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Competitive balance and medal distributions at the Summer Olympic Games 1992-2016: Overall and gender-specific analyses

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Abstract

This article examines competitive balance at the Summer Olympic Games between 1992 and 2016 by measuring the distribution of gold medals, medals and medal points among nations. The analysis differentiates between all competitions, and competitions for male and female athletes. Five competitive balance-related performance indicators were used – a normalised version of the Herfindahl-Hirschman Index (HHIN), proportion of gold medal-winning nations (PGMWN) and proportion of medal-winning nations (PMWN), coefficient of variation (CV) in nations' market share, and concentration ratios (CR). The key findings are overall, there has been no improvement in competitive balance since the 1992 Olympics. There is some evidence that competitive balance has improved in male competitions, as shown by decreased HHIN, CV and CR4 values. The analysis of female competitions suggests that competitive balance has remained largely unchanged. However, the CV Gold indicator provides evidence of a significant decline in competitive balance. The findings facilitate a more evidence-based evaluation of

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existing policy measures and strategies, and their refinement where appropriate. Policy suggestions are proffered for the International Olympic Committee (IOC) and various International Federations (IFs), and non-major nations to promote a more balanced development and competition particularly for women.

Keywords: Summer Olympic Games; competitive balance; (gold) medal distribution; male competitions; female competitions

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Introduction

The Olympic Games, as the most influential international sports event, has spawned widespread government interest and investment. The concomitant intensification of competition at the Summer Olympic Games was described by Oakley and Green (2001, quoted in De Bosscher, Bingham, Shibli, Van Bottenburg & De Knop, 2008, p. 13) as a "global sporting arms race". However, the distribution of medals has been largely concentrated amongst a small number of "major" sports powers (Houlihan & Zheng, 2013, p. 347). This skewed pattern of medal distribution is likely to impair the long-term development of the Olympic Games as an international event. But there is little research quantifying the distribution of medals at the Summer Olympic Games. None includes the most recent 2016 Olympic Games and gender-specific analyses are not available. This is incommensurate with the burgeoning number of female events following the gender equity campaign of the International Olympic Committee (IOC).

Competitive balance in sport is the extent to which participants (i.e. individuals or teams) are evenly matched (Fort & Quirk, 1995). Competitive balance is desirable because, according to the outcome uncertainty hypothesis (Rottenberg, 1956), higher levels of competitive balance stimulate increased match attendances, television audiences, overall interest and revenues (Knowles, Sherony & Haupert, 1992; Rascher, 1999; Szymanski, 2002; Weber et al., 2016). However, despite the increased number of studies exploring medal distributions and competitive balance at various sports events (e.g., at the Commonwealth Games, Ramchandani & Wilson, 2014; at the Winter

Olympic Games, Weber, Kempf, Shibli & De Bosscher, 2016) or in particular sports (e.g., in athletics, Truyens, De Bosscher & Heyndels, 2016; in boxing, Chaplin & Mendoza, 2013; 2017), there is a dearth of research that comprehensively analyses the distribution of medals amongst nations at recent Summer Olympic Games, including the distribution of medals amongst nations in male and female competitions. This research bridges this research gap.

It is timely to conduct an analysis of Olympic medal distributions. The quantification of the distribution of medals at the most recent Summer Olympic Games provides the IOC and various International Federations (IFs) of Summer Olympic sports with empirical evidence to monitor the competitions, and to evaluate the effectiveness of their policy initiatives to facilitate the medal winning prospect of a large number of "medium" and below-medium nations including many small states (Houlihan & Zheng, 2015). According to Houlihan and Zheng (2013, p. 346), "medium" powers refer to non-top ten nations that won "at least two gold medals at a single Summer Olympic Games" at least twice between 1992 and 2016. The underlying philosophy is that competitive imbalance is detrimental to the long-term prosperity of the Olympic Games, because it erodes outcome uncertainty, negatively affects public interests and hence broadcasting and match attendance, and discourages a large number of non-major nations from investing in or even passionately participating in the Olympic Games, and therefore adversely affects the international status of the Olympic Games in general and certain specific Olympic sports and disciplines (Truyens, De Bosscher & Heyndels, 2016). As a result, a more balanced and diverse distribution of (gold) medals would be appealing to

the IOC, which pursues "an exciting sporting event that reflects genuine global competition" (Weber, Kempf, Shibli & De Bosscher, 2016, p. 400).

In addition, a more thorough understanding of the latest Olympic medal "configuration" provides a salient global context for nations to (re)position themselves and respond in a more evidence-based way to achieve better (gold) medal performances. This research is likely to also advance Olympic medal analysis-related research. This research will provide elite sport policy and management researchers with more concrete and up-to-date quantitative data suitable for comparative studies.

This paper comprises six sections. This introductory section is followed by a literature review section which defines competitive balance, highlights the importance of competitive balance in sport competitions and critically summarises existing studies on competitive balance. The subsequent section clarifies research methods employed in this article. Details on data collection and analysis are provided. After this, overall and gender-specific results in relation to competitive balance trends of gold medals, medals and medal points are presented. The penultimate section further discusses the results generated, and makes comparisons on competitive balance levels between overall, male and female competitions and between different indicators applied. Underlying explanations are explored. Moreover, this section compares the competitive balance and medal distributions at the Summer Olympic Games with research on other events. Some existing examples from various nations and IFs are introduced to afford some possible solutions. The paper concludes with a discussion of the IOC's efforts to promote competitive balance at the Summer Olympic Games, the limitations of the study and suggestions for future research.

Literature review: Competitive balance in sport competitions

This research is underpinned by the concept of competitive balance. Competitive balance occurs within an industry when no single organisation outperforms any of its competitors. According to Fort and Quirk (1995), competitive balance refers to the extent to which competitors are evenly matched. In other words, competitive balance measures if all teams/participants have equal playing strengths (Scully, 1989).

A higher level of competitive balance contributes to increased outcome uncertainty, which is usually associated with an increase in match attendances, television audiences, overall interest and revenues particularly in terms of but not limited to sponsorship and broadcasting (Knowles, Sherony & Haupert, 1992; Rascher, 1999; Szymanski, 2002; Weber et al., 2016).

Within the literature, there are two distinct but related streams of competitive balance studies related to sport. These are analysis of competitive balance (ACB) and uncertainty of outcome hypothesis (UOH). As O'Reilly, Nadeau and Kaplan (2011, p. 73) highlighted, 'competitive balance (CB) is arguably the strongest determinant of league profitability in professional sport'. Increases in inequality between leagues lead to competitive imbalance, which is detrimental to the welfare of the sport consumers/fans and therefore league revenues (Schmidt & Berri, 2001). Consumers/fans are most attracted to a contest if the outcome is uncertain, which also contributes to a distinctive aspect of the appeal of sport marketing (Parks, Quarterman & Thibault, 2011). For example, research by Trung, Booth, Brooks and Schnytzer (2015) established a correlation between television audience demand and match uncertainty in the Australian Football League. This observation bolstered previous finding by Gan, Yuggle, Mitrook,

Coussement and Zillmann (1997), who identified that the enjoyment of the National Collegiate Athletic Association (NCAA) Men's basketball tournament by male student viewers was underpinned by outcome uncertainty. Madrigal's (1995) research on fans' event attendance in the context of women's university basketball games also confirmed the impact of expectancy disconfirmation, a proxy for outcome uncertainty, on fan satisfaction and enjoyment. Because consumers and fans are central to the value of broadcasting, merchandising and sponsorship agreements, a lack of outcome uncertainty poses a threat to the long-term development or even survival of the respective sports events. Competitive imbalance impairs the growth of the sport and event (Schmidt & Berry, 2001).

Despite traditionally being discussed in the context of professional sports leagues, the utility of competitive balance and outcome uncertainty is by no means confined to professional leagues. Multi-sport sports events such as the Olympic Games, the FIFA World Cup and the Commonwealth Games are also reliant upon participating nations' engagement, global spectators, sponsors and broadcasters for long-term development and prosperity. The importance of competitive balance in these multi-sport events is reflected in the number of recent academic studies exploring competitive balance at the Summer and Winter Olympic Games, the Commonwealth Games and sport-specific World Championships. However, previous competitive balance studies for these events are either anachronistic, or centred on only a small number of sports. Tcha and Pershin (2003) investigated the Revealed Comparative Advantage (RCA) of nations between 1988 and 1996. Truyens et al. (2016) examined competitive balance of athletics at the Olympics between 2000 and 2012. Forrest, McHale, Sanz and Tena (2017) examined

the distribution of medals for nations in 15 individual sports at the Summer Olympic Games between 1992 and 2012, and observed a significant positive correlation between income and Olympic medals, and more equal medal distributions in sports practised in multi-sports settings. However, the distribution patterns at the most recent Olympic Games (Rio de Janeiro 2016) remain absent from any study. In addition, Baimbridge (1998) explored the outcome uncertainty in sporting competition using the Summer Olympic Games (1896-1996) as a case study, while Chaplin and Mendoza (2013) focused on competitive balance in Olympic boxing during the period 1904-2012. Both studies highlighted that a small number of nations have a dominant market share of Olympic medals in general and in Olympic boxing specifically.

There are more complete examinations of competitive balance for the Winter Olympics and the Commonwealth Games. For example, Otamendi and Doncel (2014) analysed medal distributions at the Winter Olympics between 1992 and 2010, highlighting the different medal concentrations amongst differing sports. In addition, Weber et al. (2016) explored the competitive balance of six disciplines at the seven most recent Winter Olympic Games from Albertville 1992 to Sochi 2014. Biathlon and short track speed skating manifested the most notable changes in competitive balance. Ramchandani and Wilson's (2014) research on competitive balance at the Commonwealth Games included all editions between 1930 and 2010, finding a significant deterioration in competitive balance from 1930 to 1990, and a more balanced competition amongst male athletes compared to their female counterparts. Finally, Chaplin and Mendoza (2017) analysed the competitive balance in boxing at the Commonwealth Games. They identified a general trend of greater competitive balance

from the 1930s through 1970s, a sharp decline in competitive balance in the 1980s and a steady deterioration of competitive balance since the 1990s.

In brief, despite a recent rise in the number of studies on Olympic medal analyses, a comprehensive analysis of medal distributions amongst nations at the recent Summer Olympic Games, which has important implications for the future decision making of the IOC, is not available. Additionally, gender-specific medal distribution pattern changes and competitive balance trends at the most recent Summer Olympic Games are both relatively uncharted territories.

Accordingly, this paper analyses competitive balance at the seven most recent Summer Olympic Games (from Barcelona 1992 to Rio de Janeiro 2016). More specially, the paper is structured around the following two research questions: 1) How has the overall distribution of gold medals, all medals and medal points across nations changed between 1992 and 2016? and 2) How has this distribution changed for male and female competitions (and gender comparisons).

Methods

Data collection.

A database of every Summer Olympic medal awarded between 1992 and 2016 was constructed using data collected from the IOC website (https://www.olympic.org/olympic-results). There were 6,400 medals awarded (2,040 gold, 2,042 silver and 2,318 bronze) during this period. The database was compiled in November 2016 and hence it does not reflect any subsequent decision to withdraw and/or re-allocate medals after this date.

The Barcelona 1992 Olympic Games was selected as the starting point because it heralded an era largely free of boycotts and significant changes to participating nations. More specifically, there were major nations absent at Moscow 1980 (e.g., the USA and China), Los Angeles 1984 (e.g., Soviet-Union-led Eastern Bloc nations) and Seoul 1988 (e.g., Cuba). Therefore, the medal distribution pattern at Moscow 1980, Los Angeles 1984 and Seoul 1988 may not reflect the genuine configuration amongst nations. For example, if Soviet Union participated in the 1984 Olympics, then the medal distribution in weightlifting and artistic gymnastics would have been significantly different, with a consequential impact on the overall medal tally for China and the USA. This also applied to Cuba's absence from Seoul 1988 and the concomitant impact on the medal distribution pattern of boxing. Moreover, Barcelona 1992 was the first Olympic Games held in the post-Cold War era, following the division of the former Soviet Union, former Yugoslavia and Czechoslovakia. The number of nations participating in the Olympic Games has remained relatively stable since 1992.

Performance measures. The study draws on three performance measures for each nation – the total number of gold medals, medals, and medal points. Medal points are calculated by awarding three points for each gold, two points for each silver and one point for each bronze medal awarded. This formula for medal points calculation is inspired by and consistent with most existing studies on elite sport success analysis (Balmer, Nevill & Williams, 2003; Chaplin & Mendoza, 2017; De Bosscher et al., 2008; De Bosscher, Shibli, Westerbeek & Van Bottenburg, 2015; Ramchandani & Wilson, 2014; Truyens et al., 2016). For mixed gender events, the weight or proportion of (gold) medals and points awarded to each gender is proportional to the ratio of male and

female athletes of each nation. For example, in mixed-doubles badminton, male and female athletes are each awarded half of the (gold) medals and medal points.

Data analysis: Indicators of competitive balance.

The research uses five indicators of competitive balance – a normalised version of the Herfindahl-Hirschman Index (HHIN); proportion of gold medal-winning nations (PGMWN) and proportion of medal-winning nations (PMWN); coefficient of variation (CV) in nations' market share; and two types of concentration ratios (CR). When used in combination, these indicators provide a comprehensive examination of competitive balance at the most recent Summer Olympic Games.

(Normalised) Herfindahl-Hirschman Index. This study employs a normalised version of HHI (HHIN). The HHI is a well-established measure of market concentration (Forrest et al., 2017; Otamendi & Doncel, 2014; Ramchandani & Wilson, 2014; Truyens et al., 2016). The HHI for each single Olympic Games is the sum of the squared market shares of each nation. The market share refers to each nation's share of the medals awarded (Shibli, 2003). HHI is calculated as follows:

$$HHI = \sum_i MS_i{}^2$$

The rationale for using HHIN is that the conventional HHI measure is sensitive to changes in the number of nations competing. HHIN can address this issue. HHIN is more prevalent in existing research on competitive balance in various sports events, evidenced in studies of medal distributions at the Commonwealth Games (Ramchandani & Wilson, 2014) and in Olympic and World Championships table tennis competitions (Zheng, Oh, Kim, Dickson & De Bosscher, 2018).

The HHIN formula for each edition is:

$$HHIN = \frac{(HHI - \frac{1}{N})}{(1 - \frac{1}{N})}$$

In this study, N refers to the number of all participating nations, including those failing to win an Olympic medal. The underlying logic is that every participating nation is eligible to win a medal as long as they are represented at the Olympic Games (Forrest, et al, 2017). HHIN is calculated using each of the three performance indicators for overall, male and female competitions, and applies to all specific editions. The range of the HHIN is between 0 and 1, and a high HHIN is the result of a large concentration of success among a small number of nations.

Proportion of (gold) medal-winning nations. P(G)MWN is calculated by dividing the number of nations that won a gold medal or a medal of any colour in a given edition by the number of participating nations. The P(G)MWN indicator can range from 1/N to 1, where N is the number of participating nations. A high P(G)MWN indicates a high level of competitive balance, and a de-concentrated market. P(G)MWN has been applied in sports research, featuring in recent studies of performance variation at the Commonwealth Games (Ramchandani & Wilson, 2014) and competitive balance in athletics at the Olympic Games and World Championships (Truyens et al., 2016).

Coefficient of variation. CV is a pervasive indicator of data dispersion defined as the ratio of standard deviation to the mean (Ramchandani & Wilson, 2014; Truyens et al., 2016). The CV formula divides the standard deviation by its mean. In this paper, N includes all participating nations, irrespective of whether they won a medal. The underlying premise of this decision is that every participating nation is granted the

opportunity to win a medal as long as they participate in the Olympic Games (Forrest, et al, 2017). A low CV indicates a clustering of data around the mean (i.e. equality amongst nations and hence competitive balance) whereas a high CV indicates more dispersion (i.e. inequality amongst nations and competitive imbalance).

Concentration ratios. CR4 and CR10 are the respective sums of the market shares of top 4 and top 10 nations in a given edition (Truyens et al., 2016). A higher CR indicates a higher level of concentration of gold medals, medals or medal points and therefore less competitive balance.

The competitive balance indicators for each of the seven Olympic Games were calculated in Microsoft Excel. After transferring data into SPSS (Version 24), a Spearman rank-order correlation coefficient (two-tailed) between the time and each performance measure (gold medals, medals and medal points) was performed. Spearman correlation was selected for its suitability for non-parametric data. Pearson correlation is best suited for parametric data (Gratton & Jones, 2010). Spearman rank-order correlation, or correlation with time, was applied in recent studies of medal distributions at international sport events (Ramchandani & Wilson, 2014; Truyens et al., 2016; Zheng et al., 2018). More specifically, the correlation is focused on the chronological trends of medal distributions from 1992 (edition 1) to Rio de Janeiro 2016 (edition 7). In other words, 1-7 are only symbols of the editions of the seven respective Summer Olympic Games rather than examining the correlation between two meaningful sets of data variable, such as between financial figures and medal performances.

A negative correlation for all HHIN, CV and CR results indicate a trend towards an increased level of competitive balance. In contrast, a negative correlation for

PGMWN and PMWN signifies a decline in competitive balance (i.e., a more concentrated market for medals).

Results

All competitions

It is apparent from Table 1 and Table 2 that there are no significant changes to HHIN, PGMWN, PMWN, CV or CR indicators between Barcelona 1992 and Rio de Janeiro 2016. Although ultimately insignificant, it is evident that, overall, the Spearman correlations between medal measures and time were negative, indicating a trend towards increased competitive balance.

**** Table 1 near here****

**** Table 2 near here****

Male competitions

For male-specific medal performances at the Summer Olympic Games during the period 1992-2016, all indicators again trended towards an increased competitive balance. HHIN Medals (ρ = -0.964, p = 0.000) and HHIN Medal points (ρ = -0.964, p = 0.000) had a statistically significant increase in competitive balance. Positive correlations were evident in PGMWN and PMWN, but none were significant. The negative correlations for CV Medals (ρ = -0.857, p = 0.014) and CV Medal points (ρ = -0.929, p = 0.003) are significant, indicating an increased competitive balance of distribution of medals and medal points amongst nations. Similarly, significant negative correlations were found in

CR4 Medals (ρ = -0.857, p = 0.014), CR4 Medal points (ρ = -0.893, p = 0.007). None of the CR10 results achieved significance (see Table 2).

Female competitions

According to Table 1, there were no significant HHIN trends for female competitions. All correlations are positive, indicating that generally the competitive balance decreases. CV Gold (ρ = 0.821, p = 0.023) provided a significant positive correlation, reflecting a decreased competitive balance in the distribution of gold medals. None of the PGMWN, PMWN, CV or CR indicators had significant changes (see Tables 1 and 2).

Discussion

This article studied the changes to competitive balance at the Summer Olympic Games between Barcelona 1992 and Rio de Janeiro 2016. The key findings are that overall, there has been no improvement in competitive balance since Barcelona 1992. There is some evidence that competitive balance has improved in male competitions, as shown by decreased HHIN, CV and CR4 values. The analysis of female competitions suggests that competitive balance has remained largely unchanged. However, the CV Gold indicator showed a significantly declined competitive balance. A possible explanation of the gender difference is that for male competitions, the number of gold medals and medals at each Olympics remained largely stable from Barcelona 1992 to Rio de Janeiro 2016 (169 gold medals in 1992 and 166.5 gold medals in 2016, and 536.25 medals in 1992 and 533.75 medals in 2016). The number of nations winning (gold) medals gradually increased from 1992 to 2016, which, in part, contributed to the improved

competitive balance in male competitions, measured by gold medals, medals and medal points. However, in comparison, the number of gold medals and medals for female competitions increased dramatically from Barcelona 1992 to Rio de Janeiro 2016 (from 91 gold medals in 1992 to 140.5 in 2016, and from 278.75 medals in 1992 to 440.25 in 2016). Yet, the number of (gold) medal winning nations only experienced a modest increase over the same period, despite the significant increase in the number of participating nations in female competitions. This indicates that most new participating nations in female competitions failed to share any (gold) medals and hence affects the CV result particularly CV Gold.

This research employs four general types of indicators – HHIN, P(G)MWN, CV and CR. Results of varying indicators are largely consistent in overall analyses, where all indicators demonstrate a convergent trend towards an insignificantly higher competitive balance for overall competitions over time. Male analyses indicate a significantly increased competitive balance in half of all indicators in particular in relation to the distribution of medals and medal points. Compared to CV, all three HHIN results indicate a stronger trend towards an improved competitive balance. Using different indices to measure the competitive balance is informative, because, as pointed out by Joo and Oh (2015), indicators using market shares such as HHI(N) have invariant results when the number of teams change, while indices using the ratio of deviation such as CV are amenable to the number of participants. It is important to note that HHI(N) focuses on “concentration” (Rhoades, 1993, p. 188), whilst CV concentrates on “dispersion” (Brown, 1998, p. 155). It is clear from Table 2 that CR10 Gold for male competitions experiences a near-significant trend towards

competitive balance, indicative of a less concentrated distribution of gold medals amongst top nations. This is reflected in the near-significant correlation result of HHIN Gold medals for male competitions (ρ = -0.679, p = 0.094) rather than CV gold medals which tend to be less sensitive to changes in concentration ratios. This explains the more significant trend in HHIN *vis-à-vis* CV.

In comparison, all three CV results for female competitions indicate a reasonable trend towards a declined competitive balance. This is in stark contrast with the insignificant trends towards an improved competitive balance observed in most other indicators including HHIN Medals and Medal points, and almost all CR indicators. In particular, CV Gold indicates a significant trend towards a reduced competitive balance. One explanation is that CV, which mainly measures dispersion, is more sensitive to the changes in the number of participating nations. The number of participating nations in female competitions increased from 133 at Barcelona 1992 to 202 at Rio de Janeiro 2016, whilst the increase in male competitions over the same period is notably more modest (from 169 in 1992 to 206 in 2016). However, it is apparent from Table 2 that CR10 Gold for female competitions remains largely stable over the same period. This means that despite the burgeoning number of participating nations, most nations fail to achieve an average level of achievements, and therefore there have been more nations deviating from the mean. Despite this difference, all these indicators are well-established statistical "mirrors" reflecting competitive balance applied in existing research literature. The slightly complementary nature of using different indicators facilitates a more thorough understanding of the changes of (gold) medals at the most recent Summer Olympic Games. This includes, for example, the concentration rates of

top nations, dispersion or deviation of nations' performances around the mean, and the proportion of (gold) medal-winning nations *vis-à-vis* their non-winning counterparts.

This research provides a thorough examination of the overall and gender-specific trends of the distribution of medals at the seven most recent Olympic Games. Comparing these findings to other studies is not easy. Weber et al's (2016) study focused on six particular disciplines at the Winter Olympic Games, and the most significant changes in competitive balance were observed in biathlon and short track speed skating. No overall or gender analysis was conducted. Similarly, Otamendi and Doncel's (2014) research centred on sport- and nation-specific analyses without overall or gender analyses to enable comparison of edition-specific results.

Ramchandani and Wilson (2014) analysed competitive balance at the Commonwealth Games. Key findings included the significant deterioration in competitive balance, and more competitive balance in male events compared to female and mixed events. Both overall and gender-specific results for HHIN medal points based on PMWN, CV and HHIN are clarified. For overall competitions, despite the consistency of an insignificant trend towards improved competitive balance, the HHIN Medal points for the Commonwealth Games ranged from 0.10 to 0.16 between 1990 and 2010. The equivalent HHIN values at the Summer Olympics over the largely similar period 1992-2012 ranged from 0.040 to 0.064. This indicates that the competition at the recent Summer Olympic Games is twice as balanced as the Commonwealth Games. If competitive balance is a problem at the Olympic Games, then it is hugely problematic for the Commonwealth Games between the early 1990s and the early 2010s. Similar findings are notable on a gender-specific basis. It is also noteworthy that male-athlete

competitions tend to be more balanced than female-athlete competitions at the most recent Summer Olympic Games. This observation is consistent with Ramchandani and Wilson's (2014) finding for the Commonwealth Games.

Implications. The lack of notable improvements in overall competitive balance, or even deterioration in female competitions should concern the IOC and the participating IFs. As noted above, outcome uncertainty underpins competitive balance and competitive balance is important in attracting the engagement of fans, supporters, consumers, broadcasters, merchandisers, sponsors and the long-term morale of the majority of participants (Gan et al., 1997; Madrigal, 1995; Trung et al., 2015). A lack of outcome uncertainty and competitive balance is very likely to downgrade the appeal of respective sport competitions and events, impair the revenue and profit and compromise the long-term development of the respective sport and event (O'Reilly et al., 2011; Schmidt & Berri, 2001).

The IOC and some IFs have adopted various policy initiatives, for example, through financial support for less developed nations, and human resources. Examples include the Olympic Solidarity programme (International Olympic Committee, IOC, 2017b) and the leading coaching support in International Training Centre in Switzerland to serve cyclists from lagging nations, organised by the Union Cycliste International (UCI) (Zheng, 2016). These measures could be further developed and promoted to more sports to facilitate a more global and balanced development of female sports. In addition, the double bronze policy adopted in all combat sports, could be stably applied to other elimination-based sports such as table tennis, tennis, badminton, fencing and archery. Some Olympic sports already limit the number of events that each nation can participate

in. For example, in weightlifting a nation can provide a maximum of four athletes despite there being seven women's weightlifting events. Similarly, in taekwondo, nations can participate in only four of the eight taekwondo events, with the only exception of South Korea which can participate in five events. This policy can be introduced to boxing, judo and wrestling, or even medal-abundant sports and disciplines most notably athletics and swimming.

Competition format changes such as those introduced recently in shooting and archery that seek to undermine the traditional dominance of some nations in certain sports by increasing outcome uncertainty, could also be recommended to the IFs of other Olympic sports. China once dominated in the gold medal table in shooting on the Olympic stage in the 2000s (between Sydney 2000 and Beijing 2008), but managed only a single gold at Rio 2016. This demonstrated the immediate impact of an increased competitive balance derived from the format change in shooting by excluding the qualification results from the final round. Last, the addition of certain new sports, disciplines and events may enhance the medal prospect for "medium" and below-medium nations. Salient examples include Fiji's first gold medal from rugby sevens, Chinese Taipei, Jordan and Côte d'Ivoire's first ever gold medal, and Gabon, Niger, Afghanistan and Vietnam's first ever medal from taekwondo, Colombia's first gold medal from women's weightlifting, and second and third gold medals from BMX cycling, Bahrain's first ever gold medal from women's 3000m steeplechase, and Iceland's medal performance in women's pole vault. All these sports, disciplines and events are relatively new and were not included in the Olympic Games until this century,

and they help to promote a more diverse distribution of (gold) medals amongst a range of previously non-(gold) medal winning nations.

Female events provide an opportunity for "medium" and below-medium nations to access more medals. This is particularly important in the context of the gender equity campaign of the IOC and the concomitant increased number of female sports, disciplines and events added to the Olympic repertoire. A recent example is the International Boxing Association's (AIBA) attempt to enhance gender equality by increasing the number of female events (divisions) from three to five while reducing male events from ten to only eight at the forthcoming Tokyo 2020, and the inaugural AIBA Gender Equality Forum held in September 2018 in Sofia, Bulgaria.

China and Romania provide some useful experience in early and longstanding strategic prioritisation of female sports, disciplines and events. China (118.5 gold medals won by female vs. 88.5 by male at the Summer Olympic Games during the period 1992-2016) has prioritised women's sports and disciplines at the central policy level for many years (Zheng & Chen, 2016). Romania (29 gold medals won by female vs. 5 by male at the Summer Olympic Games during the period 1992-2016) has relied overwhelmingly on women's artistic gymnastics and women's rowing. The significant increase in the number of gold medals won by female athletes was also crucial to the USA's dominance at London 2012 and Rio de Janeiro 2016. Female USA athletes are winning more gold medals (27.5 vs. 18.5 in 2016, and 29 vs. 17 in 2012, but 15.5 vs. 20.5 in 2008 and 12.25 vs. 22.75 in 2004) and medals than their male compatriots. Increasingly significant contributions of female athletes are not a characteristic limited to "major" sports powers. Some "medium" and below-medium nations have ascended

the medal tally, largely because of their female athletes. This trend is particularly notable in women's heavy sports. For example, Thailand, Kazakhstan and North Korea are emergent powers in women's weightlifting, Chinese Taipei found stable sources of Olympic (gold) medals from women's weightlifting and taekwondo, whilst Kosovo is having success in women's judo. In other sports and disciplines, Malaysia is making breakthroughs beyond its traditional fortress of badminton. The nation won two medals in total in women's diving at London 2012 and Rio de Janeiro 2016, fuelled by government's deliberate strategic targeting and concomitant policy and financial support (Nikkei Asian Review, 2016).

Conclusions

There is some evidence of an improved competitive balance in the distribution of medals amongst male athletes at the seven most recent Summer Olympic Games. However, there is a lack of improvement of, or even a decline in competitive balance in female competitions, which affects the overall trend. Promoting a more balanced distribution of medals amongst female athletes and teams is a pressing issue for the IOC and the various IFs. It is not an overstatement to say that the unequal distribution of gold medals and medals of any other colour constrains the long-term development of the Olympic Games. Almost two thirds of participating nations fail to win a medal at each edition, a factor which almost certainly erodes interest in the Olympics within these countries.

The relatively more puzzling competitive balance issue in relation to female competitions especially in terms of the distribution of gold medals amongst nations

cannot be underrated. First, the lack of increased competitive balance for female competitions does not augur well for the promotion of female events in many sports. Second, the IOC and various IFs of Summer Olympic sports have consistently endeavoured to raise the profile of female athletes on the Olympic stage and significantly increased the number of female events and athletes in a wide range of sports. However, there is a risk that the increased number of female events may increase the market share of gold medals and medals for traditional "powerhouse nations". This is evidenced in the USA's recent expansion of its advantage in the gold medal table, derived from the significant increase in gold medals and medals won by its female athletes.

There are various means of promoting a more equal distribution of medals at the Olympic Games. These include the provision of financial, policy and human resources (technology, training and coaching) support to the majority of non-major nations particularly non-achievement nations and regions, the restrictions on the number of both events and athletes each nation or even continent can send, more extensive use of the *repechage* system and double-bronze medal systems in other elimination-based sports (e.g., badminton, table tennis, tennis and fencing), and the addition of new sports, disciplines and events. For example, the distribution of (gold) medals in the relatively new Olympic sport of taekwondo is relatively diverse, with a number of nations winning their first Olympic (gold) medal. This is, in part, attributable to the limit on the number of taekwondo events a single nation can enter (for most nations, the maximum event number is four out of eight) and the relatively balanced qualification system across continents. However, in judo and women's wrestling, top nations most notably Japan

can participate in all events, which decreases the (gold) medal winning chances for nations without a history of success in these sports. Applying these demonstrably effective policies to other combat sports such as judo, boxing, wrestling and the new member of karate, particularly for women's events, is a worthy consideration. The ultimate goal is to enhance the probability of non-traditional sporting powers to win (gold) medals. This is challenging but by no means impossible outcome.

The findings of this study facilitate a more evidence-based evaluation of existing policy measures and strategies, and their refinement where appropriate. Policy suggestions are proffered for the IOC and IFs, and non-major nations to promote a more balanced development and competition particularly for women. However, despite the utility of this research, three limitations should be noted in this study. First, the analysis does not take into account the effect of home team advantage. The advantage may result in additional medals won by the host nations. Second, this study does not analyse the competitive balance on a sport- and discipline-specific basis. Future research can explore the rich tapestry of competition and distribution of (gold) medals of varying Olympic sports and disciplines, and make horizontal sport-to-sport comparisons. This would be instrumental in propelling IFs and nations' more effective and detailed responses. A third limitation of this research resides in its focus on nations as the unit of analysis. Regional and continental analyses are not included. A diverse and balanced distribution of (gold) medals amongst a large number of nations from the same region or continent would be vastly different from the competitive balance amongst a wide variety of nations pertaining to different regions and continents. Future research is hence encouraged to unveil the enigma of competitive balance amongst regions and continents.

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Table 1. Trends in Competitive Balance at the Seven Most Recent Summer Olympic Games: HHIN, P(G)MWN and CV results.

		Normalised Herfindahl-Hirschman Index (HHIN) (Rank)			*Proportion of (Gold) Medal-Winning Nations (P(G)MWN)* (Rank)		*Coefficient of Variation (CV)* (Rank)		
Gender	**Edition**	**Gold Medals**	**Medals**	**Medal Points**	**Gold Medals**	**Medals**	**Gold Medals**	**Medals**	**Medal Points**
Overall	1992	0.079(7)	0.058(7)	0.064(7)	0.220 (7)	0.381 (6)	3.631 (7)	3.107 (7)	3.259 (7)
	1996	0.054(4)	0.039(5)	0.043(4)	0.270 (3)	0.403 (4)	3.240 (4)	2.771 (4)	2.891 (4)
	2000	0.049(2)	0.037(2)	0.040(1)	0.261 (6)	0.402 (5)	3.115 (2)	2.724 (1)	2.815 (1)
	2004	0.047(1)	0.039(3)	0.041(3)	0.280 (2)	0.370 (7)	3.069 (1)	2.771 (3)	2.852 (2)
	2008	0.061(5)	0.041(6)	0.045(6)	0.266 (4)	0.424 (1)	3.509 (5)	2.880 (6)	3.014 (6)
	2012	0.061(6)	0.039(4)	0.044(5)	0.265 (5)	0.417 (3)	3.520 (6)	2.827 (5)	3.005 (5)
	2016	0.050(3)	0.037(1)	0.040(2)	0.285 (1)	0.420 (2)	3.207 (3)	2.761 (2)	2.877 (3)
	corr.	-0.179	-0.571	-0.286	0.571	0.643	-0.179	-0.286	-0.179
	p	0.702	0.180	0.535	0.180	0.119	0.702	0.535	0.702
Male	1992	0.083(7)	0.052(7)	0.060(7)	0.196 (7)	0.375 (3)	3.742 (7)	2.950 (7)	3.179 (7)
	1996	0.055(6)	0.037(6)	0.041(6)	0.216 (6)	0.371 (5)	3.262 (5)	2.691 (5)	2.819 (6)
	2000	0.046(2)	0.037(5)	0.039(5)	0.226 (5)	0.362 (6)	3.012 (1)	2.704 (6)	2.776 (5)
	2004	0.046(3)	0.036(4)	0.038(4)	0.253 (1)	0.354 (7)	3.019 (2)	2.655 (4)	2.736 (3)
	2008	0.053(5)	0.035(3)	0.038(3)	0.233 (4)	0.401 (1)	3.263 (6)	2.644 (2)	2.754 (4)
	2012	0.048(4)	0.033(1)	0.036(1)	0.238 (2)	0.396 (2)	3.115 (4)	2.563 (1)	2.682 (1)
	2016	0.045(1)	0.034(2)	0.036(2)	0.233 (3)	0.374 (4)	3.058 (3)	2.648 (3)	2.729 (2)
	corr.	-0.679	-0.964	-0.964	0.750	0.286	-0.321	-0.857	-0.929
	p	0.094	0.000	0.000	0.052	0.535	0.482	0.014	0.003
Female	1992	0.085(6)	0.077(7)	0.079(7)	0.173 (5)	0.271 (7)	3.355 (2)	3.206 (5)	3.248 (5)
	1996	0.065(3)	0.047(4)	0.051(4)	0.210 (1)	0.287 (5)	2.589 (1)	2.805 (1)	2.926 (1)
	2000	0.063(2)	0.043(1)	0.047(1)	0.174 (4)	0.311 (2)	3.453 (4)	2.850 (2)	2.973 (2)
	2004	0.061(1)	0.046(3)	0.050(2)	0.183 (3)	0.277 (6)	3.400 (3)	2.975 (3)	3.082 (3)
	2008	0.079(5)	0.055(6)	0.061(5)	0.165 (7)	0.304 (3)	3.920 (6)	3.280 (6)	3.429 (6)
	2012	0.090(7)	0.054(5)	0.063(6)	0.165 (6)	0.300 (4)	4.238 (7)	3.287 (7)	3.539 (7)

	2016	0.068(4)	0.045(2)	0.050(3)	0.188 (2)	0.327 (1)	3.696 (5)	3.023 (4)	3.191 (4)
	corr.	0.179	-0.286	-0.143	-0.143	0.679	0.821	0.464	0.464
	p	0.702	0.535	0.760	0.760	0.094	0.023	0.294	0.294

Notes: (1) Numbers in the parentheses indicate the ranking of each edition regarding the level of competitive balance.

(2) All the figures are rounded to the third decimal place only.

Table 2. Trends in Competitive Balance at the Seven Most Recent Summer Olympic Games: CR results.

		Concentration Ratios of Top 4 Nations (CR4) (Rank)			*Concentration Ratios of Top 10 Nations (CR10)* (Rank)		
Gender	**Edition**	**Gold Medals**	**Medals**	**Medal Points**	**Gold Medals**	**Medals**	**Medal Points**
Overall	1992	0.504 (7)	0.437 (7)	0.460 (7)	0.754 (7)	0.643 (7)	0.675 (7)
	1996	0.391 (4)	0.331 (4)	0.352 (4)	0.620 (4)	0.555 (5)	0.572 (4)
	2000	0.377 (2)	0.321 (1)	0.338 (1)	0.583 (2)	0.525 (1)	0.542 (1)
	2004	0.375 (1)	0.328 (3)	0.343 (3)	0.575 (1)	0.530 (2)	0.542 (2)
	2008	0.427 (5)	0.345 (5)	0.365 (5)	0.649 (6)	0.565 (6)	0.586 (6)
	2012	0.452 (6)	0.349 (6)	0.377 (6)	0.645 (5)	0.545 (4)	0.577 (5)
	2016	0.384 (3)	0.322 (2)	0.341 (2)	0.593 (3)	0.531 (3)	0.548 (3)
	corr.	-0.179	-0.250	-0.250	-0.214	-0.321	-0.179
	p	0.702	0.589	0.589	0.645	0.482	0.702
Male	1992	0.522 (7)	0.393 (7)	0.432 (7)	0.734 (7)	0.605 (7)	0.638 (7)
	1996	0.406 (6)	0.320 (4)	0.339 (6)	0.624 (6)	0.531 (3)	0.548 (3)
	2000	0.350 (1)	0.323 (5)	0.323 (5)	0.602 (3)	0.559 (6)	0.574 (6)
	2004	0.353 (2)	0.353 (6)	0.314 (2)	0.597 (2)	0.528 (2)	0.541 (2)
	2008	0.399 (5)	0.313 (3)	0.322 (4)	0.622 (5)	0.535 (5)	0.558 (5)
	2012	0.385 (4)	0.299 (2)	0.318 (3)	0.611 (4)	0.534 (4)	0.554 (4)
	2016	0.365 (3)	0.297 (1)	0.311 (1)	0.592 (1)	0.525 (1)	0.538 (1)
	corr.	-0.429	-0.857	-0.893	-0.714	-0.607	-0.607
	p	0.337	0.014	0.007	0.071	0.148	0.148
Female	1992	0.547 (7)	0.535 (7)	0.543 (7)	0.821 (7)	0.744 (7)	0.762 (7)
	1996	0.422 (2)	0.356 (2)	0.378 (2)	0.668 (1)	0.622 (4)	0.640 (4)
	2000	0.432 (4)	0.349 (1)	0.369 (1)	0.704 (4)	0.590 (2)	0.617 (2)
	2004	0.415 (1)	0.367 (4)	0.384 (4)	0.694 (3)	0.604 (3)	0.626 (3)
	2008	0.472 (5)	0.413 (6)	0.434 (5)	0.731 (6)	0.626 (5)	0.652 (5)
	2012	0.535 (6)	0.413 (5)	0.452 (6)	0.715 (5)	0.628 (6)	0.653 (6)
	2016	0.423 (3)	0.362 (3)	0.382 (3)	0.678 (2)	0.563 (1)	0.585 (1)
	corr.	-0.107	-0.036	0.000	-0.179	-0.393	-0.393
	p	0.819	0.939	1.000	0.702	0.383	0.383

Notes: (1) Numbers in the parentheses indicate the ranking of each edition regarding the level of competitive balance.

(2) All the figures are rounded to the third decimal place only.