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FACULTY OF ECONOMICS AND BUSINESS

# Characteristics of international collaboration in sport sciences publications and its influence on citation impact

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MSI_1501

**Title**: Characteristics of International Collaboration in Sport Sciences Publications and Its Influence on Citation Impact

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**Keywords**: COLLABORATION, CITATION IMPACT

**Word Count**: 5680

## ABSTRACT

**Background:** Some bibliometric research has been carried out in sport sciences, but compared with other disciplines there is still no intensive study at macro level, especially on international collaboration.

**Aim:** This study attempts to observe the status and trend of international collaboration in sport sciences at macro level, and to look at its relationship with academic impact.

**Methods:** 20804 publications from 63 consistently issued journals belonging to the *Sport Sciences* category in Web of Science database *in* 2000–2001 & 2010–2011 were analyzed. The main objects include co-authorship links of country pairs, the share of international co-authored publications, tendency and "affinity" in collaboration, and citation impact of international publications. Differences between countries and periods were observed.

**Results:** There is a rapid increase of the share of international collaboration in sport sciences. In some countries the share is even above 2/3; Co-authorship networks imply some cultural, political or geographical factors for collaboration, and their changes exhibit some new trends; Selected countries have strong tendency in collaboration; International collaborated publications have a higher performance than domestic ones in citation impact. But gaps between countries are narrowing.

**Conclusions**: International collaboration really intensified in this field. European, especially Nordic countries are very fond of collaboration and have gained outstanding performance as a partner. It is meaningful to further explore the underlying motivation behind international collaboration in sport science research.

## INTRODUCTION

Bibliometrics is a set of methods in library and information science to study the patterns of publications.[1] It has become a useful method to track the academic progression. In sport sciences, there are already some articles using bibliometrics to explore the disciplines development. Most of them made bibliometric studies on specific sports or topics, such as judo, rugby, physical activity and aging, anabolic steroids and drug abuse, rehabilitation, disability sport, adapted physical activity, cardiology and sport and sport psychology.[2-10] Others just focus on one journal, such as *International Review for the Sociology of Sport*,[11] *Journal of Orthopaedic & Sports Physical Therapy*,[12] *Journal of Rehabilitation and Medicine*,[13 14] or on several journals, normally relate to sub-disciplines in sport sciences, such as physical and rehabilitation medicine, rehabilitation, sport management and marketing or sports economics.[15-18] Sometimes they also focus on sport sciences in specific country or region, such as Spain, Iran, Croatia and South America.[19-22] Only a few articles studied sport sciences covering the entire discipline.[23 24]

The above mentioned papers study mainly trends in publication output and citation impact, at different levels of aggregation like authors, institutions and countries, authors. Indicators often include publication counts and citations per article. And the Impact Factor is still the most commonly used indicator, sometimes in combination with other indicators like SJR.[13 15] Some researchers are keen on exploring the fulfillment of Price, Lotka and Bradford Laws in sport sciences.[2 3 8] Overall speaking, all these studies find a growing trend of sport sciences publications, including the international publications. Some authors summed up the reasons for the observed increase: the proliferation of English has made it the standard academic language; the Internet has made the communication easier and cheaper; publishing on journals indexed by ISI database becomes a criterion for academic evaluation and the extended coverage of this bibliographic database.[16] Meantime, in order to increase the journals' international contacts, more foreign experts are accepted as members of Editorial Boards,[14] which also contributes to the increase of international articles and international collaboration. In addition, the increased ratio of multi-authored papers is similar to results of other disciplines.[16 25] Interestingly, some find that the publication output on a specific topic at country level has a similar pattern as competitive sport performances.[2 3]

As an important topic, collaboration also is mentioned in these studies. A common approach is to use co-authorship network analysis to identify author clusters.[2 5] The benefits and challenges of collaborative research in sport also are discussed.[26] Some researchers find the collaboration tendency of in specific sport topics, such as Spain tend to work with South America, and Iran prefers to collaborate with English-speaking countries, like Canada, England, Australia and the USA.[19 20] Compared with other disciplines, such as mathematics, physics and biology, international collaboration in sport sciences has not been adequately studied, especially from the macro-level perspective.[27-30] Do sport sciences tend to research alone like mathematics, or tend to study with a big team like biology? Or whether collaboration in sport sciences enhances productivity? Does international collaborated publications have a higher citation impacts than domestic ones? Is there some close partnership between certain countries in sport sciences? This paper, based on bibliographic data of two periods (2000-2001 & 2010-2011) from sport sciences journals, aims to observe the status and trends of international collaboration in sport sciences from the macro-level perspective and explore its influence on citation impacts.

### Collaboration Research in bibliometrics

Scientific collaboration itself has become one of the favorite topics in bibliometric research. The first comprehensive study on international collaboration using co-operativity measures has been published by Schubert and Braun and found a dramatic increase of international collaboration on the SCI publications.[31] Of course, not all countries showed an increasing trend, such as in Turkey, South Korea and Saudi Arabia the

share of international co-authored publications decreased. They also found that foreign co-authorship can be approximated by national publication productivity through a power law in which the exponent is less than one. Although big countries have a relatively lower share of international co-publications than medium-sized or small countries have, the increase is thus a global law independently of the countries' size. Glänzel and Schubert studied international co-authorship networks and found the collaboration has been intensified and the density of the networks has increased.[32] International co-authorship links will undergo dramatic structural changes over time and collaboration is determined by geographic, political, economic and other reasons. In addition to the symmetric network analysis, some scientists also observed the asymmetric network (specific unidirectional 'affinities' between countries), a possible way to characterize the relative 'importance' of other countries for selected countries.[33] Glänzel even outlined a methodological scheme for the analysis of international co-publication patterns. Besides, the relationship between collaboration and scientific productivity also is an important research point.[34] Some scientist, explored the idea that "collaboration will increase productivity", and found that this does not necessary always hold.[35 36] In different fields, cooperation may have different correlations, even positive relationship, with productivity.

## METHODS

### Data retrieval

The results of present study are based on the bibliographic data extracted from the 2000–2001 and 2010–2011 volumes of Thomson Reuters Web of Science (WoS). Only document the types Articles, Notes, Proceeding Papers and Reviews, and assigned to the Subject Category *Sport Sciences* were taken into consideration. Finally, 63 consistently issued journals were covered by the SCI-EXPANDED (SCIE) database in one or both periods, so only documents published in these journals were used in this study. Changes of journal titles have been considered. Publications were assigned to countries on the basis of their corporate addresses, which appear in the by-line of the publication.

The main purpose of this study is to observe the international collaboration in sport sciences, and not to explore research topics or themes. According to this aim, limiting the publication set to the Sport Sciences category is appropriate to fulfill this task. So we did not collect publications outside this category related to sport research.

Altogether, 8,304 publications from 2000-2001, and 12,500 publications from 2010-2011 met the selection criteria. Their Accession Number, Addresses, Publication Year and all citation information were downloaded and were imported into an Oracle database for further analysis.

### Data processing

In this paper, when two or more countries appear in the author's addresses of one publication, it is considered to be an international collaborated publication and it is counted in full for each of the contributing countries. Also for the citations we apply this full counting scheme. For the analysis of the international collaboration strength between country pairs, we used the Salton's cosine measure.[37]

For the citation analysis, a three-year citation window has been applied, beginning with the publication year and next 2 years (e.g. 2000, 2001, 2002 three years for papers published in 2000). The definition of self-citation applied in this study was the same as that applied earlier, e.g., by Snyder and Bonzi.[38]

MOCR, MECR and RCR were chosen as the citation indicators. They can be presented in tables or plotted in relational charts and have proven to be useful instruments in cross-national comparisons of national research performance. So definitions of these indicators are as follows:

• Mean Observed Citation Rate (MOCR) is defined as the ratio of citation count to publication count.

• Mean Expected Citation Rate (MECR) is defined as the ratio of the expected citation count to publication count. The expected citation count is calculated on the basis of the average number of citations that papers have received in each particular journal within the same citation window.

• Relative Citation Rate (RCR) is the ratio of MOCR to MECR.[39] RCR=0 corresponds to uncitedness; RCR<1 represents an observed citation impact lower than can be expected; RCR>1 represents higher-than-the-average and finally RCR=1 means that the papers received the number of citations expected on the basis of the average citation rate of the publishing journals.

## RESULTS

### Basic data

**Table 1**. Data overview of two periods

| Periods | 2000-2001 | 2010-2011 |
|---|---|---|
| Publications | 8304 | 12500 |
| International Publications (%) | 14.4% | 22.6% |
| Citations | 22629 | 54779 |
| Self-Citations (%) | 28.2% | 23.9% |

(*Data sourced from Thomson Reuters' Web of Science Core Collection*)

Although publications are limited to 63 journals, there is a big increase in the total amount of publications. On the other hand, the growth of publications (50.5%) is significantly slower than that of citations (142.1%), which results in a substantial increase of impact factors. Here the "domestic publications" refers all publications whose corporate addresses are only from one country, and correspondingly, "international publications" means that there are two or more countries appear in corporate addresses. As been shown, the share of self-citations decreased in spite of the increase of the share of international collaborated publications, so international collaboration in sport sciences has indeed broaden the audiences.

### Share of Internationally Co-authored Publications

International collaboration can be traced back to 19th century.[40] However, many recent studies have shown that this phenomenon has increased during the last two decades.[32 34 41 42] Several factors, such as cost-savings, the growing importance of interdisciplinary fields and geographical, economical or cultural interests are pointed out to contribute for the establishment of international collaboration.[43] The absolute number of international papers and their share in the total national publication output serve as basic indicators of international co-authorship and scientific collaboration. Table 1 presents the national publication output,, the share of international co-authored publications to the national total and the share of national publication output to the world total in sport sciences in each of the two periods.

**Table 2.** Scientific output, share of international co-publications in each country and share of every country in the world

| Rank | Country/Region | 2000/2001 | | | 2010/2011 | | |
|---|---|---|---|---|---|---|---|
| | | Papers | A(%) | B(%) | Papers | A(%) | B(%) |
| 1 | Switzerland | 126 | 48.4 | 1.52 | 397 | 70.3 | 3.18 |
| 2 | Ireland | 30 | 33.3 | 0.36 | 92 | 67.4 | 0.74 |
| 3 | Portugal | / | / | / | 117 | 66.7 | 0.94 |
| 4 | New Zealand | 84 | 59.5 | 1.01 | 284 | 66.5 | 2.27 |
| 5 | Sweden | 224 | 31.3 | 2.70 | 333 | 58.0 | 2.66 |
| 6 | Austria | 64 | 48.4 | 0.77 | 133 | 54.9 | 1.06 |
| 7 | Norway | 68 | 25.0 | 0.82 | 258 | 54.7 | 2.06 |
| 8 | Denmark | 122 | 32.8 | 1.47 | 230 | 54.3 | 1.84 |
| 9 | South Africa | 40 | 47.5 | 0.48 | 81 | 54.3 | 0.65 |
| 10 | Spain | 76 | 34.2 | 0.92 | 374 | 51.1 | 2.99 |
| 11 | Australia | 466 | 31.3 | 5.61 | 1078 | 49.6 | 8.62 |
| 12 | UK | 718 | 26.2 | 8.65 | 1319 | 48.9 | 10.55 |
| 13 | Finland | 139 | 38.1 | 1.67 | 119 | 47.9 | 0.95 |
| 14 | Belgium | 107 | 30.8 | 1.29 | 252 | 47.6 | 2.02 |
| 15 | Italy | 223 | 29.1 | 2.69 | 508 | 45.9 | 4.06 |
| 16 | France | 373 | 28.4 | 4.49 | 584 | 45.0 | 4.67 |
| 17 | Netherlands | 210 | 39.0 | 2.53 | 451 | 43.2 | 3.61 |
| 18 | P R China | 52 | 36.5 | 0.63 | 250 | 43.2 | 2.00 |
| 19 | Canada | 766 | 33.7 | 9.22 | 1012 | 42.0 | 8.10 |
| 20 | Germany | 359 | 26.5 | 4.32 | 728 | 40.8 | 5.82 |
| 21 | Brazil | 37 | 54.1 | 0.45 | 369 | 40.7 | 2.95 |
| 22 | Greece | 49 | 49.0 | 0.59 | 135 | 40.0 | 1.08 |
| 23 | Israel | 76 | 39.5 | 0.92 | 100 | 39.0 | 0.80 |
| 24 | South Korea | 24 | 33.3 | 0.29 | 275 | 25.1 | 2.20 |
| 25 | Poland | 56 | 23.2 | 0.67 | 89 | 22.5 | 0.71 |
| 26 | Taiwan | 71 | 23.9 | 0.86 | 173 | 22.0 | 1.38 |
| 27 | USA | 4106 | 13.3 | 49.45 | 4857 | 21.8 | 38.86 |
| 28 | Japan | 412 | 20.1 | 4.96 | 535 | 19.6 | 4.28 |
| 29 | Turkey | 38 | 10.5 | 0.46 | 131 | 18.3 | 1.05 |
| | World | *8304* | | | *12500* | | |

Ranked by 'A' in 2010/11 (A: share of international co-authored papers to national total outputs, B: share of national outputs to the world total outputs; World values are set in italics); "/": In 2000/01 Portugal has no data because its literatures are less than 10. (*Data sourced from Thomson Reuters' Web of Science Core Collection*)

Similar to many other research fields, USA is the most prolific country in sport sciences. In the first period, New Zealand, Brazil and Portugal have the highest share of international papers. Exactly the reverse, Turkey, and USA have the lowest share of international papers, and the amount of papers of the latter one is nearly half of the world total. So in the first period, it could be said that international collaboration in sports science is not very common. In the second period, the growth of the world total outputs (50.5%) is far beyond the growth of

USA (18.3%). Almost all countries show an increase in their share to the world total, except for six countries where the 'B' value drops. USA has the largest decline in share but holds its position as leading country. And of course, there is a general increase in indicator 'A', except for a decrease in 7 countries. Although the 'A' indicator for USA increases a lot in 2010/11, USA still ranks low in this indicator among the 29 selected countries. It's worth noting that there is a significant decrease of Brazil in 'A' (from 54.1% to 40.7%). In this period, the most internationalized countries in sport sciences research are Switzerland, Ireland and New Zealand. The share of these countries' international co-authored papers was even higher than two-thirds. 18 countries have an increase in both indicators, and the growth of 'A' was greater than 'B' in these countries. It indicates that the growth of national total outputs mainly due to the growth of international papers. UK, Australia, Germany, Italy and Norway all have a faster growth than the other countries in both two indicators.

It is worth mentioning that Brazil and South Korea both have an increase in 'B' value and a decrease in 'A' value. This indicates that these two countries' authors pay more attention on domestic partnership or independent research, which led to the overall increase of their national outputs.

**Co-authorship links**

As Leta et al. have mentioned, the analysis of international co-authorship patterns by country pairs is the most intelligible approach to analyse the strength of a given country's collaboration links with other countries.[41] Here we only consider the international collaboration links with more than 10 co-publications. In the co-authorship analyses, weighted links between countries or regions were studied. A link between two countries is established whenever the two given countries co-occurred in the corporate address in the by-line of a publication. Salton's measure is used as a measure of international collaboration strength. The collaboration matrix was imported into Pajek to create a undirected map (Figure 1a-1b).[44] The depth of the line between each country pairs represents the value of Salton's measure. For a simplified representation of the network, only relations that reached a minimum strength (cosine value above 0.02) are showed here.

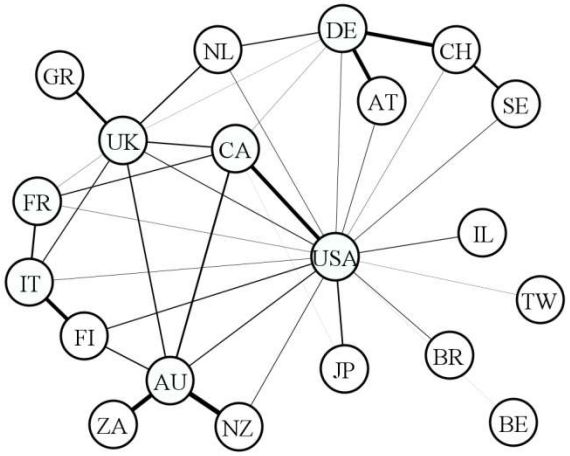


**Figure 1a**. International collaboration map for most active countries in sport sciences in 2000/01 based on Salton's measure (line thickness according to the cosine value).

(*Data sourced from Thomson Reuters' Web of Science Core Collection*)

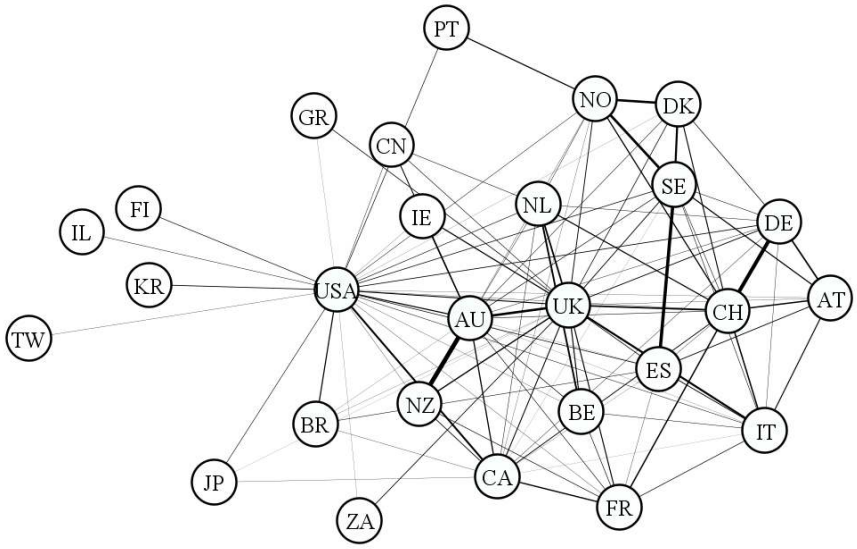


**Figure 1b.** International collaboration map for most active countries in sport sciences in 2010/11 based on Salton's measure (line thickness according to the cosine value).

(*Data sourced from Thomson Reuters' Web of Science Core Collection*)

In 2000/01, 20 countries have a co-authorship with other countries, and USA, clearly, locates in the center. There are some strong relationships between USA and Canada, Germany and Switzerland, Germany and Austria, Australia and New Zealand, Australia and South Africa, Finland and Italy (Salton's cosine measure value is above 3.9). No strong triads are observed. In 2010/11, 27 countries form a cooperative network. The sub-network that most European countries formed intensified and Australia and UK seem to lie with USA in the center of the whole network. Several strong triads pop up in the last period.

South Africa has shifted his main collaboration partner from Australia in 2000/01 to UK and USA in 2010/11. It is worth mentioning that the Nordic countries strengthened their inner cooperation in sport sciences in 2010/11 with exception of Finland who preferred to collaborate with USA. Brazil doubles its collaboration strength with USA. Half of international co-authored papers of Brazil are published in collaboration with USA., while its share of international papers declined to 13.4%. Different to South Africa and Brazil, China strengthens its cooperation with Australia and several European countries in 2010/11, although at the same time USA still plays its most important international partner. There are several strong collaboration links, like USA-Canada, Germany-Switzerland, Australia-New Zealand, which all remain stable in two periods. Geographical and cultural factors may be the main reason for these stable country pairs collaboration.

**Co-authorship "affinity": Asymmetry in co-authorship relationship**

The "co-authorship affinity" has been mentioned and measured before.[45] The affinity between a selected country and one of its collaborating partners can be explained as the share of one partner country in the internationally co-authored papers of the selected country divided by the share of the total number of this partner country's publications in the "rest of the world" total, i.e., the world total minus the number of publications of the selected country. A formal definition can be found in Schubert and Glänzel (2006).[46]

In general, this affinity relationship between two countries is asymmetrical. In order to make comparisons convenient, the direct and reverse indicator values of specific co-authorship affinity are showed in table 4 and 5

(Appendix). For example, in 2000/01, the direct value of the USA→UK affinity is thus 0.58 (9.9% vs. 17.1%), while for the reverse value, UK→USA, its value is 0.53 (28.7% vs. 54.1%). Since there are too many zero values, we only show the specific affinity values of the 29 selected countries toward the 7 most important partner countries. (No values are indicated where the number of joint publications was less than 10).

In 2000/01, there are 5 values above 10, for example, Australia→New Zealand. And two values are close to 10, UK→Greece and Sweden→Switzerland. These "excessive affinity", which means that indicator 'A' has 10 times the value of indicator 'B', have been presented in symmetrical co-authorship links. But at the same time, this asymmetric co-authorship shows that it's not so intimate between these each country pairs in the opposite direction, which can't be seen in undirectional mapping.

Glänzel and Schubert also mentioned strongly asymmetric "skew pairs", i.e., those cases where the indicator value in one direction is less than 1, while in the reverse direction is greater than 1.[45] In 2000/01, we find 6 "skew pairs", e.g., New Zealand is somewhat "over-represented" as a co-operating partner for USA, while USA is definitely "under-represented" as a partner for New Zealand. The same phenomenon occurs in the rather unidirectional USA→Austria, Canada→Germany, Canada→Japan, Finland→Italy, France→Italy relationships.

In 2010/11, "excessive affinity" almost disappears, which means most countries try to collaborate with more partners, of course, given that the share of the total publication output of each country (except for the USA) is increasing. We still can see some strong affinities, e.g., in Germany↔Switzerland, Germany↔Austria, Netherlands↔Belgium, Australia↔New Zealand (bidirectional). But for most countries, the corresponding indicator values are below 3. It is worth mentioning that there are twelve "skew pairs" in this period. A possible reason for the sudden increase of this kind of pairs is that the number of joint papers has increased in 2010/11 and passes the threshold of 10.

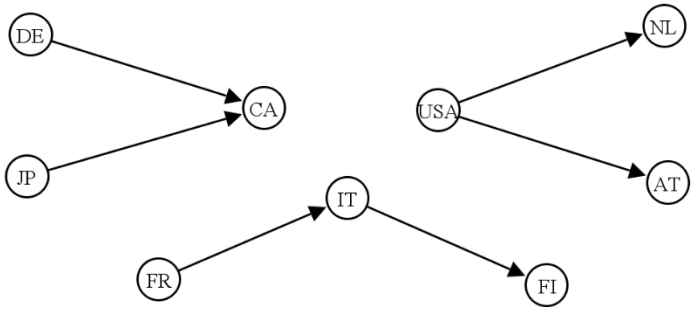


**Figure 2a.** Directed graph of strongly asymmetric co-authorship links in 2000/2001

(*Data sourced from Thomson Reuters' Web of Science Core Collection*)

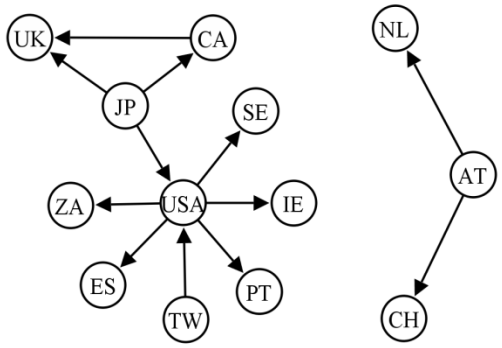


**Figure 2b.** Directed graph of strongly asymmetric co-authorship links in 2010/2011

(*Data sourced from Thomson Reuters' Web of Science Core Collection*)

Figure 2a and 2b display in a directed graph format the strongly asymmetric "skew pairs" in two periods. If arrow points from X to Y, it means X→Y co-authorship affinity value is greater than 1, while in the reverse direction, Y→X affinity value is less than 1. In 2000/01, Canada seemed to be an attraction node in the collaboration network. USA and Italy were in an "intermediary position". In 2010/11 the situation somewhat changed, as Japan and Austria have become a "repulsion node", while UK seemed to be an "attraction node". USA was again in a "intermediary" position, particularly, "repulsing" for Europe and "attracting" for Asia.

**International co-authorship and citation impact**

The Mean Observed Citation Rate (MOCR) reflects the factual citation impact of a unit, whereas the Mean Expected Citation Rate (MECR) is based on the 3-year mean citation rate of the journals in which the unit under study has been publishing. This journal citation measure is used as the reference standard for papers published in the corresponding journal. Here a unit is the country. Relative Citation Rate (RCR) is defined as the ratio of the observed and the journal-based expected citation impact, that is, RCR = MOCR/MECR. RCR measures whether the publications of a country attract more or less citations than expected on the basis of the average citation rates of the journals in which they appeared. The indicator ranges between 0 and infinity, the neutral value is 1. RCR<1 (RCR>1) means a citation score below (above) expectation. The MOCR and RCR for all papers combined and for international publications of 29 selected countries are showed in table 3.

**Table 3**. Relative citation indicators of international publications

| Label | Country/Region | 2000-2001 | | | 2010-2011 | | |
|---|---|---|---|---|---|---|---|
| | | $MOCR_{all}$ | $RCR_{all}$ | $RCR_{int}$ | $MOCR_{all}$ | $RCR_{all}$ | $RCR_{int}$ |
| 0 | Australia | 3.40 | 1.20 | 1.47 | 6.17 | 1.25 | 1.31 |
| 1 | Austria | 2.84 | 1.03 | 1.39 | 4.36 | 1.08 | 1.21 |
| 2 | Belgium | 3.03 | 1.03 | 1.09 | 5.62 | 1.25 | 1.43 |
| 3 | Brazil | 2.30 | 0.69 | 0.54 | 3.50 | 0.87 | 0.92 |
| 4 | Canada | 3.57 | 1.16 | 1.39 | 4.87 | 1.13 | 1.33 |
| 5 | Denmark | 4.11 | 1.26 | 1.09 | 7.49 | 1.46 | 1.81 |
| 6 | Finland | 3.70 | 1.30 | 1.52 | 4.49 | 1.01 | 1.29 |
| 7 | France | 2.17 | 0.88 | 1.06 | 4.16 | 1.07 | 1.36 |
| 8 | Germany | 2.59 | 1.10 | 1.38 | 4.35 | 1.13 | 1.40 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9 | Greece | 1.08 | 0.54 | 0.69 | 3.96 | 0.96 | 1.19 |
| A | Ireland | 2.83 | 1.01 | 1.52 | 5.00 | 1.15 | 1.31 |
| B | Israel | 1.72 | 0.67 | 0.78 | 3.75 | 0.96 | 1.28 |
| C | Italy | 2.42 | 1.03 | 1.13 | 5.17 | 1.26 | 1.43 |
| D | Japan | 2.17 | 0.89 | 1.04 | 3.06 | 0.76 | 0.90 |
| E | Netherlands | 2.92 | 0.98 | 1.03 | 5.81 | 1.27 | 1.47 |
| F | New Zealand | 3.04 | 1.07 | 1.06 | 4.64 | 1.04 | 1.10 |
| G | Norway | 2.96 | 1.06 | 1.28 | 6.34 | 1.27 | 1.38 |
| H | P R China | 1.83 | 0.74 | 0.83 | 3.59 | 0.88 | 1.02 |
| I | Poland | 1.13 | 0.76 | 0.65 | 2.26 | 0.94 | 1.40 |
| J | Portugal | 2.00 | 0.92 | 0.88 | 4.32 | 1.18 | 1.24 |
| K | South Africa | 3.65 | 1.27 | 1.58 | 5.94 | 1.11 | 1.24 |
| L | South Korea | 2.38 | 1.11 | 1.86 | 3.87 | 0.85 | 0.93 |
| M | Spain | 4.38 | 1.39 | 1.22 | 5.21 | 1.27 | 1.47 |
| N | Sweden | 3.5 | 1.27 | 1.43 | 6.76 | 1.44 | 1.50 |
| O | Switzerland | 2.95 | 1.13 | 1.22 | 5.82 | 1.33 | 1.47 |
| P | Taiwan | 1.89 | 0.69 | 0.73 | 3.03 | 0.73 | 0.96 |
| Q | Turkey | 0.95 | 0.44 | 0.29 | 2.53 | 0.78 | 1.21 |
| R | UK | 2.42 | 1.04 | 1.16 | 5.19 | 1.16 | 1.29 |
| S | USA | 3.08 | 1.11 | 1.20 | 4.55 | 1.10 | 1.21 |

(*Data sourced from Thomson Reuters' Web of Science Core Collection*)

The standard deviation of $RCR_{int}$ decreases from 0.34 in 2000/01 to 0.19 in 2010/11. All international co-authored publications tend to perform better in the second period. The biggest rise of $RCR_{int}$ comes from Turkey (from 0.29 to 1.21) and Poland (from 0.65 to 1.40). In Figure 3b, countries seem to concentrate together, and distribute on the top of the diagonal. That means international collaborations of these countries are getting more citations than before. Vice versa, eight countries have a decrease in $RCR_{int}$. By the way, only Brazil, Japan, South Korea and Taiwan have a $RCR_{int}$ value less than 1, and the largest decline comes from South Korea (from 1.86 to 0.93).

In order to gain more inside into the citation impact and the publication strategy in sport sciences, the citation-impact relational charts for 29 selected countries are presented in figure 3a-3b. The country labels used are the same as in Table 2. The horizontal and vertical lines indicate the rate of each country observed or expected citation impact to the standard in the world in sport sciences. The standard in the world is the mean citation rate of all papers published in the same period in sport sciences (limited to 63 journals in this study). The diagonal line indicates RCR=1. Above the diagonal means the country has a higher citation score than average, RCR>1. Vice versa, RCR<1. So we can see the difference of $MOCR_{int}$, $MECR_{int}$ and $RCR_{int}$ value of publications between 29 selected countries in one figure. In 2000/01, it seems that Spain (M) and Denmark (5) were able to publish in highly cited journals (highest $MECR_{all}$ values), and indeed these papers attracted relatively more citations than other countries. Finland and Ireland have the best performance on their international papers in sport sciences. Overall, there are only 6 countries' $MOCR_{int}$ (MOCR for international papers) value lower than $MOCR_{all}$ (MOCR for total papers) value, with the biggest deviation in Turkey and Brazil (0.45) and only 4 countries' $MECR_{int}$ (MECR for international papers) value lower than $MECR_{all}$ (MECR for total papers) value, with the largest deviation in Turkey (0.43).

In 2010/11, somewhat changed and nearly in all selected countries the $MOCR_{int}$ value is higher than $MOCR_{all}$ value, and the largest deviation in this respect can be observed for Turkey and Poland. Finally, only 6 countries' $MECR_{int}$ value was lower than $MECR_{all}$ value. A closer look at the differences in citation impact between two periods provides the following picture: all selected countries have an increase in $MOCR_{all}$ value. Only South Korea shows a decrease (0.64) in $MOCR_{int}$ value. Denmark, Greece and Turkey have a big increase (avg. 4.79) in $MOCR_{int}$ value. That means international collaborated papers for these countries have attracted above on an average 4 more citations for each paper than before.

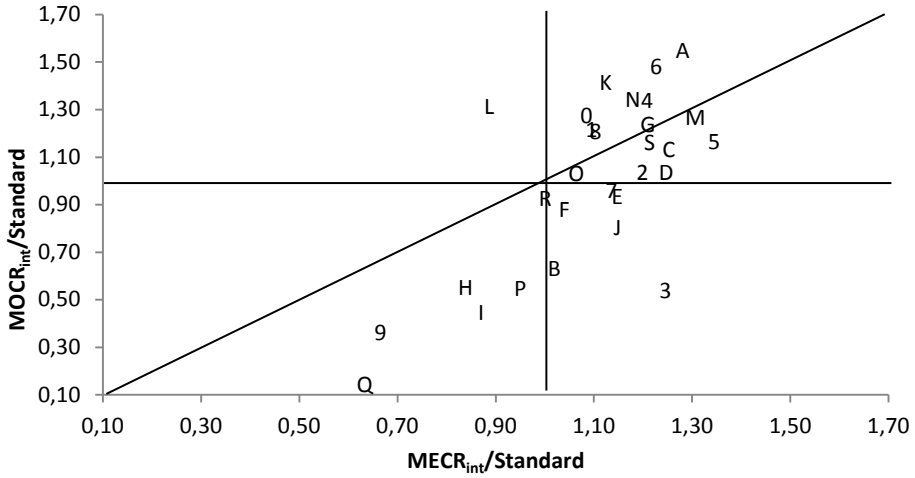


**Figure 3a**. Relational chart of expected and observed citation rate of international publications for 29 selected countries MECR/Standard vs. MOCR/Standard in 2000/2001.

(*Data sourced from Thomson Reuters' Web of Science Core Collection*)

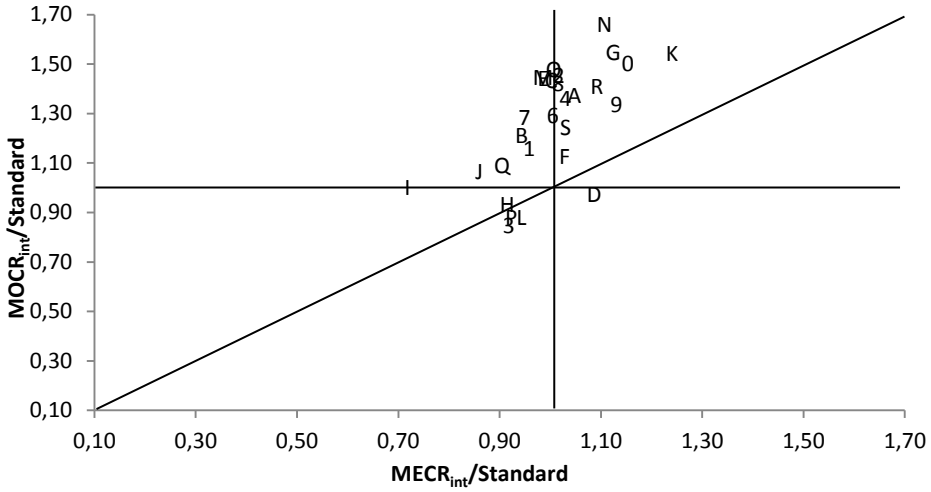


**Figure 3b**. Relational chart of expected and observed citation rate of international publications for 29 selected countries MECR/Standard vs. MOCR/Standard in 2010/2011.

(*Data sourced from Thomson Reuters' Web of Science Core Collection*)

**Citation distributions over domestic and international papers**

Figures 4a and 4b present a comparison of the frequency distribution of citations received by domestic and international papers for all selected countries in sport sciences in 2000/01 and 2010/11 respectively. Figure 4b is less polarized, and has longer tail.

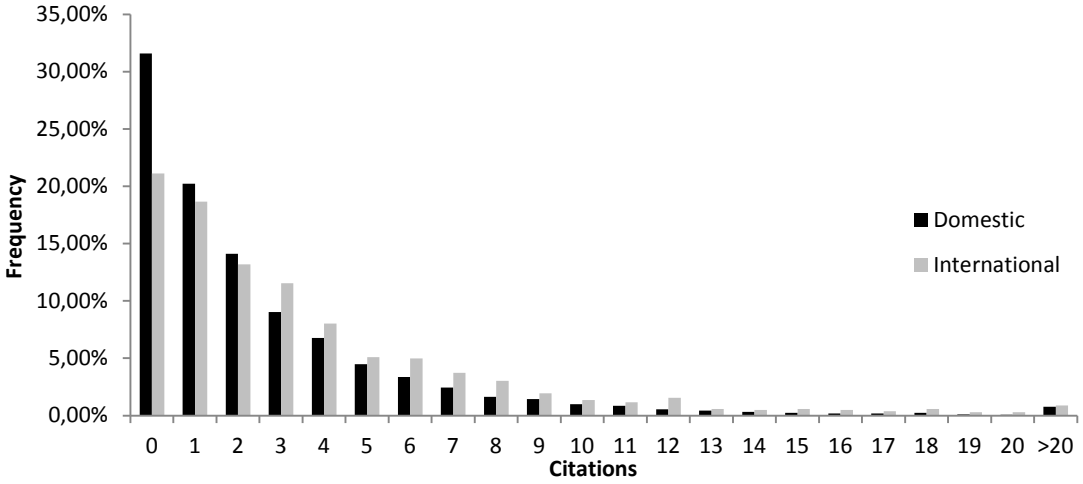


**Figure 4a**. Frequency distributions of citations over domestic vs. international publications in 2000/01. (**black**: distribution in domestic publications, **grey**: distribution in international publications).

(*Data sourced from Thomson Reuters' Web of Science Core Collection*)

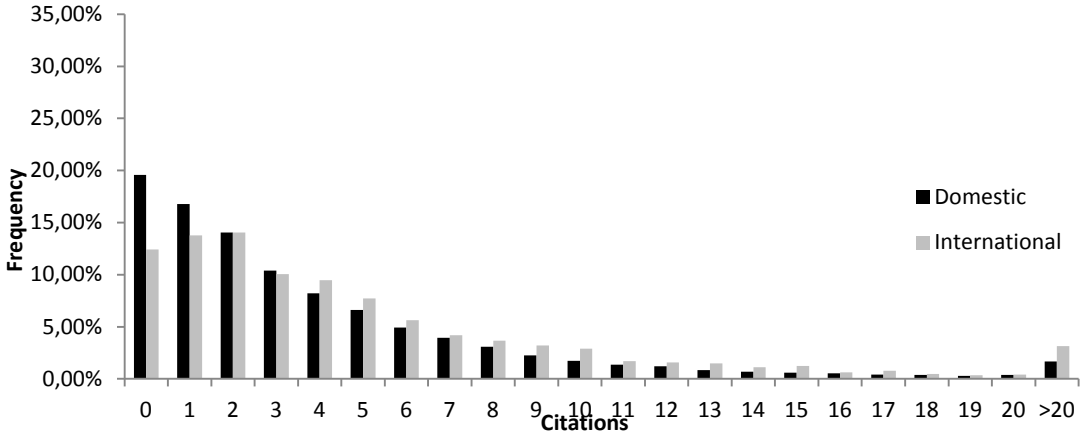


**Figure 4b**. Frequency distributions of citations over domestic vs. international publications in 2010/11.(**black**: distribution in domestic publications, **grey**: distribution in international publications).

(*Data sourced from Thomson Reuters' Web of Science Core Collection*)

In 2000/01, 51.8% of domestic papers were uncited or cited only 1 time. This percentage dropped to 36.4% in 2010/11. So the 'head' of the distribution was getting smaller, and at the same time, the 'trunk' and the 'tail' becomes longer. In 2000/01, 21.1% of international papers were uncited, but this percentage was 12.4% in 2010/11. And papers cited 3 times have the highest percentage (14.0%). The proportion of international papers cited more than 20 times increased a lot from 0.88% to 3.14%(longer tail).

We only show the distribution citations of total publications in all selected countries. We will find a significant difference if we compare distributions of citations between different countries. Prolific countries' distribution

of citations is more similar to the overall. Low-yielding countries show a more random distribution, such as 2 or 3 bulges in the middle. While Nordic countries tend to exhibit one bulge in the front middle of the distribution. It means that the percentage of domestic publications cited 1 or 2 times usually accounts for the first and the percentage of international publications cited 2 or 3 times ranks first. Of course, bulges move towards the tail in the second period.

**Citation analysis of co-authorship links by country-pairs**

In this part, the expected and observed citation rates of international co-publications will be analyzed through country pairs. Similar to previous sections, in order to obtain statistically reliable results, links with less than 10 joint papers were omitted. The indicators for seven selected countries are presented in tables 6 and 7(Appendix). Table 6 shows the mean observed and expected citation rates of co-authorship links of USA, UK, Canada, Germany, Australia, Netherlands and Switzerland with their partner countries in sport sciences publications in 2000/2001. Data are arranged in descending order by the observed citation rates. All citation data are based on 3-year citation windows.

The field impact of sport sciences  is 2.73 in 2000/01. Almost all the seven selected countries have higher citation rates for their international co-publications of  than for their domestic publications. The selected countries' MOCR values for domestic publications are almost at the bottom of each column and their values are around the field impact value. Strong links with a mean citation rate greater than the domestic MOCR of any of the two contributing countries were called *hot links*.[45] In this paper, according to this definition, the following links definitely may serve as examples for such *hot links*: USA-Canada ($r_{ij}$=8.1%, MOCR=5.01), Switzerland-Sweden ($r_{ij}$=6.0%, MOCR=6.30). ('r' means Salton's cosine measure value).

USA has many co-publication links and most of them have MOCR and MECR values distinctly above the field impact standard. And it is worth mentioning that USA, Canada, Australia and Netherlands' MOCR value for domestic publications all lie above the field impact standard. Nevertheless, the 'hottest' link could be Germany-Austria ($r_{ij}$=7.9%, MOCR=6.92). *Cool links*, co-authorship links with a mean citation rate smaller than the corresponding domestic MOCR values of two contributing countries, also could be seen in table 6, such as UK-Greece and USA-Brazil.[45]

In 2010/01, more co-authorship links are presented in table 7. The field impact increased to 4.38 and MOCR values generally increased a lot. The co-authorship links between Denmark and 4 selected countries (USA, UK, Australia, Germany) have a high MOCR above 15. Especially, Australia-Denmark and USA-Denmark co-publications' MOCR are above 20. It is worth mentioning that Australia, Denmark, Netherlands, Norway and Sweden's domestic publications' MOCR are all above the field impact standard. And several *hot links* are found around these countries. Germany-Austria is not the 'hottest link' any more. While, these links, Switzerland-Denmark, Switzerland-France, and Australia-Canada, could be called *hot links*. While only Australia-China link could be called *cool link*. Surprisingly, three Nordic countries, Denmark, Sweden and Norway show impressive citation results as a partner.

This section illustrates that international co-authorship in sport sciences generally attracts more citations than domestic publications. Two collaborated partners with high value of domestic publications MOCR normally will publish papers with higher value of MOCR. Of course, in few cases, international collaboration even attracts less citations than domestic standards of both partner(s). *Cool links* seems to have happened to those countries with lowest value of domestic publications' MOCR in this field.

## DISCUSSION

This study tried to explore the status of international collaboration in sport sciences and its influence on citation impact, while prior studies have provided strong evidence that international collaboration is increasing in many other disciplines and some subjects in sport sciences.[2 4 5 28-30] Now results presented here clearly suggest a significant increase of collaboration in sport sciences and a large increase in citation impacts of international co-authored publications at a macro-level perspective. These results also raise a number of issues with implications for future work related to collaboration and collaboration propensity in sport sciences.

### Collaboration as the drive of growth

Physiologically, sport sciences is a discipline that studies how different parts of human body collaborate during exercise, and how this collaborative work promote health or fitness from different perspectives. Sociologically, athletes have to collaborate with coaches, and they all have to collaborate with a multidisciplinary team to improve performances by sharing information and making team-decisions.[47] Operationally, sports need four elements, technical, tactical, physical, and mental abilities, to work together. Originally, the formation of sport sciences just integrated technologies and achievements of multidisciplinary, especially electrophysiology and biomechanics. And today further subdivision of sport sciences need multidisciplinary scientists to work together on experiments.[48] Of course, prosperity of sports events, improvement of communication technologies and transportation modes, etc. also contributes to the collaboration in sport sciences.

Many academic alliances have been established between universities and among countries, which breaks national boundaries through academic collaborations.[49] In spite of problems in knowledge products sharing, research alliances surely improved academic outputs.[50] This kind of academic alliance surely covers sports academic institutions. Meantime, increased frequency of sports conferences and meetings also provided more channels for communicating and collaboration between different countries' researchers.[51] This paper gets similar results with previous findings that there is a positive relationship between international collaboration and productivity in medicine.[52] Moreover, the share of international collaboration increases faster than the total academic outputs. So international collaboration has become the main driving force of growth of sport sciences research (limited to WoS data).

### Collaboration propensity

"Collaboration propensity" means an individual researcher engaging in collaboration at a particular point in time and with regard to current research interests.[53] At the micro-level prospective, this tendency depends on multiple factors, like prior experiences of participants, institutional constraints, the availability of "attractive" collaborators in terms of influence or unique skills, or needs for access to special data or equipment.[54-57] At meso-level prospective, more and more inter-organizational alliances were founded in different countries.[58] The main purpose of alliances is to share their scientific and technological assets, and also to provide opportunities for researchers to collaborate.[59] At macro-level prospective, inter-units propensity is supported by national R&D policies or even supranational R&D policies.[60] Different economic, cognitive and social factors may shape the motives for research collaboration, and these vary by scientific fields and countries.[61] Interestingly, smaller countries tend to have higher levels of international collaboration.[62]

Previous results fit exactly our findings. In sport sciences, low-yielding countries, especially in European, normally have a higher level of international collaboration. There is no theory that could explain this phenomenon, which only could be understood as a consequence of the greater division of specialization, improvements in mobility and ICT, and the emergence of English as a world language in science.[63] It's also

interesting that sport researchers showed strong tendency in collaboration. Finland, for example, different with other Nordic countries, prefers to collaborate with USA, similar to previous results.[64] In another case, South Africa has a tendency in collaboration with Australia, which is different from previous results.[65] But in the second period, South Africa has shifted his main partner from Australia to UK and USA, which is similar with previous findings on the overall scientific collaboration of South Africa. These results exhibit the traits of this discipline different from others or the overall.

If we take into account 29 country's continental properties, we'll find that the strongest co-publication link happens between European countries and Oceanian countries, and it's bi-directional. For North America, Europe always is the most important partner, and Oceania is the second one. But for Asia, the co-publication links with other continents haven't changed much between two periods and Asian didn't formed a tight collaboration network like European. Therefore, it is meaningful to explore the sociological reason behind collaboration propensity in sport sciences.

**Asymmetry in collaboration**

International co-authorship relations represent a large range of frameworks and motivations, extending from bilateral or even multinational programs to co-operation between individual scientists.[34] Bibliometric methods even could dig out the deep willingness of scientists to collaboration. Of course, this willingness is bilateral. That means one country maybe an active partner for another country, but it is not necessarily in turn. It is incapable to reflect any asymmetry present in symmetrical co-authorship analysis. So some researcher use two relative "importance" values to define the asymmetry relationship and called it "affinity".[33]

In this study, "affinity" values also tell sports scientists' one-way willingness to collaborate. The USA, as a central node of collaboration network, have a unilateral tendency of collaboration with European countries, while Far East countries all have a strong tendency of collaboration with the USA, which is similar with previous results that the USA are a not an important partner for Europe but an important partner for Israel and some Far East countries.[34] Since the asymmetric collaboration willingness is always related to the USA, perhaps some relevant research results can provide some reference. (E. g., immigrant scientists are playing an important role in asymmetric international collaboration).[66] Coincidentally, results in unilateral collaboration intention seem to have some similarities with the performance of international immigrations.

**Relative decline of Asian and rising of Nordic countries**

International collaboration does not always bring high citation impact. Nevertheless, most results are positive.[43] Conversely, a few research found the negative or unaffiliated results.[67] It seems that in this paper, there is a positive relationship between collaboration and citation impact in sport sciences and international collaborations broaden the audiences around this field. On the other hand, there is big difference of the gap in various countries between two periods. In Brazil, South Korea, Japan and Taiwan, there is a relative decline of the normalized index of citation impacts for international co-authored publications. First need to declare is that, in these countries, the number of international collaboration and citations to these publications are really growing while the share of international collaboration is below 41%, and the growth rate is lower than that of country's overall outputs. In contrast it is in the opposite trend in many western countries: international collaborated papers is above 50% or even more, and the growth rate of international papers is higher than all outputs'.

In many countries, publishing articles in international journals, especially journals included by SCI/SSCI, has become a paramount criterion to evaluate academic research output.[68] Contribution to journals with relative

lower impact factor values seems to be a better choice for researchers in academic emerging countries given no requirements of journal IF. And at the same time, there are no interaction between authors publishing international papers and authors publishing domestic papers in these countries, like Turkey and Brazil.[69 70] These two reasons make it difficult to expand the audiences and get more citations.

In some western countries, especially the Nordic countries, exhibited an amazing performance as international partners. Previous study already showed that the Nordic is passionate about academic collaboration.[33] They always have strong co-authorship links with highly developed countries in West Europe and North America. The relatively greater number of professors and the larger number of foreign Ph.D. students in sport sciences are the basement of frequent international collaboration among Nordic countries.[71] Postdoctoral training, especially in strong academic institutions outside the Nordic countries like USA or UK, has become essential for a scientist to obtain an academic research position. From the perspective of world overall research investment and outcome, Denmark and Sweden have far higher R&D spending rates with higher numbers of researchers than other countries.[72] All these policies are encouraging researchers in this area to participate more in international collaboration.

## CONCLUSIONS

This analysis confirmed that the international collaboration has also strongly intensified in sport sciences in the last decade. The growth rate of international co-authored publications exceeds that of domestic ones. Sport sciences researchers show various collaboration propensity and asymmetric collaboration willingness in various countries. It is very meaningful to investigate the underlying motivation behind collaboration, especially social factors. Asian countries seem to lag behind other continents in terms of international collaboration. There is a positive relationship between international collaboration and attractivity of citations in sport sciences. Differences of impact performance between selected countries are in the fall. The Nordic countries, especially Denmark, have shown remarkable citation attractivity in international co-authored publications.

## ACKNOWLEDGMENTS

The first author would like to thank Bart Thijs for his invaluable contributions to the data collection; Specially thanks are given to Prof. Dr. Wolfgang Glänzel, for his guidance on this studies' design and framework; thanks are also given to: Wouter Jeuris and Mehmet Ali Abdulhayoglu, colleagues at ECOOM of K.U.Leuven.

**Funding** Support for this study was received from Shanghai University of Sport, Ph.D. Academic Visiting Program (shtyfx20130111).

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## Appendix

**Table 4**. Specific co-authorship affinity indicator values in 2000/01

| | Australia | | Canada | | Germany | | Netherlands | | Switzerland | | UK | | USA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | | | 1.82 | 2.30 | | | | | | | 2.80 | 1.79 | 0.81 | 0.64 |
| Austria | | | | | 15.68 | 8.88 | | | | | | | 1.68 | 0.91 |
| Belgium | | | | | | | | | | | | | 0.79 | 0.67 |
| Brazil | | | | | | | | | | | | | 2.29 | 1.11 |
| Canada | 2.30 | 1.82 | | | 1.20 | 0.90 | | | | | 1.53 | 1.18 | 1.44 | 1.20 |
| Denmark | | | | | | | | | | | | | | |
| Finland | 3.86 | 3.31 | | | | | | | | | | | 1.49 | 1.10 |
| France | | | 1.49 | 1.86 | | | | | | | 1.19 | 1.15 | 0.58 | 0.51 |
| Germany | | | 0.90 | 1.20 | | | 2.75 | 3.98 | 6.35 | 11.28 | 1.12 | 1.16 | 0.66 | 0.63 |
| Greece | | | | | | | | | | | 9.88 | 5.75 | | |
| Ireland | | | | | | | | | | | | | | |
| Israel | | | | | | | | | | | | | 1.72 | 1.14 |
| Italy | | | | | | | | | | | 2.53 | 2.42 | 0.79 | 0.70 |
| Japan | | | 0.71 | 1.24 | | | | | | | | | 1.30 | 1.27 |
| Netherlands | | | | | 3.98 | 2.75 | | | | | 3.70 | 2.20 | 0.88 | 0.58 |
| New Zealand | 12.14 | 6.70 | | | | | | | | | | | 1.56 | 0.68 |
| Norway | | | | | | | | | | | | | | |
| P R China | | | | | | | | | | | | | | |
| Poland | | | | | | | | | | | | | | |
| Portugal | | | | | | | | | | | | | | |
| South Africa | 16.11 | 11.20 | | | | | | | | | | | | |
| South Korea | | | | | | | | | | | | | | |
| Spain | | | | | | | | | | | | | | |
| Sweden | | | | | | | | | 5.99 | 9.16 | | | 0.89 | 0.73 |
| Switzerland | | | | | 11.28 | 6.35 | | | | | | | 0.98 | 0.52 |
| Taiwan | | | | | | | | | | | | | 1.19 | 1.30 |
| Turkey | | | | | | | | | | | | | | |
| UK | 1.79 | 2.80 | 1.18 | 1.53 | 1.16 | 1.12 | 2.20 | 3.70 | | | | | 0.58 | 0.53 |
| USA | 0.64 | 0.81 | 1.20 | 1.44 | 0.63 | 0.66 | 0.58 | 0.88 | 0.52 | 0.98 | 0.53 | 0.58 | | |

**Table 5**. Specific co-authorship affinity indicator values in 2010/11

| | Australia | | Canada | | Germany | | Netherlands | | Switzerland | | UK | | USA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | | | 1.55 | 1.31 | 0.92 | 0.73 | 1.15 | 0.95 | 0.89 | 1.18 | 2.10 | 2.20 | 0.86 | 0.56 |
| Austria | | | | | 6.85 | 5.35 | | | 4.89 | 6.40 | 1.30 | 1.28 | 0.98 | 0.63 |
| Belgium | 1.69 | 1.89 | | | | | 6.62 | 6.11 | | | 2.13 | 2.40 | 0.74 | 0.55 |
| Brazil | 0.75 | 0.98 | 1.10 | 1.20 | | | | | | | 0.70 | 0.92 | 1.49 | 1.27 |
| Canada | 1.31 | 1.55 | | | 0.94 | 0.89 | 1.28 | 1.26 | 1.24 | 1.97 | 0.99 | 1.19 | 1.35 | 1.60 |
| Denmark | 1.49 | 1.46 | | | 2.76 | 2.16 | | | 3.20 | 3.96 | 1.66 | 1.64 | 0.66 | 0.42 |
| Finland | | | | | | | | | | | | | 1.70 | 1.25 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| France | 1.20 | 1.18 | 2.22 | 2.15 | | | | | 2.38 | 3.65 | 1.40 | 1.61 | 0.52 | 0.39 |
| Germany | 0.73 | 0.92 | 0.89 | 0.94 | | | 1.44 | 1.49 | 5.10 | 8.39 | 1.50 | 1.32 | 0.78 | 0.64 |
| Greece | | | | | | | | | | | 2.18 | 2.95 | 0.85 | 0.75 |
| Ireland | 4.41 | 3.53 | | | | | | | | | 3.77 | 3.30 | 1.10 | 0.58 |
| Israel | | | | | | | | | | | | | 1.51 | 1.37 |
| Italy | 0.63 | 0.72 | 0.69 | 0.66 | 1.33 | 1.2 | | | 2.56 | 3.89 | 2.53 | 2.89 | 0.7 | 0.52 |
| Japan | | | 0.86 | 1.91 | | | | | | | 0.39 | 1.40 | 0.75 | 1.31 |
| Netherlands | 0.95 | 1.15 | 1.26 | 1.28 | 1.49 | 1.44 | | | 2.31 | 3.74 | 2.27 | 2.76 | 0.83 | 0.66 |
| New Zealand | 7.59 | 6.60 | 2.19 | 1.47 | | | | | | | 2.32 | 1.86 | 0.74 | 0.39 |
| Norway | 1.80 | 1.50 | 1.26 | 1.30 | | | 2.39 | 1.93 | 3.19 | 4.16 | 1.81 | 1.78 | 0.95 | 0.61 |
| P R China | 2.22 | 2.74 | | | | | 2.72 | 2.77 | | | 1.39 | 1.72 | 0.92 | 0.75 |
| Poland | | | | | | | | | | | | | | |
| Portugal | | | | | | | | | | | | | 1.73 | 0.92 |
| South Africa | | | | | | | | | | | 3.00 | 3.00 | 1.16 | 0.76 |
| South Korea | | | | | | | | | | | | | 1.31 | 1.82 |
| Spain | 0.74 | 0.77 | 0.94 | 0.82 | | | | | 1.16 | 1.60 | 1.34 | 1.4 | 1.00 | 0.68 |
| Sweden | 1.41 | 1.29 | 0.89 | 0.69 | 1.90 | 1.39 | | | 1.56 | 1.91 | 1.56 | 1.43 | 1.8 | 0.65 |
| Switzerland | 1.18 | 0.89 | 1.97 | 1.24 | 8.39 | 5.10 | 3.74 | 2.31 | | | 2.36 | 1.78 | 0.64 | 0.31 |
| Taiwan | | | | | | | | | | | | | 0.92 | 1.47 |
| Turkey | | | | | | | | | | | | | | |
| UK | 2.20 | 2.10 | 1.19 | 0.99 | 1.32 | 1.50 | 2.76 | 2.27 | 1.78 | 2.36 | | | 0.71 | 0.46 |
| USA | 0.56 | 0.86 | 1.60 | 1.35 | 0.64 | 0.78 | 0.66 | 0.83 | 0.31 | 0.64 | 0.46 | 0.71 | | |

**Table 6**.Co-authorship links and citation impact for seven selected countries in sport sciences ranked by mean observed citation rate (domestic values are set in italics; field impact in 2000/01=2.73)

| USA | | | UK | | | Canada | | | Germany | | | Australia | | | Netherlands | | | Switzerland | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MOCR. | MECR. | | MOCR. | MECR. | | MOCR. | MECR. | | MOCR. | MECR. | | MOCR. | MECR. | | MOCR. | MECR. | | MOCR. | MECR. |
| **FI** | 6.85 | 3.86 | **DE** | 5.60 | 2.88 | **DE** | 6.45 | 3.60 | **AT** | 6.92 | 2.05 | **FI** | 6.90 | 4.16 | **US** | 3.67 | 3.32 | **SE** | 6.30 | 4.01 |
| **BE** | 6.00 | 3.72 | **IT** | 4.71 | 3.07 | **AU** | 5.03 | 2.68 | **CA** | 6.45 | 3.60 | **ZA** | 6.08 | 3.80 | **DE** | 3.30 | 3.50 | **US** | 3.88 | 3.47 |
| **DE** | 5.87 | 3.37 | **CA** | 4.55 | 2.78 | **US** | 5.01 | 3.78 | **US** | 5.87 | 3.37 | **US** | 5.27 | 3.27 | **UK** | 3.00 | 3.41 | **DE** | 3.59 | 3.03 |
| **AU** | 5.27 | 3.27 | **US** | 4.39 | 2.89 | **UK** | 4.55 | 2.78 | **UK** | 5.60 | 2.88 | **CA** | 5.03 | 2.68 | ***NL*** | *2.74* | *2.97* | ***CH*** | *2.40* | *2.41* |
| **CA** | 5.01 | 3.78 | **FR** | 4.00 | 2.92 | **JP** | 4.10 | 4.39 | **CH** | 3.59 | 3.03 | **NZ** | 4.16 | 2.61 | | | | | | |
| **SE** | 5.00 | 3.62 | **AU** | 3.88 | 2.74 | ***CA*** | *3.05* | *3.09* | **NL** | 3.30 | 3.50 | **UK** | 3.88 | 2.74 | | | | | | |
| **AT** | 4.93 | 3.90 | **NL** | 3.00 | 3.41 | **FR** | 2.58 | 3.17 | ***DE*** | *2.03* | *2.17* | ***AU*** | *2.97* | *2.90* | | | | | | |
| **IT** | 4.91 | 4.01 | ***UK*** | *2.15* | *2.36* | | | | | | | | | | | | | | | |
| **UK** | 4.39 | 2.89 | **GR** | 0.83 | 1.85 | | | | | | | | | | | | | | | |
| **CH** | 3.88 | 3.47 | | | | | | | | | | | | | | | | | | |
| **JP** | 3.80 | 3.62 | | | | | | | | | | | | | | | | | | |
| **NL** | 3.67 | 3.32 | | | | | | | | | | | | | | | | | | |
| **FR** | 3.21 | 3.60 | | | | | | | | | | | | | | | | | | |
| ***US*** | *2.95* | *2.83* | | | | | | | | | | | | | | | | | | |
| **NZ** | 2.88 | 3.20 | | | | | | | | | | | | | | | | | | |
| **IL** | 2.00 | 3.14 | | | | | | | | | | | | | | | | | | |
| **TW** | 2.00 | 2.88 | | | | | | | | | | | | | | | | | | |
| **BR** | 1.18 | 3.51 | | | | | | | | | | | | | | | | | | |

**Table 7**.Co-authorship links and citation impact for seven selected countries in sport sciences ranked by mean observed citation rate (domestic values are set in italics; field impact in 2010/11=4.38)

| | USA | | | UK | | | Australia | | | Canada | | | Switzerland | | | Germany | | | Netherlands | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MOCR. | MECR. | | MOCR. | MECR. | | MOCR. | MECR. | | MOCR. | MECR. | | MOCR. | MECR. | | MOCR. | MECR. | | MOCR. | MECR. |
| **DK** | 21.14 | 6.93 | **DK** | 19.55 | 6.45 | **DK** | 20.75 | 6.12 | **DE** | 13.67 | 5.42 | **ES** | 15.20 | 5.97 | **DK** | 18.69 | 6.10 | **NO** | 16.30 | 6.05 |
| **SE** | 10.52 | 5.39 | **SE** | 12.30 | 6.14 | **DE** | 14.52 | 5.91 | **SE** | 13.09 | 6.13 | **NO** | 13.42 | 6.68 | **AU** | 14.52 | 5.91 | **AU** | 10.80 | 6.32 |
| **DE** | 9.39 | 5.45 | **CA** | 10.86 | 5.45 | **NO** | 12.92 | 6.67 | **NO** | 11.67 | 6.40 | **SE** | 13.00 | 5.87 | **CA** | 13.67 | 5.42 | **CA** | 9.57 | 4.80 |
| **AT** | 8.78 | 4.88 | **DE** | 9.34 | 5.39 | **IT** | 11.87 | 6.32 | **UK** | 10.86 | 5.45 | **AU** | 10.73 | 4.82 | **US** | 9.39 | 5.45 | **CH** | 8.29 | 4.52 |
| **UK** | 8.29 | 5.56 | **IE** | 9.30 | 4.45 | **ES** | 11.08 | 4.55 | **AU** | 9.79 | 5.03 | **DK** | 10.31 | 6.34 | **UK** | 9.34 | 5.39 | **US** | 7.31 | 5.29 |
| **ZA** | 7.85 | 5.31 | **NO** | 9.22 | 5.86 | **NL** | 10.80 | 6.32 | **IT** | 9.77 | 4.80 | **FR** | 9.41 | 4.67 | **IT** | 8.47 | 5.29 | **DE** | 6.82 | 4.44 |
| **BE** | 7.77 | 4.97 | **ES** | 8.93 | 4.76 | **CH** | 10.73 | 4.82 | **ES** | 9.69 | 4.68 | **CA** | 8.48 | 5.09 | **SE** | 7.50 | 4.21 | **UK** | 6.76 | 4.55 |
| **ES** | 7.62 | 4.17 | **ZA** | 8.43 | 5.76 | **CA** | 9.79 | 5.03 | **NL** | 9.57 | 4.80 | **NL** | 8.29 | 4.52 | **NL** | 6.82 | 4.44 | **CN** | 6.36 | 3.08 |
| **FR** | 7.55 | 5.15 | **US** | 8.29 | 5.56 | **BE** | 9.40 | 6.06 | **CH** | 8.48 | 5.09 | **AT** | 7.60 | 4.72 | **CH** | 6.00 | 4.14 | **BE** | 5.78 | 4.32 |
| **IT** | 7.35 | 5.22 | **IT** | 7.93 | 4.81 | **IE** | 9.32 | 6.05 | **US** | 7.16 | 4.79 | **IT** | 7.57 | 4.83 | **AT** | 3.87 | 4.03 | ***NL*** | *5.41* | *4.99* |
| **NL** | 7.31 | 5.29 | **AU** | 7.82 | 6.01 | **SE** | 8.64 | 6.10 | **FR** | 6.27 | 4.43 | **UK** | 7.28 | 5.53 | ***DE*** | *3.05* | *3.69* | | | |
| **AU** | 7.27 | 5.59 | **AT** | 7.80 | 5.26 | **UK** | 7.82 | 6.01 | **NZ** | 5.00 | 5.17 | **US** | 6.34 | 4.95 | | | | | | |
| **NO** | 7.21 | 5.66 | **CH** | 7.28 | 5.53 | **US** | 7.27 | 5.59 | **BR** | 4.60 | 4.95 | **DE** | 6.00 | 4.14 | | | | | | |
| **CA** | 7.16 | 4.79 | **NL** | 6.76 | 4.55 | **FR** | 6.50 | 4.63 | ***CA*** | *4.07* | *4.37* | ***CH*** | *4.23* | *4.44* | | | | | | |
| **GR** | 7.13 | 5.01 | **NZ** | 6.05 | 4.27 | **BR** | 6.23 | 4.23 | **JP** | 3.29 | 5.10 | | | | | | | | | |
| **IL** | 6.67 | 4.87 | **GR** | 5.76 | 6.64 | ***AU*** | *5.75* | *5.07* | | | | | | | | | | | | |
| **CH** | 6.34 | 4.95 | **JP** | 5.58 | 5.35 | **NZ** | 5.09 | 5.05 | | | | | | | | | | | | |
| **IE** | 5.21 | 4.87 | **FR** | 5.40 | 4.05 | **CN** | 3.19 | 3.99 | | | | | | | | | | | | |
| **JP** | 5.11 | 4.94 | **CN** | 5.00 | 4.18 | | | | | | | | | | | | | | | |
| **NZ** | 5.03 | 4.19 | **BR** | 4.33 | 4.78 | | | | | | | | | | | | | | | |
| **FI** | 4.96 | 4.94 | **BE** | 4.26 | 4.01 | | | | | | | | | | | | | | | |
| **KP** | 4.54 | 4.68 | ***UK*** | *4.24* | *4.39* | | | | | | | | | | | | | | | |
| ***US*** | *4.29* | *4.32* | | | | | | | | | | | | | | | | | | |
| **PT** | 4.25 | 3.75 | | | | | | | | | | | | | | | | | | |
| **BR** | 3.93 | 4.17 | | | | | | | | | | | | | | | | | | |
| **CN** | 3.88 | 5.09 | | | | | | | | | | | | | | | | | | |
| **TW** | 3.50 | 4.79 | | | | | | | | | | | | | | | | | | |

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