Olympic "Great Coach" Effect Impact Model Based on Propensity Score Matching

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Abstract. Against the backdrop of increasingly fierce global Olympic competition, coaches, especially "great coaches" with outstanding achievements and transnational coaching experience, are considered to be key factors in improving project breakthroughs and medal output. This paper uses Lang Ping and Bella Karolyi as representative cases to construct the "great coach effect" hypothesis and evaluate its causal impact on the number of Olympic medals based on the propensity score matching (PSM) method. The study first quantifies the performance differences before and after the coaching through Olympic medal data, and then constructs a treatment group and a control group to eliminate interference variables, and empirically verifies the significant positive effect of "great coaches" on medal growth. The study not only fills the quantitative gap of individual coach factors in sports policy evaluation, but also provides replicable methodological support for future countries in coach introduction and strategic layout.

Keywords: Great coach effect; Olympic Games; Medal output; Propensity score matching; Sports strategy.

1 Introduction

Against the backdrop of increasingly fierce global sports competition, the Olympic Games are not only a concentrated display of the sports level of various countries, but also a symbol of a country's comprehensive strength and international influence [1, 2]. However, in this system, coaches, especially "great coach" with rich experience and outstanding achievements, are often regarded as the key factor in leading projects to break through bottlenecks and achieve medal leaps [3]. How to scientifically evaluate the actual impact of great coach and identify their marginal contribution to medal output has become an important issue in sports strategic management and policy formulation. In-depth research on “great coaches” is not only conducive to revealing the human capital effect in elite sports, but also provides empirical references for national strategies in coach selection, international cooperation, and the improvement of athletic competitiveness. Understanding their influence may offer a unique lens through which to interpret the subtle drivers behind national sports performance in global competitions.

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From the perspective of academic research, existing scholars have accumulated relatively rich theoretical and empirical results in the study of factors affecting sports performance, mainly focusing on three directions [4-9]: First, the economic perspective emphasizes the input-output relationship, and believes that there is a significant positive correlation between sports investment, athlete human capital accumulation and medal output; second, organizational behavior focuses on teamwork and leadership, and believes that great coaches can significantly improve team cohesion and combat capability; third, data science methods use tools such as machine learning to predict medal distribution, but most models focus on national factors and ignore personal factors of coaches. In general, the current quantitative research on the "great coach effect" is still in its infancy, lacking both unified measurement standards and comparable empirical results. In particular, in terms of considering interference variables and dealing with sample selection bias, related research still has obvious deficiencies.

This paper takes the Olympic events coached by Bella Karolyi and Lang Ping as representatives, and based on the medal data of previous Olympic Games, preliminarily identifies the medal change trend of the events before and after their coaching, and proposes the hypothesis of "great coach effect". Subsequently, this paper uses the propensity score matching method to construct a control group and a treatment group to identify the causal effect of great coaches on medal output. This study not only provides empirical evidence for the existence or non-existence of the "great coach effect", but also attempts to construct a quantitative analysis framework applicable to other competitive events and countries, providing methodological support for the promotion of the "great coach strategy" on a wider range in the future. Overall, this study not only has theoretical value, but also provides a practical reference for the country to optimize resource allocation and strengthen coach training and introduction mechanisms in its competitive sports development strategy.

2 Methodology

2.1 Data Collection and Preprocessing

In order to identify and quantify the impact of the "great coach effect" on the number of Olympic medals, this paper selects two representative "great coaches" - Lang Ping and Béla Károlyi as research objects, representing typical transnational coaching cases in volleyball and gymnastics respectively. The data source mainly includes the medal statistics of previous Olympic Games released by the official website of the International Olympic Committee. To ensure the validity of the econometric model and the comparability of the samples, this paper conducted the following preprocessing after data collection: First, the medal data of each country in the relevant years were standardized to ensure the comparability of data between different years; second, a binary treatment variable was constructed, with "great coach coaching" set to 1 and "non-great coach coaching" set to 0, so as to facilitate grouping in the subsequent propensity score matching (PSM); third, the years of absence from the Olympics due to special circumstances such as war and ban were excluded to avoid the interference of extreme values

on the model estimation results; finally, the control variables such as project medal history and host country effect were normalized to provide a basis for model matching.

2.2 Model Construction

In order to scientifically evaluate the impact of the "great coach effect" on the number of Olympic medals, this paper uses the Propensity Score Matching (PSM) modeling analysis [10, 11]. This method simulates a quasi-natural experiment by constructing a "treatment group" and a "control group" that are similar in covariates, and identifies the causal effect of the treatment variable "whether there is a great coach" on the number of medals.

Estimation of Propensity Score. To estimate the probability of an individual accepting treatment, that is, the propensity score, this paper uses a logistic regression model. Specifically, we include covariates such as (i) previous Olympic medal performance of the country in the same sport, (ii) historical cumulative medals in that event, (iii) whether the country is the host, and (iv) average global performance trend in the sport during that period. After estimating the scores, we implement 1:1 nearest neighbor matching without replacement, with a caliper of 0.1 to avoid poor matches. We further check the covariate balance before and after matching to ensure comparability, using standardized mean difference (SMD) as a diagnostic metric. This helps to ensure that the treatment and control groups are well matched and mitigate selection bias.

$$\begin{aligned} e(X_i) &= \Pr(D_i = 1 | X_i) \\ &= \frac{1}{1+\exp(-\beta_0 - \beta_1 X_{1i} - \beta_2 X_{2i} - \cdots - \beta_k X_{ki})} \end{aligned} \tag{1}$$

where D_i indicates whether unit *i* is in the "great coach" state. X_i represents the set of covariates, including: the number of medals won by the country in the previous Olympic Games, the cumulative value of historical medals won by the country in the previous Olympic Games, whether it is the host country (0/1 dummy variable) and other information.

After the logistic model is estimated, the propensity score $e(X_i)$ is obtained for each observation unit *i*.

Sample Matching and ATT Estimation. After the propensity score calculation is completed, this paper uses the nearest neighbor matching method (Nearest Neighbor Matching) to pair similar samples, that is, for each treatment group unit *i*, find the control group unit *j* with the closest propensity score, so that:

$$j = \arg \min_{j \in \{D_j = 0\}} \left| \hat{e}(X_i) - \hat{e}(X_j) \right| \tag{2}$$

After pairing, the average treatment effect (ATT, Average Treatment Effect on the Treated) is calculated as follows:

$$ATT = \frac{1}{N_T}\sum_{i\in T}\left(Y_i^1 - Y_j^0\right) \tag{3}$$

where T is the set of all treatment group samples, NT is the number of samples; Y_i^1 is the actual number of medals of the treatment group unit, and Y_j^0 is the number of medals of the matched control group unit.

3 Results

We used Python software to solve the model and quantified the number of medals won in Olympic sports coached by two coaches. We set the gold, silver and bronze awards at 10, 3 and 1 points respectively, with no points for the rest. Of course, we also took into account the existence of team events, and we averaged their scores to avoid repeating scores and causing a large deviation in the quantification of awards. The result of "Great Coach" effect impact are show in Fig. 1 and Table 1.

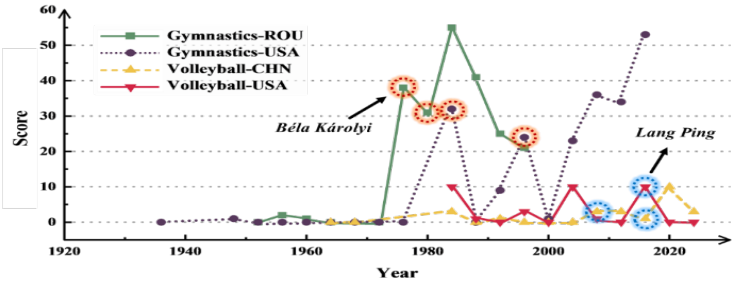

Fig. 1. Identification of key indicators.

From Fig. 1, we can see that before 1984, the ROU award score had been in a very low situation. However, in 1984, under the guidance of Bela Karolyi, scores have exploded, and it can even be said that in gymnastics, ROU has taken a place. Since then, ROU has also achieved better results in this sport. The same is true for the USA, where the results were very low and then there was a sharp rise. As for Lang Ping, the effect on her in this figure is not very prominent. It can only be said that it is guided by the general trend, and the strength of its effect needs to be analyzed further.

Table 1. The impact of excellent coaches on the number of medals won

Sport	Weighted medals	Increase (%)
China Volleyball	73.52	158.17
American Volleyball	174.00	-589.70
Romania Gymnastics	507.25	21919.68
American Gymnastics	336.00	4200

Table 1 provide key insights when analyzing the impact of “great coaches” on medal counts in various sports. The Chinese women’s volleyball team increased its medal count by 158.17% under the guidance of Lang Ping, indicating that her coaching played a significant role in improving the international competitiveness of the team. However, the situation is very different for the US women’s volleyball team, which had a growth rate of -589.70% despite a weighted medal count of 174.00. This may reflect that in a specific period, despite the involvement of great coaches, the team failed to achieve the expected results. Several factors may contribute to such variation, including: (i) the existing talent pool and pipeline in the coached country, (ii) cultural adaptability and communication style of the coach, (iii) administrative support and training infrastructure, and (iv) the duration of the coach’s tenure. For example, Lang Ping's effectiveness in China benefited from strong national sports support and a historically successful volleyball program, while her time in the U.S. might have faced cultural and systemic constraints that limited her impact. For the Romanian women’s gymnastics team, Bela Karolyi’s coaching was obviously very effective, with a medal count increase of 21949.68%. Similarly, the US women’s gymnastics team increased its medal count by 4200.00% under the leadership of Bela Karolyi. This result demonstrates his outstanding contribution to the American gymnastics community and shows that his coaching strategy has successfully improved the overall strength and international competitiveness of the American women's gymnastics team. This significant growth may also be related to the booming development of American gymnastics and the strengthening of system support. Overall, the effect of "great coaches" varies in different countries and events.

4 Conclusion

This study constructed an Olympic "great coach" effect impact model based on the propensity score matching method. By analyzing the coaching data of two outstanding coaches, Bella Karolyi and Lang Ping, the coaching effects of them in different countries and events were quantified. The results show that the impact of "great coaches" on the number of Olympic medals varies from country to country and event to event. Some events have achieved significant medal growth under the guidance of "great coaches", but there are also individual events that have failed to achieve the expected results. Future research can further expand the sample range. Meanwhile, policymakers and national sports authorities can take several strategic actions based on this study’s findings [12, 13]: (1) Prioritize long-term strategic appointments of experienced international coaches in underperforming events; (2) Establish cross-cultural training and support systems to improve coach-team integration; (3) Leverage data analytics to monitor coaching effectiveness in real time; (4) Foster domestic “great coaches” through mentoring and international exposure programs. These strategies can help countries maximize the value of coaching investments and build sustainable competitive advantages.

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