS | Europe | | | TS | Africa | | | TS | Oceania | | | TS | Asia | | | TS | South America | | | TS |
|------------|---------------|--------|--------|-----|--------|--------|--------|-----|--------|--------|--------|-----|---------|--------|--------|----|------|--------|--------|----|---------------|--------|--------|----|
| | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | | Gold | Silver | Bronze | |
| 24th(1988) | 13 | 9 | 7 | 106 | 22 | 28 | 31 | 256 | 5 | 3 | 3 | 40 | 1 | 1 | 0 | 8 | 0 | 0 | 1 | 2 | 1 | 1 | 1 | 10 |
| 25th(1992) | 15 | 14 | 17 | 151 | 21 | 17 | 16 | 188 | 5 | 9 | 5 | 62 | 0 | 0 | 3 | 6 | 2 | 3 | 3 | 25 | 0 | 0 | 1 | 2 |
| 26th(1996) | 16 | 10 | 11 | 132 | 17 | 20 | 20 | 185 | 7 | 9 | 10 | 82 | 0 | 2 | 0 | 6 | 2 | 3 | 2 | 23 | 2 | 0 | 1 | 12 |
| 27th(2000) | 11 | 14 | 14 | 125 | 22 | 19 | 20 | 207 | 9 | 8 | 12 | 93 | 1 | 2 | 0 | 11 | 3 | 2 | 0 | 21 | 0 | 1 | 1 | 5 |
| 28th(2004) | 15 | 14 | 10 | 137 | 21 | 19 | 24 | 210 | 6 | 10 | 7 | 74 | 0 | 1 | 2 | 7 | 4 | 1 | 1 | 25 | 0 | 1 | 2 | 7 |
| 29th(2008) | 16 | 17 | 16 | 163 | 16 | 13 | 16 | 151 | 11 | 11 | 8 | 104 | 2 | 3 | 1 | 21 | 0 | 3 | 3 | 15 | 2 | 1 | 2 | 17 |
| 30th(2012) | 18 | 21 | 15 | 183 | 14 | 13 | 15 | 139 | 8 | 7 | 11 | 83 | 3 | 1 | 0 | 18 | 3 | 6 | 5 | 43 | 1 | 1 | 0 | 8 |
| 31th(2016) | 21 | 17 | 18 | 192 | 11 | 9 | 14 | 110 | 9 | 11 | 6 | 90 | 0 | 2 | 4 | 14 | 4 | 5 | 5 | 45 | 2 | 3 | 0 | 19 |
| 32th(2020) | 16 | 17 | 17 | 165 | 19 | 15 | 15 | 170 | 8 | 7 | 8 | 77 | 0 | 1 | 4 | 11 | 4 | 4 | 2 | 36 | 2 | 3 | 2 | 23 |

TS = Total Scores

4. Discussion

4.1. Intercontinental Competitive Strength Distribution in the First Stage

From the 1st Summer Olympic Games in 1896 to the 5th

Summer Olympic Games in 1912 (hereinafter referred to as the "Summer Olympics"), the number of participating countries increased from 9 to 26. Except for Australia, South Africa, Turkey, and Japan, all participating countries were from Europe and North America. During this stage, Europe and North America demonstrated significant dominance, both classified as "High Share-High Growth" types. North

America's share was higher than Europe's, but its growth rate was lower. This was primarily because the 1904 Summer Olympics were held in North America for the first time, resulting in fewer European athletes participating due to long-distance travel and high costs, as well as concerns over the Russo-Japanese War in the Far East. Only six European countries or regions sent athletes to compete in athletics events, indirectly leading to a decrease in the number of medals and a subsequent surge in Europe's medal growth rate in the next Olympics. Oceania and Africa were both classified as "Low Share-Low Growth" types, with shares of 1.6% and 1.4%, respectively. Oceania's performance deteriorated during this stage, resulting in a negative growth rate of 50.7%. Africa won a gold medal in the 100m and a silver medal in the marathon at the 1908 Summer Olympics, and gold and silver medals in the marathon at the 1912 Summer Olympics, leading to a growth rate of 0%. Despite Japan and Turkey participating in the 1912 Summer Olympics, they did not win any medals. In the first stage of the Summer Olympics, global athletics displayed three levels of performance: "High, Medium, and Low." North America led significantly in medal count, occupying the high level. Europe, while trailing North America, still far surpassed Oceania and Africa, thus occupying the medium level. Africa and Oceania won very few medals, placing them at the low level.

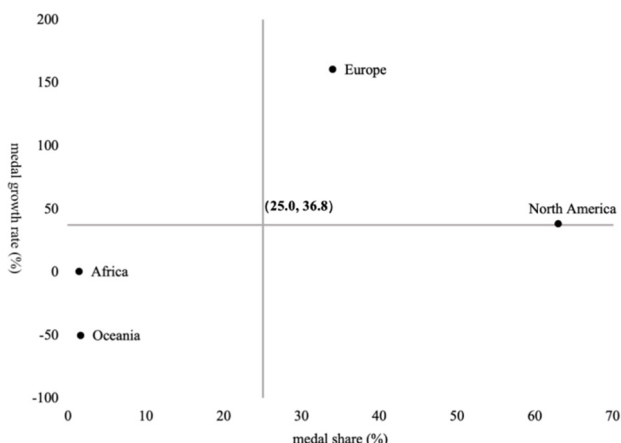


Figure 2. Distribution Situation of Intercontinental Athletic Power in the First Stage

4.2. Intercontinental Competitive Strength Distribution in the Second Stage

During this stage, Europe fully capitalized on the opportunity presented by the introduction of new events. For example, Finland achieved the remarkable feat of winning four consecutive titles in the men's 3000m steeplechase. This allowed Europe to maintain a "High Share-High Growth" status with a slight advantage. Although North America's USA and Canada were strong in events such as the women's 100m, high jump, and 4x100m relay, they could not compete with the broad distribution of European medal winners. Fourteen European countries won medals, demonstrating wide distribution, extensive coverage, and coordinated balance. Consequently, for the first time, Europe's medal share surpassed that of North America. However, due to North America's failure to continue its previous successes in the 7th to 11th Olympics, it experienced a negative growth rate of 3.8%.

Africa continued to decline, even facing the embarrassment of not winning any medals at the 11th Summer Olympics, thereby maintaining its "Low Share-Low Growth" status.

Oceania, thanks to Australia's 1 gold and 1 bronze in the triple jump and 1 gold in the 3000m race walk (only included as a Summer Olympics athletics event in 1920) and New Zealand's 1 gold in the 1500m and 1 bronze in the 100m, shifted to a "Low Share-High Growth" status. Asian countries began to emerge at the 9th Summer Olympics, with Japan winning 4 gold, 4 silver, and 5 bronze medals and the Philippines winning 2 bronze medals, showcasing a "Low Share-High Growth" trend and representing a new force and reserve power. South America remained in the "Low Share-Low Growth" category, winning only one medal in each of the three consecutive Olympics from 1924 to 1932, providing a glimmer of hope but indicating a long road ahead. The second stage of global athletics was characterized by the dominance of Europe and North America, with the two continents collectively capturing 92.9% of the medals and 93.6% of the gold medals.

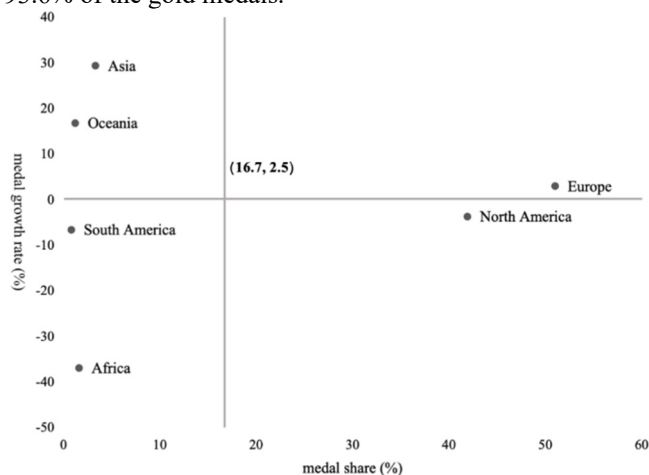


Figure 3. Distribution Situation of Intercontinental Athletic Power in the Second Stage

4.3. Intercontinental Competitive Strength Distribution in the Third Stage

North America has performed steadily but lacks depth. Apart from the United States and Jamaica, other medal-winning countries have shown intermittent performance. There is a disparity in strength among countries, with Cuba and Trinidad and Tobago acting as the core forces filling the gap, while countries like Panama and Canada are more fleeting in their success. Both the total number of gold medals and overall medals have seen significant reductions. North America has been in a "high share-low growth" situation for two consecutive stages, indicating it has reached a saturation point. During the third stage, Europe had 15 countries winning gold medals and 19 countries winning medals overall, creating a competitive scene with widespread success and diverse competition. At the 1972 Summer Olympics, Europe dominated the medal table and gold medal tally with an overwhelming advantage of 29 gold, 25 silver, and 21 bronze medals. The winning events were diversified, covering groups that included power, speed, endurance, and all-around events. Europe, particularly the Soviet Union, exhibited dominance in both gold and medal counts. The Soviet Union excelled in new Olympic events such as women's long jump, shot put, 800m, 1500m, and men's 20km race walk. This dominance is closely linked to the progress in natural and social sciences in Europe, which promoted the scientific, systematic, and theoretical development of sports training. For instance, in the 1950s, German cardiologist Reindell and instructor Beishler proposed interval training theory, and

Soviet scholar Verkhoshansky pioneered the method of super-long strength training. In the 1960s, Soviet sports training expert Matveev introduced the theory of periodization.

Africa turned around its previous decline by leveraging inherent advantages such as genetic traits and high-altitude environments to focus on its potential strengths. This strategy yielded immediate results in middle- and long-distance events, peaking at the 19th Summer Olympics with 5 gold, 5 silver, and 2 bronze medals. Africa transitioned to a "Low Share-High Growth" type, signaling its rise. Oceania, thanks to the impressive performances of Australia and New Zealand in short-distance events, maintained its position. Although Oceania remained a "Low Share-High Growth" type during this stage, it failed to win more than three medals in two consecutive Olympics from 1972 onwards. Without timely "remediation," it risked repeating past failures in the next

stage. Unexpectedly, Japan, which had performed well in the previous stage, saw a significant drop, winning only 1 silver and 1 bronze. The remaining 2 silvers and 2 bronzes were won by Sri Lanka, Turkey, and Chinese Taipei. This poor performance caused Asia to fall to a "Low Share-Low Growth" type, with both medal share and growth rate ranking lowest among all continents. Brazil's breakthrough in the triple jump (2 golds, 1 silver, and 3 bronzes) was a highlight but did not change South America's "Low Share-Low Growth" status. Moreover, the ratio of South America's gold medal share to total medal share was less than one-third, indicating a significant imbalance and a lack of top-level gold medal contenders. The third stage of global athletics continued the trend of "the strong becoming stronger, the weak remaining weak, with a stark contrast between the two."

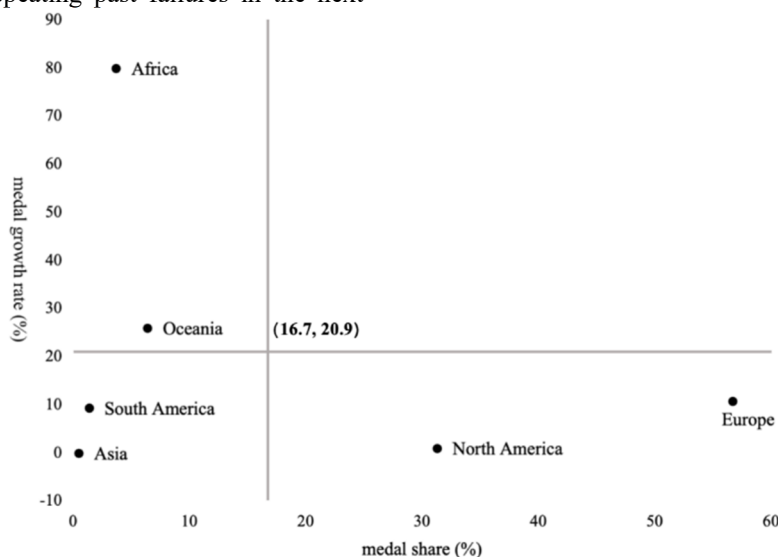


Figure 4. Distribution Situation of Intercontinental Athletic Power in the Third Stage

4.4. Intercontinental Competitive Strength Distribution in the Fourth Stage

In the early 1990s, Eastern Europe underwent significant changes with the dissolution of the Soviet Union and the reunification of Germany. Starting from the 1996 Atlanta Olympics, the former Soviet republics participated in the Summer Olympics as independent nations. During this stage, due to the dissolution of the Soviet Union and the Russian doping scandal, Europe's medal share exhibited an "inverted N" pattern over time. In contrast, North America's performance showed a "positive N" pattern, resulting in an "interwoven" medal share between the two continents. Both Europe and North America continued the "High Share-Low Growth" trend from the previous stage. However, their dominance was increasingly challenged by other continents, as their leading events were gradually encroached upon. Consequently, the combined medal share and gold medal share of the two continents decreased to 71.8% and 74.3%, respectively.

Ethiopia, Kenya, Uganda, and other African countries capitalized on the inclusion of women's 3000m steeplechase, 10,000m, and marathon events in the Olympics, significantly boosting Africa's medal share. The presence of "reigning champions" and "double champions" from these countries contributed to their continuous and collective success in long-distance events. Due to limited economic resources and conditions, African countries prioritized cost-effective events,

focusing on those with relatively lower demands on manpower and materials or those allowing athletes to compete in multiple events, achieving exceptional results with minimal investment. At the 2008 Beijing Olympics, Africa achieved its best historical performance with 11 gold, 11 silver, and 8 bronze medals, becoming the third continent to win double-digit gold medals in athletics. Many scholars consider the 29th Olympics a turning point in the competitive landscape of global athletics. African athletes dominated the 800m and 5000m events, securing the top three positions in both men's and women's categories. Beyond their monopoly in middle and long-distance events, they also made significant strides in the long jump, triple jump, and 4x100m relay, earning 1 gold and 3 silver medals. Africa's balanced medal distribution between male and female athletes, coupled with success in multiple events, allowed its medal share to exceed the average for the first time, positioning it in a "High Share-Low Growth" trend.

After 40 years of decline, Asia made a comeback at the 1992 Barcelona Olympics, winning 2 gold, 3 silver, and 3 bronze medals. This marked the beginning of a resurgence, gradually improving its standing and becoming the continent with the fastest medal growth rate. In the fourth stage, Asia became a "Low Share-High Growth" region, with the number of gold-winning and medal-winning countries increasing from 0 and 4 in the previous stage to 9 and 13, respectively. This stage saw countries such as Syria, Kazakhstan, Tajikistan, India, and South Korea hearing their national anthems on the

Olympic athletics podium for the first time. Additionally, countries like Saudi Arabia, Turkey, Iran, and Sri Lanka made brief appearances on the podium. Notably, China, Qatar, Bahrain, and Japan demonstrated consistent competitiveness in certain events.

South America's performance has been inconsistent, showing an overall upward trend, which places it in the "Low Share-High Growth" category. Countries like Colombia, Venezuela, and Brazil have excelled in jumping and racewalking events, pushing the growth rate above the average for the first time. However, due to the lack of standout gold medal contenders, South America still ranks lowest in medal share. Oceania's medal share is similarly low at 2.5%, primarily because it consists of fewer countries, with only Australia and New Zealand winning medals. The athletic career span of top athletes is approximately 8-12 years, allowing participation in 2-3 Olympic Games[5-6]. However, Oceania's athletes struggle to maintain peak performance, often lacking successors in medal-winning events from previous games. Most medals come from sporadic, exceptional talents, making it difficult to sustain success. After nearly a century of changes in the competitive landscape, Oceania has reverted to a "Low Share-Low Growth" status, similar to its position in the first stage.

In the fourth stage, global athletics has reached a "convergence" state. This occurs due to the law of diminishing marginal returns, where initially developed countries experience slower growth, while later-developing countries gain development opportunities and catch-up advantages, thereby reducing the development gap and ultimately achieving convergence [7]. During this stage, Europe, North America, and Africa together hold 91.0% of the total medal share, firmly controlling the overall landscape of world athletics. Meanwhile, Asia, South America, and Oceania share the remaining 9.0% of the medals, highlighting the significant disparity in strength between the groups and the difficulty in forming a strong counterbalancing force.

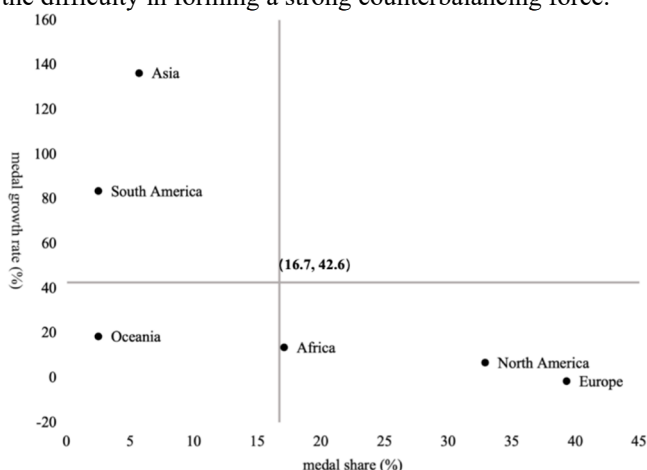


Figure 5. Distribution Situation of Intercontinental Athletic Power in the Fourth Stage

5. Conclusion

The distribution of competitive strength among continents has shifted from severe polarization in the first stage to the current more stable "inverted pyramid," reflecting a dynamic development process. Europe and North America have moved from "high share-high growth" to "high share-low growth," indicating saturation. Africa has shown the most significant improvement, transitioning from "low share-low growth" to "high share-low growth." Asia has followed a "V" development pattern, moving from "low share-high growth" to "low share-low growth" and back to "low share-high growth." Oceania still faces a long road to significant improvement, exhibiting an "inverted V" trend. South America continues to struggle, lacking medal competitiveness.

The number of participating countries (or regions) remains around 200, with the ratio of gold medal-winning countries to medal-winning countries fluctuating around 1:1.5. World athletics has reached a "convergence" state, where "the strong get stronger and the weak remain weak," resulting in a clear distinction between the strong and the weak. In the future, the overall competitive landscape is expected to maintain a stable dynamic balance, predominantly under the control of Europe, North America, and Africa.

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