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Measuring sports performance by country according to the natural advantages/ desadvantages of competing nations

Medición del rendimiento deportivo por país de acuerdo con las ventajas/desventajas naturales de las naciones competentes

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Key words

- Statistical indexes
- Sports results
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- Tokyo 2020

Abstract

Sports results have mattered to societies and their rulers, given their impact on the economy, the country's image and political implications. Therefore, it has also been in their interest to find alternative methods to refine their measurement (such as those that weight according to the country's population and quality of life). This paper introduces a methodological proposal for measuring sports results based on Tokyo Olympic Games 2020 (held in 2021). To this end, two indexes were created, each with two different versions: unstandardised and standardised. The first included Olympic diplomas in the scoring system; the second counted the number of medal-winning athletes; finally, the third and fourth indexes weighed the previous results on the basis of population and per capita income. Our proposal will make it possible to highlight the sporting performances of countries whose income and population do not allow them to stand out in the traditional rankings. By making their sporting results visible, their governments will be encouraged to make further investments in the sport sector, with consequent socio-economic benefits for the population as a whole.

Palabras clave:

- *Índices estadísticos*
- *Resultados deportivos*
- *Clasificaciones deportivas*
- *Medallas olímpicas*
- *Tokio 2020*

Resumen

Los resultados deportivos han sido importantes para las sociedades y sus gobernantes, dado su impacto en la economía, la imagen del país y las implicaciones políticas. Por ello, también ha sido de su interés encontrar métodos alternativos para afinar su medición (como los que ponderan en función de la población y la calidad de vida del país). En este trabajo se presenta una propuesta metodológica para medir los resultados deportivos a partir de los Juegos Olímpicos de Tokio 2020 (celebrados en 2021). Para ello, se crearon cuatro índices. El primero incluyó los diplomas olímpicos en el sistema de puntuación; el segundo contabilizó el número de atletas ganadores de medallas; finalmente, el tercer y cuarto índices ponderaron los resultados anteriores en función de la población y el ingreso per cápita. Nuestra propuesta permitirá destacar el desempeño deportivo de países cuyo ingreso y población no les permite destacar en los rankings tradicionales.

Introduction

Sports results matter to societies and their governments and this has been clear throughout history. The main reasons for institutions in a given country to invest in sport performance are (1) the economic impact, proved both by the increase of the GNI and the creation of employment (Heinneman 1998), (2) the external image and the consequent self-esteem of society, as well as (3) the political factor: the totalitarianisms of the mid-20th century, or the Cold War, would be examples of image campaigns to transmit to the rest of the world, through sport, the feeling that a country's project works (Contreras and Gómez-Lobo 2006).

When addressing the policies of a nation, Shen (2020) recently presented his case study on the Chinese sports boom since the 1980s. He concluded that the major institutional efforts - with demonstrated results in post-Mao China - were driven by two main reasons: (1) to promote an atmosphere of optimism and citizen satisfaction with the national sport programme (a project of their own); and (2) to generate some satisfaction and conformity with the ongoing governmental regime.

In fact, it is clear to governments that it is profitable to invest in the design of public policies that facilitate the achievement of sports results (Brouwers, Sotiriadou and De Bosscher 2015). Furthermore, it is crucial to ensure that the resources invested for this purpose are adequately rationalised. This was evidenced by a study that compared public investments made by the UK and Spain to win Olympic medals from2008 to 2016. The UK, in addition to triplicating the number of medals compared to Spain, achieved a much lower medal cost per inhabitant, mainly due to the fact that they invested on sports in which the country had certain natural advantages: previous successes and/or strong links to their own culture and tradition (González-Ruíz et al. 2018).

This study focuses on countries' sporting performance, although it is important to consider that the reasons why nations invest in sport are very diverse. In fact, the achievement of results in competitions is only one aspect of sport development policies. According to Acquah-Sam (2021, 172): "Sufficient and sustained levels of all kinds of investment in sports, coupled with strong institutions, good governance, and practical and interrelated policies, are critical for sports development and economic growth and development in developing countries". This study identifies the 8 major benefits that countries obtain by investing in the development of sport in socio-economic terms (Ibid. 2021): jobs creation; new incomes for clubs; sports staff and ancillary workers; tax revenues for the administration; infraestructures; promotion of social cohesion; enhancement of the image of the country; healthier citizens for a higher productivity; and foreign relationships.

Sport has become a key factor in achieving both social improvements and implementing further economic development. More and more countries are

investing in the sector under the argument of achieving improvements for society (Mohamed, Sayyd and Ghreeb 2024). In the same trend, a recent study by Dubinsky (2024) suggests that the specialisation of countries or cities in the sports sector, taking major events as a pillar, has become an effective strategy to boost infrastructures, facilitate the presence of professionals, attract tourism, encourage volunteering and grassroots sport. Moreover, sport successfully connects with the education system (Kiuppis 2018). In this regard, it should be noted that improving the sporting performance of countries contributes to activating the social and economic development processes described above (Brouwers, Sotiriadou and De Bosscher 2015). In addition, it should be considered that investments in elite sport are supported by the public at large (Praet et al. 2024; analysing 7 European countries).

The aim of this research is to present new tools (indexes) to measure sports results obtained in major international competitions by weighting certain factors that burden or benefit some countries compared to others (Note 1). These tools will favour countries whose natural conditions make it difficult to reach the top of sports rankings, so that they are recognized for their competitiveness through alternative rankings, weighing these disadvantages. In this way, their efforts to promote public policies towards competitive sports would be rewarded, obtaining a certain international recognition and encouraging their institutions to develop new sports initiatives (De Bosscher et al. 2009).

Sports performance by country at the Olympic Games and main drivers

The demonstrated interest of governments and societies in their sports performance entails the need for more precise measurement of these results, identifying proper criteria for comparing and ranking countries. In this regard, the traditional measurement of sports performance has often relied on Olympic medal counts. On the one hand, traditional medal ranking counts the gold medals of each country, using silver and bronze for the respective ties. This ranking was criticised for focusing only on the first position of the podium, and underestimating the total number of medals won by each delegation (when grouping the three medals together). For this reason, alternative rankings were presented, with the New York Times (2008) being the most notable. Their proposal assigned 4 points to gold medals, 2 to silver medals and 1 to bronze medals, so each step upwards of the podium doubled the value of the previous one. These measurements and comparisons have been generally conducted taking into account raw numbers. There have also been some initiatives to generate statistical models that have considered population or quality of life as explanatory factors for the sporting achievement (De Bosscher et al. 2009), although without much academic or media impact.

On the other hand, international comparisons force us to deal with the overrepresentation of sports with numerous events that have access to medals, as opposed to those without such division into events (particularly frequent in team sports). In view of this, models such as the one proposed by Knuepling and Broekel (2022) were developed, which aggregated the successful results obtained in sports by grouping events. These authors considered all the events accessible to the same athletes (e.g. speed events in athletics) as a single output; and they also grouped the results of distinct categories in combat sports. Therefore, they simplified all the Olympic Games competitions to only 61 results in their rankings.

When identifying the causes of sporting success, literature has usually relied on four dominant factors: population size, per capita income, political regime and host advantage (Ibid. 2022). The model has been complemented in some academic works by other factors of lesser relevance: religion and culture (De Bosscher et al. 2009), specialisation in certain types of sports (Seiler, 2013) or competitive experience (Truyens et al. 2016). In general, it is noteworthy that only variables like population and per capita income contributed to explain more than 50% of sport success (Knuepling and Broekel 2022). Even if we find contributions in the literature that weight sports outcomes based on income or population (Dutta, Lanvin and Wunsch-Vincent 2018), no contributions have introduced both variables at the same time in the index.

In addition, a shared feature of the aforementioned studies is that those selected variables were considered independent factors in multivariate models, intended to assess their ability to explain the behaviour of the dependent variable "sporting achievement". However, our proposal is different. In this paper, these variables related to population and wealth were added in the calculation of the indexes to standardise each country's performance in sports.

Sport policies focusing on elite performance: De Bosscher's 9 pillars

The strategies chosen in the development of sport policies have also been highlighted as relevant

factors in previous literature. This is the case of the potential podium strategies, conducted by countries such as the United Kingdom and the Netherlands with some success in the 2012 and 2016 Olympic Games. This strategy involves concentrating investment in sports that do not require a large investment of resources and, at the same time, have a wide variety of events at the Olympics and World Championships, allowing a considerable number of medals to be won (Gibson 2016). These result-oriented policies could have a much greater impact on the elite than on the sport development of the country as a whole. This was shown by Moscoso-Sánchez, Rodríguez Díaz and Fernández-Gavira (2015) in their research on the Spanish case. Since the 1990s, investments have been focused on promoting sports elites, without this being backed up by investments of a more social nature (new facilities, sporting schools or integration programmes through sport).

Furthermore, literature has shown that it is profitable to invest in sports with a long tradition in the country, as their development is facilitated by the presence of infrastructures and human capital, already formed through working groups with extensive experience in the activity, for example, coaches and physical trainers (Weber et al.2019). In this line, the positive influence of strategies that foster connectivity between sports and specialities has also been found (Knuepling and Broekel, 2022). In general, the concentration of resources and investments in relatively small spaces of action is effective, as it facilitates the generation of "hotbeds" of sports results that, even today, are strongly linked to geographical locations (González-Ruíz et al. 2018).

In an attempt to guide these strategies, De Bosscher et al. (2009) suggested, after extensive quantitative and qualitative research searching for associations, that government policies should focus on 9 pillars to achieve sporting success. The first one was financial support (1), the only one researchers classified as an input. Furthermore, they added eight other pillars as processual elements (throughputs), which led to the results (outputs): sporting success. These were listed in the model as follows: (2) structure and organisation of sport policies; (3) participation of the population; (4) development of talent recruitment systems; (5) career support for athletes; (6) training support services; (7) professional performance of coaches and their staff; (8) capacity to host and participate in international competitions; and (9) scientific research applied to sport.

Government policies are factors that each state can control, and much merit is to be found in their proper management. The room left for improvement is a great incentive for countries to work on them conscientiously. However, we must accept the inevitable inequalities generated by inputs (financial support), which in turn depend on the standard of living (per capita income) and the country's population (see the case of China, its large population that fully compensates for its low per capita income: GDP of 17 trillion in 2020; 10,408.67 US$ per capita income; source: World Bank (2020).

In brief, the measurement of sports results requires the inclusion of indicators that are standardised by certain factors that consider achieved results in relative terms. In this sense, variables that are very difficult to control through the policies of the countries themselves are particularly interesting: e.g. being a small country (with regards to population), with less than one million inhabitants and with low standards of living. Little can be done through the country's own policies to change such circumstances in a brief period of time. Transformation in these characteristics would depend on long-term public policies, in many cases fighting against adverse natural conditions (climate, geopolitics or natural resources). For these reasons, we propose the creation of two indexes weighted by these variables (see methodological section), offering alternatives to the current classifications that - for example - measure performance by countries with more than 200 million inhabitants with the same scale as countries with 5 million inhabitants. In addition, the instruments make it possible to correct the unequal sport competition of nations that exceed the per capita income of others by large proportions.

In addition to the above, the enormous weight that the variables related to population and standard of living had in the achievement of sports results according to previous researches (more than 50% of the total, as we referred above) justifies the appropriateness of constructing indexes that weight the sports results of nations based on both factors.

On the other hand, the emergence of sports superstars capable of winning multiple medals - even in the same event - tends to be mostly exclusive of a small group of powerhouses in each sport, further widening the gap of countries constrained by the factors mentioned above. This circumstance invites us to look for a second instrument capable of minimising the differences created by a small group of superstars in elite sports (think of the advantages obtained by the US with Michael Phelps, or by Spain with Rafael Nadal). That is why this paper also proposes an index that counts medal-winning athletes, rather than medals.

Finally, the construction of such instruments and their dissemination would generate incentives for those countries that are relegated to the bottom of

Olympic medal rankings and other sport rankings. The use of alternative scoring methods that reflect the good policies of particular countries by recognising their achievements in leveraging their natural conditions would further increase the investments of their institutions. Moreover, the impact of such recognition on the self-perception of the population of that country and the trust generated to invest in new sports projects has been demonstrated.

Data and methodology

Data

Results from Tokyo 2020 Olympic Games were used for this research. Specifically, a data file created from the information available on the official website of the International Olympic Committee (Olympics 2021). Two perspectives were applied for collecting the data: a) medals and diplomas up to the 6th position were counted for each country and sport, so for each country six values were registered: total number of gold medals, total number of silver medals, total number of bronze medals and, similarly, the total number of 4th, 5th and 6th position diplomas; b) athletes with a medal were counted for each sport and country. If an athlete had more than one medal, the highest metal was assigned (for instance, if an athlete won a gold and a bronze medal, she would be registered as a gold medallist). For this index, persons with at least one medal were counted for each country, which means that sport teams added as many medals as athletes were in the team. The first approach intended to expand the merits beyond the 3rd ranking. The second approach intended to value team sports, by adding persons, although diminishing the fact that the same person could have achieved more than one medal in individual sports with various events.

In order to standardise the previous data, two additional variables were gathered: 2021 population aged 15-39 years and the Gross National Income (GNI) per capita for each country. Population data came from the UN Demographic Statistics Database (United Nations, 2022) and the 2017 GNI per capita, PPP (current international $), from the HDR 2020 report Statistical Annex (see Table 1 in Annex), provided by United Nations Development Program (2020). Then, the few missing values in the previous data bases were collected from the World Bank (2022): GNI for Aruba, Bermuda, Cayman Islands, Puerto Rico, Kosovo, and Somalia. Since population data were not updated for a few countries, data from 2021 UN projection was used for them.

Countries with less than half million inhabitants between the ages of 15 and 39 were omitted from the analysis (San Marino, Mauritius, Cyprus, Estonia, Fiji, Suriname, Montenegro, Bahamas, Grenada, Bermuda, British Virgin Islands), due to the fact that one single medal or diploma could dramatically change the country's position in the ranking, not reflecting the sport trajectory and real performance of this country. These nations and their sporting results are also of general interest (Note 1), but their small demographic sizes advised against adapting the scales to them.

Creation of indexes

Two different indexes were built from the previous data. The numerator for the first one (Medal Index) extended the proposal of the New York Times 2008 that calculated country scores using the following weights: 4 for gold medals, 2 for silver medals and 1 for bronze medals. Now, 4th, 5th and 6th positions were added, with the following weights (following the same logic of halving the previous weight): 0.5, 0.25 and 0.125.

The numerator for the second one (Medallist Index) was computed by adding the number of winners of gold, silver and bronze medals for each country and applying the NY Times weighting. Since nominative information by country was not included for athletes with diplomas on the website (a data search by athlete provided no information on diplomas), this approach was just focused on medals.

Standardising the approach according to GNI per capita and the population aged 15-39 allows the creation of new rankings of countries that value the results of the Tokyo Olympic Games per person and PPP dollar. Although the interest was more in the ranking of the country than in the specific value of the index, the quotient was multiplied by 10^6 to avoid very small numbers (Appendix).

Medal index

$$I_1(Medal\ index) = 10^6 * \frac{(4 * g + 2 * s + b + 0.5 * d4 + 0.25 * d5 + 0.125 * d6)}{population\ 15-39 * GNI\ per\ capita}$$

where *g* is the number of the country gold medals, *s* the number of silver medals, *b* the number of bronze medals and *d4*, *d5* and *d6,* the number of diplomas for the 4th, 5th and 6th positions.

Medallist index

$$I_2(Medallist\ index) = 10^6 * \frac{(4 * a_g + 2 * a_s + a_b)}{population\ 15-39 * GNI\ per\ capita}$$

where a_g is the number of athletes with at least a gold medal, a_s the number of athletes with at least a silver medal (and no gold medal) and a_b the number of athletes with at least a bronze medal (and no silver nor gold medals).

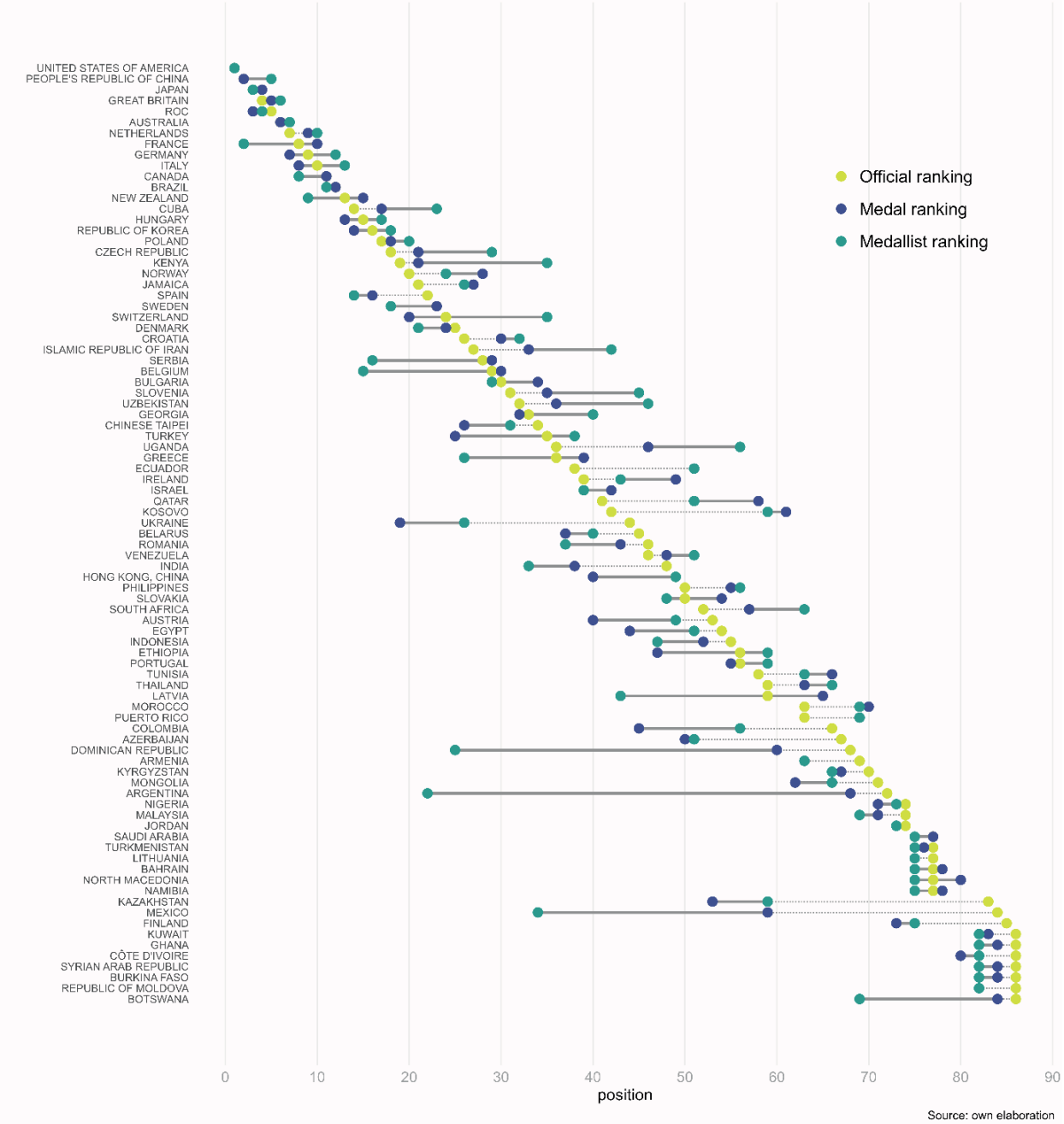
However, another methodological contribution of this paper is not about numerators, but about denominators. Creating a standardized index to evaluate countries' performance based on wealth and population size is justified by the need for a comprehensive and equitable assessment of achievement. Standardization allows for meaningful comparisons across diverse nations, ensuring that variations in size and economic output do not skew results. When comparing countries of very different sizes and when using indicators that can be affected by these differences in size, performance can be misrepresented unless indicators are adjusted on dimensions such as GDP, GNI or other size-related factors, such as population (Freudenberg 2003, Nardo 2008, Becker 2022). There exists rich academic literature on all sorts of indexes that include indicators standardized by income or population across diverse fields of research, although most studies typically opt for one approach or the other, rather than both simultaneously (Wood 2010, Ugolini et al. 2012, Dutta, Lanvin & Wunsch-Vincent 2018). Specifically, in sports performance research, wealth and population factors have been taken into account to analyse correlations or as independent variables in statistical models with some performance measure as the dependent variable (De Bosscher et al. 2006, Contreras & Gómez-Lobo 2006). For instance, the results of Halsey (2009) and Bernard and Busse (2004), based on data from Sydney, Athens and Beijing Olympics, indicated that GDP and population size were significant predictors of medal success. Similarly, Shasha et al (2022), analysing Olympic Games of Rio 2016, found that a larger workforce and higher income levels positively contributed to a country's sports achievements.

Results

Figure 1 shows the positions of those participating countries, with at least one medallist, according to three different criteria: the official ranking (that took into account the gold medals), the Medal ranking (that used the NY Times weights extended to the 6th diploma) and the Medallist ranking (that counted athletes in terms of the highest metal obtained). None of them was standardised by income and population at this first step. The ranks of the seven top countries did not change much as the new approaches were included to the official results. United States of America kept their leading position regardless the index considered, whilst China maintained the second spot according to the first two rankings but moved down to the fifth as athletes were included, indicating that team sports were not so relevant in its classification (at least not in those sports that imply many players) and that there were athletes from this country that got several medals. China really stood out in sports that are individual or played in small teams, like artistic gymnastics, athletics, badminton, shooting, swimming, table tennis or weightlifting. Japan, 3rd in the official ranking, was also the 3rd in the Medallist ranking, although dropped a position as the first three diplomas were included in the calculations. Great Britain slipped slightly in the new ranking and ROC discreetly improved its performance. France was the first from the top ten countries that was mostly benefitted from the inclusion of the number of athletes with a medal, mainly explained by the positive impact of team sports in its results. As this perspective was assumed, France rose to the second place.

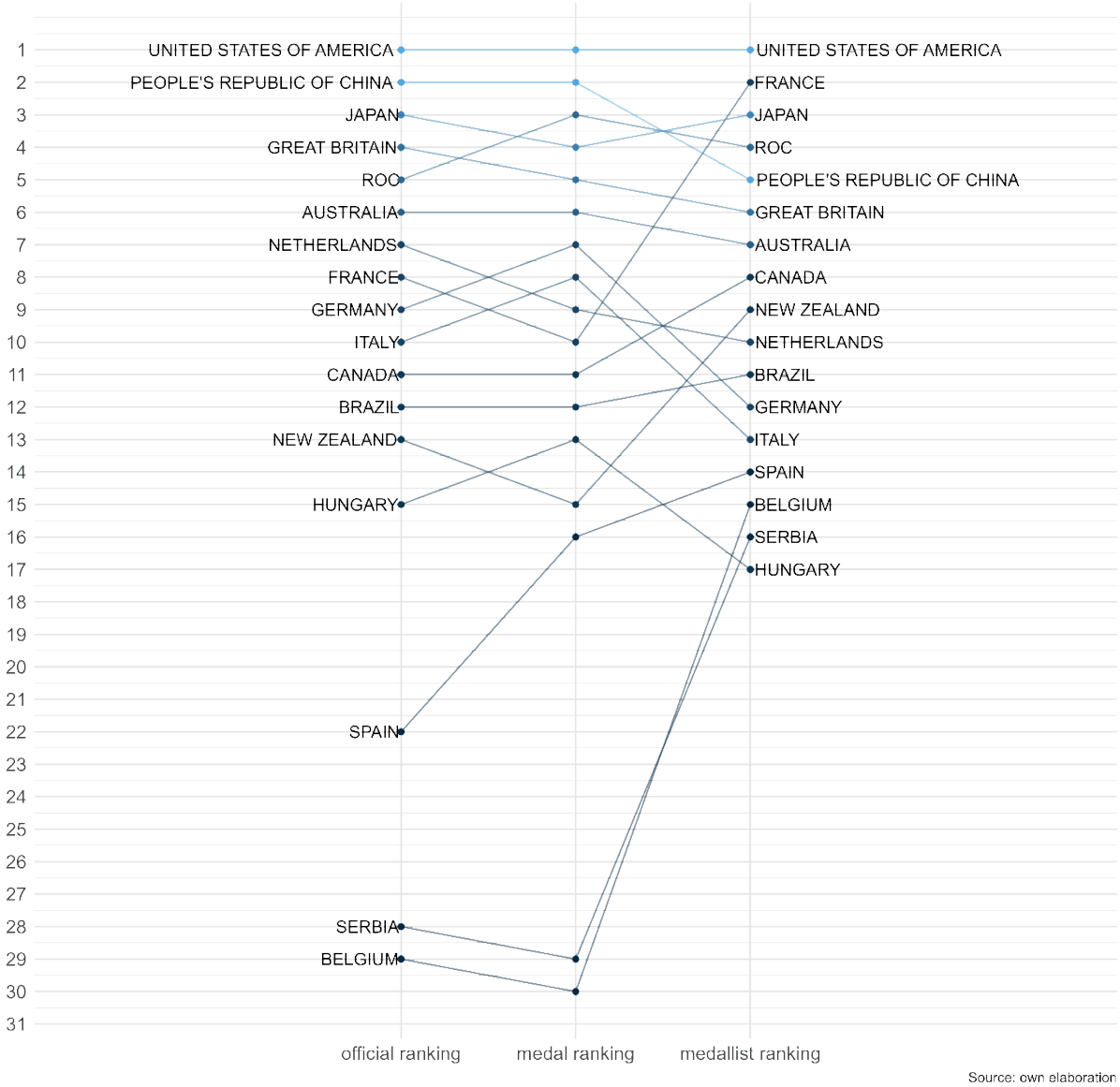
In fact, changes in the classifications were more dramatic when athletes were counted (Medallist ranking, figure 2). Thus, countries such as Canada and New Zealand managed to raise to the top 10, moving Germany and Italy backwards. Nonetheless, the names of the countries in the official top ten list kept invariant in the Medal ranking, not being much affected by the inclusion of the first three diplomas.

Figure 1. 2020 Tokyo Olympic Games. Unstandarised rankings



Source: own elaboration

Figure 2. 2020 Tokyo Olympic Games. Comparison between unstandarised rankings. Selected countries

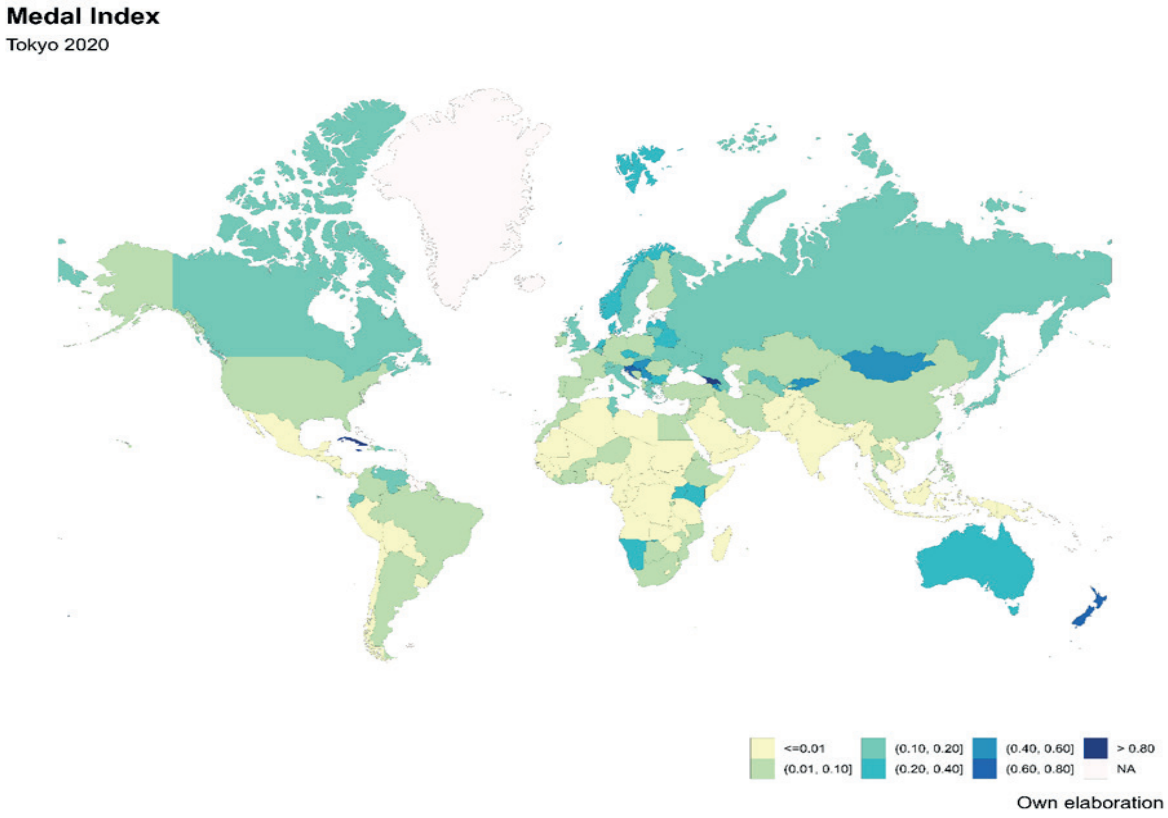


Source: own elaboration

The picture was completely different as the proposed indexes (Medal and Medallist) were standardised by income and population (figure 3). United States dropped to the 70th place according to the Medal index and to the 55th spot according to the Medallist index, strongly penalized by its population size and its high GNI. China fell to the 76th and 69th places, respectively (population size being the main reason for this worsening). In fact, the first 12th countries in the official ranking descended if the results from Tokyo 2020 Olympic Games were measured per person and dollars per person. No country from the official top ten list managed to remain in the other top ten lists, although The Netherlands and Australia did not suffer such a fall as the other eight countries and continued in the top 20 from any considered approach. Despite being wealthy countries, their population sizes are much smaller than those for the US, China, Japan, Great Britain or ROC, so they still scored reasonably well. In addition, the Netherlands has demonstrated

outstanding achievements in various individual and team sports (athletics, cycling, hockey, judo, rowing, sailing, swimming, etc.), so the falling effect of their high value in the GNI was not as intense as for other rich nations (being in the 13th position in the Medallist ranking). Australia stood out mainly for the substantial number of different individual and team sports in which the country obtained some medals or diplomas (more than 20, with a special focus on water sports). In spite of its larger population (as compared to The Netherlands) and its affluent economic situation, Australia only moved back to the 14th place in the standardised Medallist ranking and to the 19th in the standardised Medal ranking (See Graphic 1; and Tables 1 and 2 in the Appendix).

Graphic 1. Medal Index. Tokyo 2020



The first countries in the official ranking that improved their positions as the indexes were standardised were New Zealand, Cuba and Hungary (Figure 3). In the Medallist ranking, New Zealand reached the second place, after Jamaica. It is a high income and small country -in terms of population- (According to World Bank, 2020) with remarkable results in team canoe sprint and rowing, rugby, sailing and individual cycling. Cuban's success in the new rankings (2nd in the Medal ranking and 4th in the Medallist ranking) is explained by the fact that it is not a big country in terms of population, and it is just an upper middle income country, with a GNI per capita much lower than the previous top countries mentioned in the official ranking. Then Hungary, another small country in population in the high income group, was especially successful in individual and team canoe sprint events, water polo and individual swimming and wrestling

(although it also won medals and diplomas in other water and fighting sports). This team jumped from the 15th position in the official ranking to the 9th in the other proposed two.

Finally, it is worth mentioning that, apart from the case of Jamaica, first in the standardised Medallist and Medal rankings (due to the 14 medal-athletes coming from a sparsely populated country with a middle income level), Georgia's relative achievement pushed the country to the third place in the standardised medal list, whilst some Eastern European countries also appeared in the new scenario: Kosovo, Slovenia, Croatia or Serbia. Latvia joined them, making the most of its population aged 15 to 39 years with 5 medallists.

Figure 3. 2020 Tokyo Olympic Games. Standarised rankings

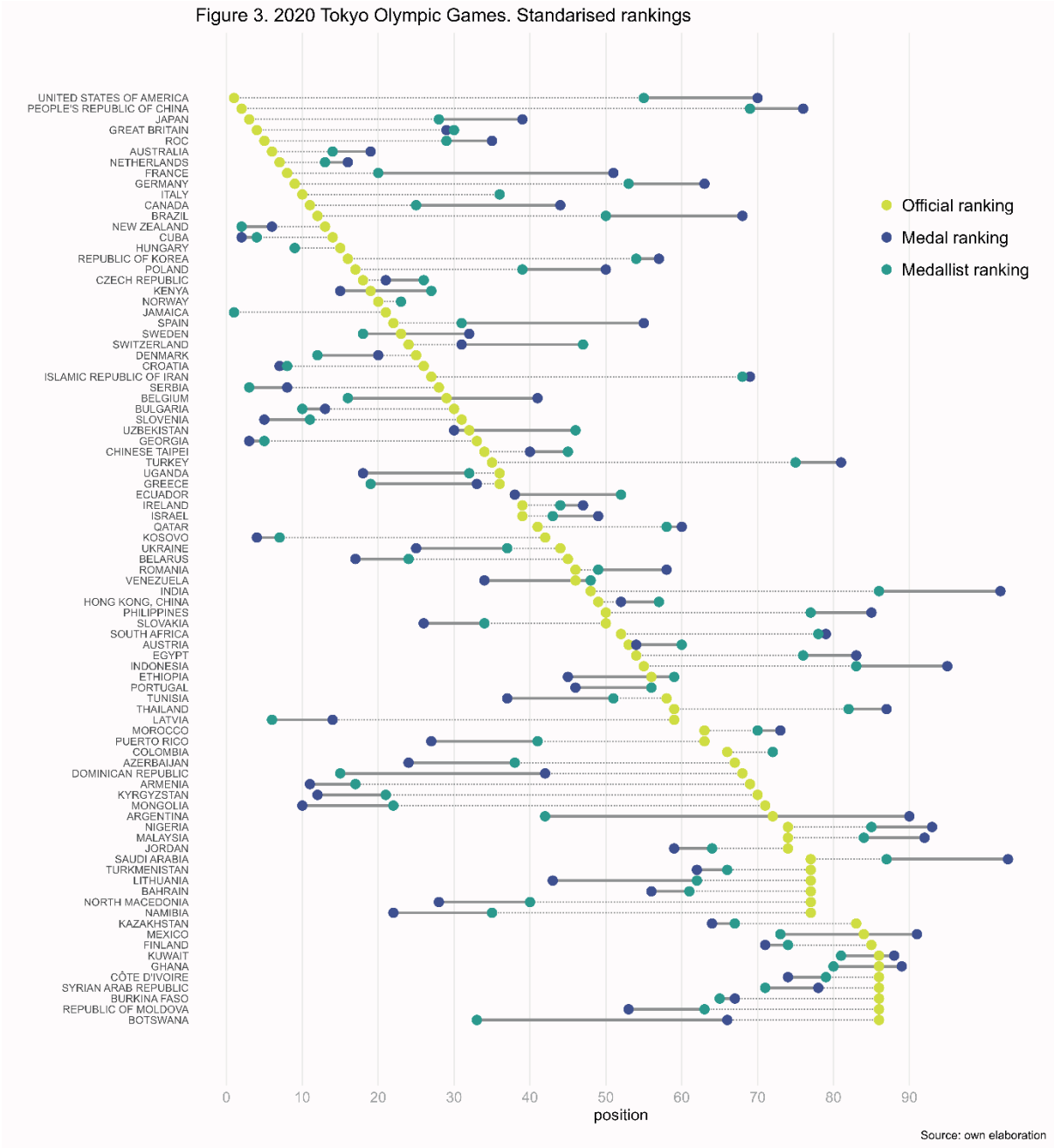


Figure 4. 2020 Tokyo Olympic Games. Comparison between standarised rankings. Selected countries

Source: own elaboration

Discussion and conclusions

The proposal presented in this paper is innovative in two aspects: 1) it adds alternative ways to measure sports success (by taken into account up to the sixth position through weights inspired by those from the New York Times and by counting medallists instead of medals, which favours the conquest of medals by teams and acts against countries with multi-medal athletes); 2) it considers variables on population and wealth in the creation of the indexes, based on the precedent literature that suggested the explanatory value of these dimensions (De Bosscher et al. 2008; Knuepling and Broekel 2020).

In general, the classification is not much affected as the official one (gold medal) is compared with the first unstandardized index (medal ranking). The most prominent top ten country list stays invariant. However, when the new medallist ranking is calculated, slight movements are observed which respond to the effect of counting athletes instead of counting medals. In this respect, China drops from the 2nd place in the previous ranking to the 5th, reflecting the focus of this country in individual sports (or in sports with very small teams) in relation to traditional team sports (football, handball, or hockey, for instance). France, on the other side, moves up due to the impact of team sports in the results for this country. Canada and New Zealand manage to jump to the top ten using this criterion, replacing Germany and Italy in the first leading positions.

When the new indexes scores are standardised by population size and GNI, the first countries classified according to the Tokyo 2020 official ranking suffer a dramatic fall, and only the Netherlands and Australia (barely penalised for their population sizes) manage to keep their places in the top 20, despite the drop in their positions. In both countries, and even applying podium potential policies (Gibson 2016), optimal performance is achieved by participating in a combination of a wide variety of individual and team sports. They could be considered as "hotbeds" (González-Ruíz et al. 2018; Knuepling and Broekel 2020), with water sports having the strongest tradition in Australia. Nonetheless, the collapse of the indexes for the US and China are drastic.

The undertaken standardisation places Jamaica in the 1st position, with 14 medallists and low population, in both new rankings, but it also highlights the role of Cuba, Georgia and other Eastern European countries, that went almost unnoticed in the official ranking, such as Hungary, Kosovo, Slovenia, Croatia, Serbia or Latvia. All in all, the results show the remarkable performance of Jamaica in recent years. Although his contribution to sport is widely recognized internationally, objective instruments are needed to position this country and its institutions where they deserve, thus rewarding their efforts.

On the other hand, we must highlight the limitations of the study identified: (1) working on the basis of Olympic Games data leaves out non-Olympic sports, which represent a considerable part of sporting activity in the world; (2) the difficulties in measuring the direct and indirect impact of sporting results on the socio-economic development of each country (although various references have been obtained from the literature); and (3) the preparation of the indexes with data from 2021 (Tokyo 2020) calls for an early update.

In conclusion, the trend to measure sports achievements by country in absolute terms prevents the work of certain countries with very commendable progress, although insufficient, to reach the top positions, from being publicly recognised. To face this adversity, the creation of new indexes that allow lowering the impact of some natural disadvantages confronted by the countries - low standards of life and population, and the consequent scarcity of sounded individualities - will draw attention to results of countries whose potential was undermined by these conditions. Disseminating the results of the highlighted countries according to the new proposed indexes will foster the international reconnaissance to the work undertaken by these countries, encouraging their rulers to continue investing their efforts in the progress of sport. The effort these countries make towards sports practice (facilities, programmes, links to the educational system) also cause important social benefits, especially relevant in developing countries.

As a result, prominent countries from this stance - such as Jamaica or Cuba - will act as models for other nations, which will consider the real options to stand out in the new rankings. This is particularly interesting for developing countries and countries with small populations, given the unique opportunity the new model offers to increase their visibility.

With regard to the practical implications of the work and its social usefulness, we should highlight the following aspects: (1) the diffusion of these indices by scientific means will make it possible to make them known and integrate them into the work of the entities and institutions that manage sport; (2) to this end, it will be crucial to continue research along these lines, incorporating the data from the recent Olympic Games in Paris 2024 and beyond into the analyses, and thus gradually build longitudinal series; (3) this will facilitate the subsequent preparation and diffusion of alternative rankings that will allow countries with

natural disadvantages to appear in better positions in the rankings of the countries with the greatest natural disadvantages. (3) This will facilitate the subsequent preparation and dissemination of alternative rankings that will allow countries with natural disadvantages to appear in better positions, in rankings that can be considered in parallel to the traditional ones; (4) The model can also be transferred to non-Olympic sporting activity of great social relevance (e.g. the major professional leagues in team sports). In short, the implementation of these actions would make it possible to activate investment in sporting practices (a process already described), as well as boosting the international image of these countries and the consequent socio-economic impact.

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Data availability

The data for this research are available upon request.

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Ethical Approval

This article does not contain any studies with human participants or animals performed by the authors.

Notes

Note 1. Results for these countries were: San Marino: 1 silver and 2 bronze, Mauritius: one 5th diploma, Cyprus: one 4th diploma, Estonia: 1 gold, 1 bronze and one 6th diploma, Fiji: 1 gold, 1 bronze, Suriname: one 4th diploma, Montenegro: one 6th diploma, Bahamas: 2 golds and one 6th diploma, Grenada: one bronze, Bermuda: one gold, British Virgin Islands: one 4th diploma.

Appendix

Table 1
Medal indexes and rankings (countries with at least one medal or diploma up to the sixth position)

Country	GNI 2019	Population 15-39 (1)	Official ranking	Medals (2)			Diplomas			Unstandard.		Standardised	
				G	S	B	4th	5th	6th	Index	R (3)	Index	R
United States of America	63.826	112897,5	1	39	41	32	25	29	24	292,75	1	0,0406	70
People's Rep. of China	16.057	483514,3	2	38	32	18	11	18	15	245,88	2	0,0317	76
Japan	42.932	31174,77	3	27	14	17	10	29	12	166,75	4	0,1246	39
Great Britain	46.071	21192,71	4	22	20	22	14	14	12	162,00	5	0,1659	29
ROC	26.157	47271,27	5	19	27	23	15	23	10	167,50	3	0,1355	35
Australia	48.085	8951,673	6	17	7	22	6	25	10	114,50	6	0,2660	19
Netherlands	57.707	5464,591	7	10	12	14	11	16	11	88,88	9	0,2818	16
France	47.173	18907,53	8	9	11	11	11	17	13	80,38	10	0,0901	51
Germany	55.314	24201,94	9	10	11	16	10	26	15	91,38	7	0,0683	63
Italy	42.776	15576,07	10	10	10	19	11	15	15	90,13	8	0,1353	36
Canada	48.527	12473,46	11	7	6	11	11	14	9	61,13	11	0,1010	44
Brazil	14.263	84769,35	12	7	6	8	5	9	3	53,13	12	0,0439	68
New Zealand	40.799	1762,495	13	7	6	7	3	4	4	50,00	15	0,6953	6
Cuba	8.621	3592,394	14	7	3	5	0	4	2	40,25	17	1,2997	2
Hungary	31.329	2876,261	15	6	7	7	10	9	3	52,63	13	0,5840	9
Republic of Korea	43.044	16280,9	16	6	4	10	12	15	1	51,88	14	0,0740	57
Poland	31.623	12089,95	17	4	5	5	4	7	7	35,63	18	0,0932	50
Czech Republic	38.109	2968,695	18	4	4	3	1	3	3	28,63	21	0,2530	21
Kenya	4.244	22583,42	19	4	4	2	5	0	1	28,63	21	0,2987	15
Norway	66.494	1761,442	20	4	2	2	3	2	0	24,00	28	0,2049	23
Jamaica	9.319	1234,396	21	4	1	4	4	2	2	24,75	27	2,1515	1
Spain	40.975	13306,01	22	3	8	6	8	10	10	41,75	16	0,0766	55
Sweden	54.508	3314,608	23	3	6	0	3	8	4	28,00	23	0,1550	32
Switzerland	69.394	2689,351	24	3	4	6	4	6	4	30,00	20	0,1608	31
Denmark	58.662	1826,438	25	3	4	4	5	5	1	27,88	24	0,2602	20
Croatia	28.070	1189,82	26	3	3	2	1	5	1	21,88	30	0,6550	7
Islamic Rep. of Iran	12.447	35530,31	27	3	2	2	0	5	1	19,38	33	0,0438	69
Serbia	17.192	2185,572	28	3	1	5	5	2	0	22,00	29	0,5855	8
Belgium	52.085	3579,447	29	3	1	3	7	4	3	21,88	30	0,1173	41
Bulgaria	23.325	1907,65	30	3	1	2	1	4	0	17,50	34	0,3933	13
Uzbekistan	7.142	13898,73	32	3	0	2	1	5	3	16,13	36	0,1624	30

Country	GNI 2019	Population 15-39 (1)	Official ranking	Medals (2)			Diplomas			Unstandard.		Standardised	
				G	S	B	4th	5th	6th	Index	R (3)	Index	R
Chinese Taipei	25.908	7917,782	34	2	4	6	3	6	0	25,00	26	0,1219	40
Turkey	27.701	33192,62	35	2	2	9	3	10	3	25,38	25	0,0276	81
Greece	30.155	2855,167	36	2	1	1	2	4	2	13,25	39	0,1539	33
Uganda	2.123	19079,52	36	2	1	1	0	1	0	11,25	46	0,2777	18
Ecuador	11.044	7441,795	38	2	1	0	0	1	1	10,38	51	0,1262	38
Israel	40.187	3102,292	39	2	0	2	2	3	3	12,13	42	0,0973	49
Ireland	68.371	1610,35	39	2	0	2	1	1	0	10,75	49	0,0976	47
Qatar	92.418	1443,798	41	2	0	1	0	1	0	9,25	58	0,0693	60
Kosovo	12.070	660,2065	42	2	0	0	0	0	0	8,00	61	1,0039	4
Ukraine	13.216	13930,2	44	1	6	12	5	10	6	33,75	19	0,1833	25
Belarus	18.546	3003,953	45	1	3	3	2	5	2	15,50	37	0,2782	17
Romania	29.497	5718,589	46	1	3	0	1	4	3	11,88	43	0,0704	58
Venezuela	7.045	10206,82	46	1	3	0	0	3	1	10,88	48	0,1512	34
India	6.681	594165,4	48	1	2	4	2	3	2	14,00	38	0,0035	102
Hong Kong, China	62.985	2170,959	49	1	2	3	1	3	0	12,25	40	0,0896	52
Slovakia	32.113	1719,754	50	1	2	1	1	0	1	9,63	54	0,1743	26
Philippines	9.778	46823,78	50	1	2	1	1	0	0	9,50	55	0,0207	85
South Africa	12.129	25331	52	1	2	0	1	3	1	9,38	57	0,0305	79
Austria	56.197	2741,096	53	1	1	5	2	1	0	12,25	40	0,0795	54
Egypt	11.466	43809	54	1	1	4	1	4	1	11,63	44	0,0231	83
Indonesia	11.459	106730,7	55	1	1	3	1	3	0	10,25	52	0,0084	95
Ethiopia	2.207	50354,94	56	1	1	2	5	1	2	11,00	47	0,0990	45
Portugal	33.967	2855,636	56	1	1	2	1	4	0	9,50	55	0,0979	46
Tunisia	10.414	4491	58	1	1	0	0	0	1	6,13	66	0,1310	37
Thailand	17.781	24202,15	59	1	0	1	1	4	0	6,50	63	0,0151	87
Latvia	30.282	535,29	59	1	0	1	2	1	1	6,38	65	0,3933	14
Puerto Rico	24.470	967,759	63	1	0	0	0	0	1	4,13	69	0,1742	27
Morocco	7.368	14382	63	1	0	0	0	0	0	4,00	70	0,0377	73
Colombia	14.257	21281,86	66	0	4	1	2	6	0	11,50	45	0,0379	72
Azerbaijan	13.784	4033,415	67	0	3	4	0	2	0	10,50	50	0,1889	24
Dominican Republic	17.591	4500,203	68	0	3	2	0	2	0	8,50	60	0,1074	42
Armenia	13.894	1027,641	69	0	2	2	0	2	0	6,50	63	0,4552	11
Kyrgyzstan	4.864	2621,472	70	0	2	1	0	1	1	5,38	67	0,4215	12
Mongolia	10.839	1262,227	71	0	1	3	1	5	0	6,75	62	0,4934	10
Malaysia	27.534	14435,41	74	0	1	1	1	0	0	3,50	71	0,0088	92
Nigeria	4.910	82174	74	0	1	1	1	0	0	3,50	71	0,0087	93
Jordan	9.858	4699,411	74	0	1	1	0	1	0	3,25	73	0,0702	59
Lithuania	35.799	810,3285	77	0	1	0	1	1	2	3,00	75	0,1034	43
Saudi Arabia	47.495	14420,82	77	0	1	0	0	1	0	2,25	77	0,0033	103

Country	GNI 2019	Population 15-39 (1)	Official ranking	Medals (2)			Diplomas			Unstandard.		Standardised	
				G	S	B	4th	5th	6th	Index	R (3)	Index	R
Namibia	9.357	1052	77	0	1	0	0	0	1	2,13	78	0,2159	22
Bahrain	42.522	673,5455	77	0	1	0	0	0	1	2,13	78	0,0742	56
North Macedonia	15.865	737,9805	77	0	1	0	0	0	0	2,00	80	0,1708	28
Kazakhstan	22.857	6776,482	83	0	0	8	1	5	0	9,75	53	0,0629	64
Mexico	19.160	50526,56	84	0	0	4	7	3	6	9,00	59	0,0093	91
Finland	48.511	1678,881	85	0	0	2	1	3	0	3,25	73	0,0399	71
Côte d'Ivoire	5.069	11121	86	0	0	1	1	2	0	2,00	80	0,0355	74
Republic of Moldova	13.664	1064,303	86	0	0	1	0	1	0	1,25	82	0,0860	53
Kuwait	58.590	1297,12	86	0	0	1	0	0	1	1,13	83	0,0148	88
Botswana	16.437	1114	86	0	0	1	0	0	0	1,00	84	0,0546	66
Burkina Faso	2.133	8689	86	0	0	1	0	0	0	1,00	84	0,0540	67
Syrian Arab Republic	3.613	8826,874	86	0	0	1	0	0	0	1,00	84	0,0314	78
Ghana	5.269	13452	86	0	0	1	0	0	0	1,00	84	0,0141	89
Chile	23.261	7357,707	94	0	0	0	1	1	0	0,75	88	0,0044	100
Costa Rica	18.486	2022,713	94	0	0	0	1	1	0	0,75	88	0,0201	86
Singapore	88.155	1995,401	94	0	0	0	1	1	0	0,75	88	0,0043	101
Pakistan	5.005	95611,82	94	0	0	0	0	2	0	0,50	91	0,0010	106
Algeria	11.174	16581	94	0	0	0	0	2	0	0,50	91	0,0027	105
Peru	12.252	13494,72	94	0	0	0	0	2	0	0,50	91	0,0030	104
Mozambique	1.250	12707,48	94	0	0	0	0	2	0	0,50	91	0,0315	77
Guatemala	8.494	7823,963	94	0	0	0	1	0	0	0,50	91	0,0075	96
Albania	13.998	1020,813	94	0	0	0	1	0	0	0,50	91	0,0350	75
Bosnia and Herzegovina	14.872	1017,145	94	0	0	0	0	1	1	0,38	97	0,0248	82
Vietnam	7.433	37770,24	94	0	0	0	0	1	0	0,25	98	0,0009	107
Cameroon	3.581	10957	94	0	0	0	0	1	0	0,25	98	0,0064	97
Niger	1.201	9103	94	0	0	0	0	1	0	0,25	98	0,0229	84
Haiti	1.709	4949,815	94	0	0	0	0	1	0	0,25	98	0,0296	80
Burundi	754	4798,859	94	0	0	0	0	1	0	0,25	98	0,0691	61
Liberia	1.258	2040	94	0	0	0	0	1	0	0,25	98	0,0974	48
Panama	29.558	1670,721	94	0	0	0	0	1	0	0,25	98	0,0051	99
Eritrea	2.793	1455,476	94	0	0	0	0	1	0	0,25	98	0,0615	65
Uruguay	20.064	1212,629	94	0	0	0	0	0	1	0,13		0,0051	98
Trinidad and Tobago	26.231	567,859	94	0	0	0	0	0	1	0,13		0,0084	94

Notes: (1) Countries with less than half million inhabitants between the ages of 15 and 39 have been omitted.
(2) G: gold, S: silver, B: bronze
(3) R: ranking

Table 2
Medallist indexes and rankings (countries with at least one medal)

Country	GNI 2019	Population 15-39 (1)	Official ranking	Medallists (2)			Unstandard.		Standardised	
				G	S	B	Index	R (3)	Index	R
United States of America	63.826	112897,5	1	102	99	56	662	1	0,0919	55
People's Rep. of China	16.057	483514,3	2	52	36	26	306	5	0,0394	69
Japan	42.932	31174,77	3	66	31	17	343	3	0,2563	28
Great Britain	46.071	21192,71	4	36	23	51	241	6	0,2468	30
ROC	26.157	47271,27	5	35	74	19	307	4	0,2483	29
Australia	48.085	8951,673	6	28	26	45	209	7	0,4855	14
Netherlands	57.707	5464,591	7	29	18	15	167	10	0,5296	13
France	47.173	18907,53	8	64	38	28	360	2	0,4036	20
Germany	55.314	24201,94	9	17	24	31	147	12	0,1098	53
Italy	42.776	15576,07	10	17	16	33	133	13	0,1996	36
Canada	48.527	12473,46	11	36	9	26	188	8	0,3106	25
Brazil	14.263	84769,35	12	29	16	9	157	11	0,1299	50
New Zealand	40.799	1762,495	13	27	26	8	168	9	2,3363	2
Cuba	8.621	3592,394	14	8	3	5	43	23	1,3885	4
Hungary	31.329	2876,261	15	9	5	32	78	17	0,8656	9
Republic of Korea	43.044	16280,9	16	11	7	16	74	18	0,1056	54
Poland	31.623	12089,95	17	10	10	6	66	20	0,1726	39
Czech Republic	38.109	2968,695	18	5	4	4	32	29	0,2829	26
Kenya	4.244	22583,42	19	4	4	2	26	35	0,2713	27
Norway	66.494	1761,442	20	5	2	16	40	24	0,3415	23
Jamaica	9.319	1234,396	21	7	0	7	35	26	3,0426	1
Spain	40.975	13306,01	22	4	44	22	126	14	0,2311	31
Sweden	54.508	3314,608	23	5	27	0	74	18	0,4096	18
Switzerland	69.394	2689,351	24	3	4	6	26	35	0,1393	47
Denmark	58.662	1826,438	25	4	21	4	62	21	0,5787	12
Croatia	28.070	1189,82	26	5	4	2	30	32	0,8983	8
Islamic Rep. of Iran	12.447	35530,31	27	3	2	2	18	42	0,0407	68
Serbia	17.192	2185,572	28	15	1	19	81	16	2,1558	3
Belgium	52.085	3579,447	29	20	1	5	87	15	0,4667	16
Bulgaria	23.325	1907,65	30	7	1	2	32	29	0,7192	10
Slovenia	38.080	601,45	31	3	1	1	15	45	0,6549	11
Uzbekistan	7.142	13898,73	32	3	0	2	14	46	0,1410	46
Georgia		1223,917	33	2	5	1	19	40		5

Country	GNI 2019	Population 15-39 (1)	Official ranking	Medallists (2)			Unstandard.		Standardised	
				G	S	B	Index	R (3)	Index	R
Chinese Taipei	25.908	7917,782	34	3	6	7	31	31	0,1511	45
Turkey	27.701	33192,62	35	2	2	9	21	38	0,0228	75
Greece	30.155	2855,167	36	2	13	1	35	26	0,4065	19
Uganda	2.123	19079,52	36	2	0	1	9	56	0,2222	32
Ecuador	11.044	7441,795	38	2	1	0	10	51	0,1217	52
Israel	40.187	3102,292	39	2	0	12	20	39	0,1604	43
Ireland	68.371	1610,35	39	3	0	5	17	43	0,1544	44
Qatar	92.418	1443,798	41	2	0	2	10	51	0,0749	58
Kosovo	12.070	660,2065	42	2	0	0	8	59	1,0039	7
Ukraine	13.216	13930,2	44	1	7	17	35	26	0,1901	37
Belarus	18.546	3003,953	45	1	6	3	19	40	0,3410	24
Romania	29.497	5718,589	46	2	7	0	22	37	0,1304	49
Venezuela	7.045	10206,82	46	1	3	0	10	51	0,1391	48
India	6.681	594165,4	48	1	2	21	29	33	0,0073	86
Hong Kong, China	62.985	2170,959	49	1	1	5	11	49	0,0804	57
Slovakia	32.113	1719,754	50	1	2	4	12	48	0,2173	34
Philippines	9.778	46823,78	50	1	2	1	9	56	0,0197	77
South Africa	12.129	25331	52	1	1	0	6	63	0,0195	78
Austria	56.197	2741,096	53	1	1	5	11	49	0,0714	60
Egypt	11.466	43809	54	1	1	4	10	51	0,0199	76
Indonesia	11.459	106730,7	55	2	1	3	13	47	0,0106	83
Ethiopia	2.207	50354,94	56	1	1	2	8	59	0,0720	59
Portugal	33.967	2855,636	56	1	1	2	8	59	0,0825	56
Tunisia	10.414	4491	58	1	1	0	6	63	0,1283	51
Thailand	17.781	24202,15	59	1	0	1	5	66	0,0116	82
Latvia	30.282	535,29	59	4	0	1	17	43	1,0487	6
Puerto Rico	24.470	967,759	63	1	0	0	4	69	0,1689	41
Morocco	7.368	14382	63	1	0	0	4	69	0,0377	70
Colombia	14.257	21281,86	66	0	4	1	9	56	0,0297	72
Azerbaijan	13.784	4033,415	67	0	3	4	10	51	0,1799	38
Dominican Republic	17.591	4500,203	68	0	6	25	37	25	0,4674	15
Armenia	13.894	1027,641	69	0	2	2	6	63	0,4202	17
Kyrgyzstan	4.864	2621,472	70	0	2	1	5	66	0,3921	21
Mongolia	10.839	1262,227	71	0	1	3	5	66	0,3655	22
Argentina	21.190	17046,93	72	0	18	25	61	22	0,1689	42
Malaysia	27.534	14435,41	74	0	1	2	4	69	0,0101	84

Country	GNI 2019	Population 15-39 (1)	Official ranking	Medallists (2)			Unstandard.		Standardised	
				G	S	B	Index	R (3)	Index	R
Nigeria	4.910	82174	74	0	1	1	3	73	0,0074	85
Jordan	9.858	4699,411	74	0	1	1	3	73	0,0648	64
Lithuania	35.799	810,3285	77	0	1	0	2	75	0,0689	62
Turkmenistan	14.909	2553,428	77	0	1	0	2	75	0,0525	66
Saudi Arabia	47.495	14420,82	77	0	1	0	2	75	0,0029	87
Namibia	9.357	1052	77	0	1	0	2	75	0,2032	35
Bahrain	42.522	673,5455	77	0	1	0	2	75	0,0698	61
North Macedonia	15.865	737,9805	77	0	1	0	2	75	0,1708	40
Kazakhstan	22.857	6776,482	83	0	0	8	8	59	0,0516	67
Mexico	19.160	50526,56	84	0	0	27	27	34	0,0279	73
Finland	48.511	1678,881	85	0	0	2	2	75	0,0246	74
Côte d'Ivoire	5.069	11121	86	0	0	1	1	82	0,0177	79
Republic of Moldova	13.664	1064,303	86	0	0	1	1	82	0,0688	63
Kuwait	58.590	1297,12	86	0	0	1	1	82	0,0132	81
Botswana	16.437	1114	86	0	0	4	4	69	0,2184	33
Burkina Faso	2.133	8689	86	0	0	1	1	82	0,0540	65
Syrian Arab Republic	3.613	8826,874	86	0	0	1	1	82	0,0314	71
Ghana	5.269	13452	86	0	0	1	1	82	0,0141	80

Notes: (1) Countries with less than half million inhabitants between the ages of 15 and 39 have been omitted.
(2) G: gold, S: silver, B: bronze
(3) R: ranking