# Modeling and Analyzing Sports Networks Revealed through K-12 Physical Education Systems: Case Studies of Korea, Japan, and the USA

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Abstract: This paper investigates the The K-12 Physical Education Systems for Korea, Japan, and the USA. To identify the relations among sports that are covered in the school curriculums, we introduce the notion of sports network where a vertex indicates a sports and an edge represents the relations between two sports. The analysis results on the three sports networks are summarized as follows. The results are as follows. We find that basic movement sports such as gymnastics and fitness are important across the three countries. Also, Korea and the USA are found to focus more on a variety of sports than just covering basic sports. On the other hand, Japan tends to focus on basic sports. Additional study is required to closely analyze the curriculum of primary and secondary schools, which can guide how to balance the different experiences of various sports and training in basic sports.

## 1 INTRODUCTION

In the modern society, people in different countries tend to enjoy different sports. For example, people in the USA are known to like American football while people in Japan tend to watch baseball. Table 1 shows the such difference in sports preferences across three countries: Korea, Japan, and the USA. In 2018, the most popular sports in Korea were walking (40.8%) and mountain climbing (23.2%). So, in the Korean apparel market, sportswear is sold after the casual wear (Korea Federation of Textile Industries, 2018). In Japan, walking (57.0%) is the most common, followed by track and field (12.2%), swimming (5.2%), and bowling (4.8%). In the USA, 66.0% of Americans are enjoying the fitness. When we compare Korea and Japan, track and field is 3.3% in Korea, whereas that in Japan is 12.2%; mountain climbing is 23.2% in Korea while that in Japan is only 3.9% (Table 1).

Such difference in sports preference is mainly due to different curriculums of K-12 Physical Education. That is, the sports that a person is likely to enjoy is the one he/she learned before (Byoung-Wook, Ahn., and Eun-Young, Cho., 2015). The K-12 Physical

Education System in Korea is based on the body movement, which consists of health management ability, physical training ability, competition performance ability, and body expression ability. Through this process, it is expected to learn various sports (Ministry of Education-Korea, 2015). Japan's K-12 Physical Education System aims to improve the health and physical strength by understanding basic movements of exercise and solving exercise tasks (Ministry of Education, Culture, Sports, Science and Technology-Japan, 2017a, 2017b, 2017c). The K-12 Physical Education System in the USA aims to improve various skills, knowledge, social behaviour, as well as recognition of the value of physical activity for health, enjoyment, challenge, self-expression and/or social interaction (Couturier, Lynn., et al., 2014).

To understand differences in sports practice across the three countries, this paper investigates the K-12 Physical Education Systems for the three countries. In particular, we seek to understand what sports are popular in different countries. In addition, this paper investigates how different sports are related with each other. In the K-12 Physical Education Systems, it is usually recommended to learn multiple

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Table 1: Popularity of community sports in Korea, Japan and the USA (Ministry of Culture, Sports and Tourism-Korea. 2018; Physical Activity Council, 2019; Japan Sports Agency, 2017).

| sports | Korea | Japan | | sports | USA |
|---|---|---|---|---|---|
| aerobic | 2.7% | .1% | | fitness sports | 66.0% |
| badminton | 7.8% | 3.1% | | | |
| baseball | 2.3% | 5.9% | | | |
| basketball | 5.3% | 1.7% | | individual sports | 45.3% |
| billiards | 8.3% | 0.1% | | | |
| bowling | 7.1% | 4.7% | | | |
| cycling | 8.9% | 10.9% | | outdoor sports | 59.2% |
| dancing | 1.4% | 2.5% | | | |
| fencing | .7% | .1% | | | |
| fishing | 4.1% | 4.5% | | racquet sports | 13.0% |
| fitness | 11.9% | 12.9% | | | |
| football | 8.9% | 4.05% | | | |
| golf | 4.0% | 11.0% | | team sports | 22.6% |
| gymnastics | 9.4% | 12.4% | | | |
| Martial arts | 1.7% | .1% | | | |
| mountain climbing | 23.2% | 3.9% | | water sports | 13.7% |
| ping pong | 3.5% | 3.2% | | | |
| rope skipping | 7.7% | 2.2% | | | |
| swimming | 8.3% | 5.2% | | | |
| tennis | 1.4% | 3.8% | | | |
| track and field | 3.3% | 12.2% | | winter sports | 7.1% |
| volleyball | 1.5% | 1.9% | | | |
| walking | 40.8% | 57.0% | | | |
| yoga | 6.3% | 6.3% | | | |

sports. Hence, understanding the relations among sports can enhance the sports education as well as help to spread community sports.

# 2 METHODS AND DATA

## 2.1 Network Model

To represent relations among sports revealed in the K-12 Physical Education Systems, we introduce the notion of the "sports network" as an undirected graph $G = (V, E)$, where a vertex indicates a sports and an edge indicates the relation between two sports. Here, we assume there exists a relation (i.e., edge) between two sports if two sports are appeared together in the K-12 Physical Education Systems. That is, for instance, if tennis and swimming are mentioned together in the K-12 Physical Education Systems, we assume those two sports are related. Note that our

proposed network is similar to various backbone networks defined in various areas such as a food network (Yong-Yeol, Ahn., et al., 2011; Wäsche, Hagen., 2015; Sohn, E., et al., 2018).

## 2.2 Data Collection and Analysis

To identify sports relations, we first selected the target sports based on the survey for the K-12 Physical Education Systems, "A survey on the participation of the public living sports". Then, three experts in physical education validated the selected sports. Finally, 23 sports were selected: aerobic, badminton, baseball, basketball, billiards, bowling, cycling, dancing, fencing, fishing, fitness, football, golf, gymnastics, Martial arts, mountain climbing, ping pong, rope skipping, swimming, tennis, track and field, volleyball, walking, yoga.

We collected education curriculum documents of the K-12 Physical Education Systems for South Korea, Japan, and the USA in Table 2. The document for South Korea contains 124 pages and 10,303 words; the document for the USA includes 136 pages and 50,174 words; the documents for Japan contain 913 pages 26,637 words. We extracted paragraphs from each document, and abnormal data was removed through the preprocessing process. Finally, 934 paragraphs for South Korea, 4,674 paragraphs for the USA, and 2,134 paragraphs for Japan were used to identify relations among sports. In each paragraph, we check whether two target sports are appeared together or not. That is, if two sports are included in a paragraph, we assume those two sports are linked in the given sports network.

Table 2: K–12 Physical Education Systems of three countries: Korea, Japan and the USA. In particular, we investigate: Ministry of Education (Korea), 2015; Ministry of Education, Culture, Sports, Science and Technology (Japan), 2017a; Ministry of Education, Culture, Sports, Science and Technology (Japan), 2017b; Ministry of Education, Culture, Sports, Science and Technology (Japan), 2017c; Couturier, Lynn., et al., 2014).

| Country | K-12 Physical Education Systems |
|---|---|
| Korea | 2015 체육과 교육과정 |
| Japan | 小学,中学, 高等学校学習指導要領解説 保健体育編・体育編 |
| USA | National Standards & Grade-Level Outcomes for K–12 Physical Education |

The statistical program 'R version 3.6.0' was used to analyze the data, and 'Gephi 0.9.2' was used for the graph visualization.

# 3 RESULTS

We build and analyze three sports networks for Korea, the USA, and Japan.
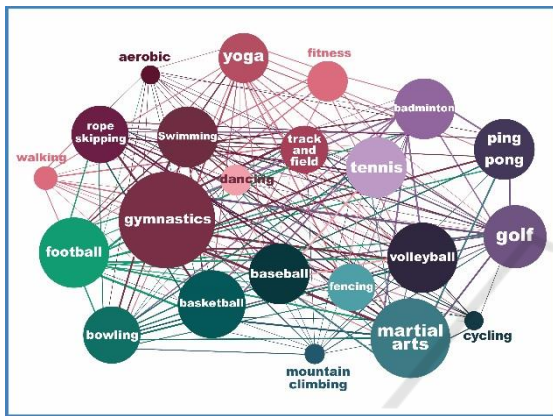
## 3.1 Korea



Figure 1: The sports network revealed through the K-12 Physical Education System in South Korea.



Figure 2: Degree of sports in the Korean sports network is illustrated.

The sports network for South Korea is visualized in Figure 1, which shows connectivities among sports in South Korea. To understand the role of each sports in terms of connectivities, we illustrate amount of shared sports, or degree, for each sports in Figure 2. That is, a larger circle in Figure 2 indicates a higher degree. As shown in Figure 2, gymnastics, martial arts, football, and volleyball have high degree, which can play roles in connecting other sports in the given sports network in Korea. On the other hand, when we
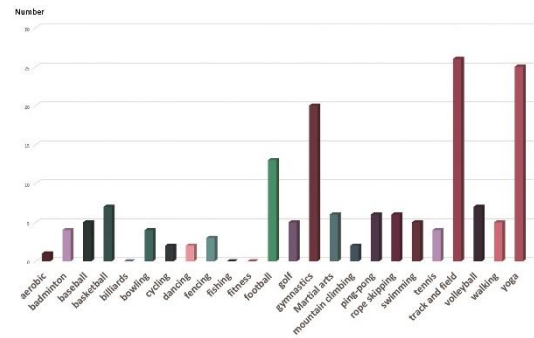


Figure 3: Number of sports revealed in Korean K-12 Physical Education System.

look at number of sports appeared in the document of the Korean K-12 Physical Education System in Figure 3, we find that track and field and yoga are the two most mentioned sports. Note that frequently mentioned sports in the K-12 Physical Education System can be regarded as popular sports in education. This indicates that sports with high degree (revealing importance in connectivities) may not be necessary popular in South Korea. This can raise a discussion that not only popularity of sports but also its connectivity needs to be comprehensively considered in physical education.

## 3.2 USA

We next illustrate the sports network for the USA in Figure 4. We also illustrate the amount of shared sports for each sports in Figure 5. As shown in Figures 4 and 5, unlike Korea, fitness plays important roles in the sports network of the USA. When we look at the popularity of sports in the USA in Figure 6, fitness also ranks at top, meaning that fitness plays important role not only in popularity but also in connectivity in the USA.
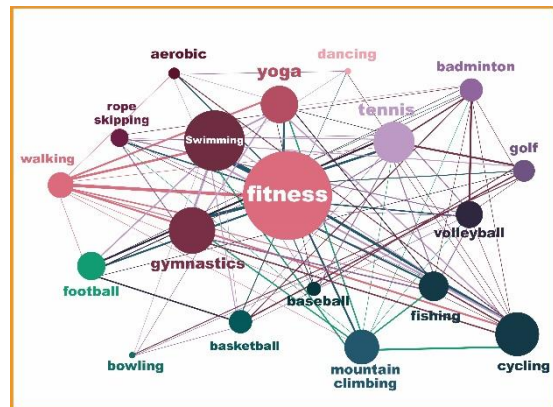


Figure 4: The sports network revealed through the K-12 Physical Education System in the USA.

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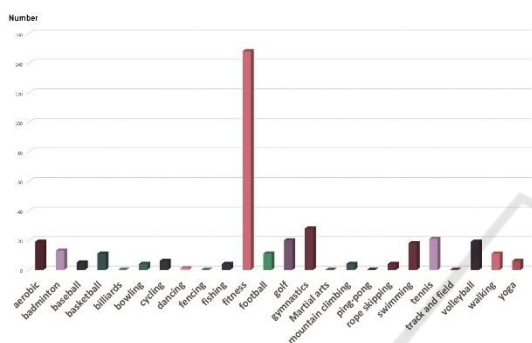Figure 5: Degree of sports in the USA sports network is illustrated.



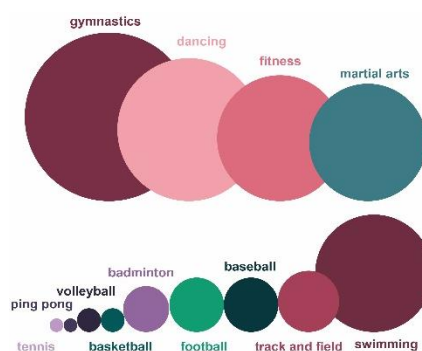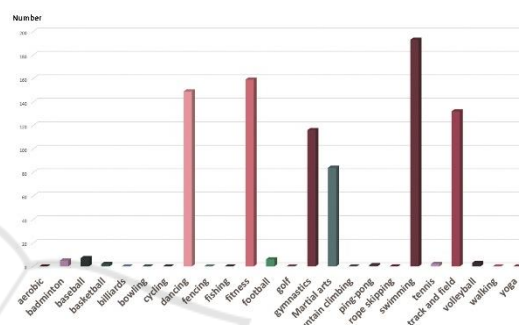Figure 6: Number of sports revealed in the K-12 Physical Education System of the USA.
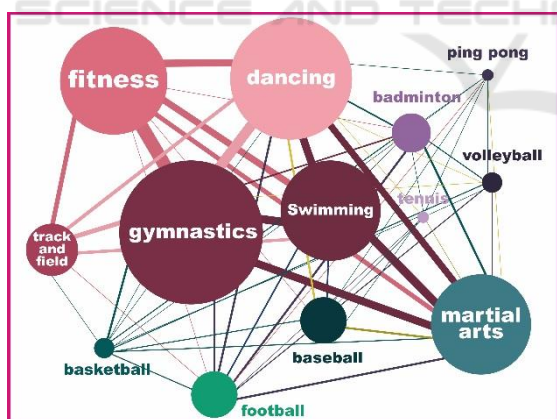
## 3.3 Japan



Figure 7: The sports network revealed through the K-12 Physical Education System in Japan.

The sports network for Japan is depicted and analyzed in Figure 7. We also illustrate the amount of shared sports for each sports in the Japan sports network in Figure 8. The sports network of Japan also shows a somewhat disparate pattern with those of Korea and the USA. In terms of connectivities, gymnastics, dancing, fitness, and martial arts play important roles



Figure 8: Degree of sports in Japan sports network is illustrated.



Figure 9: Number of sports revealed in the K-12 Physical Education System of Japan.

in the given sports network. When we look at the popularity of sports in Japan in Figure 9, swimming, fitness, dancing, track and field, and gymnastics are reported as popular in Japan. Overall, we notice that Japan focuses on basic sports training such as fitness, track and field, and gymnastic.

## 3.4 A Collective Analysis on Korea, the USA, and Japan Sports Networks

To analyze the three sports networks together, we visualize the three networks as a multi-layer network fashion in Figure 10. When we look at the diversity of sports, 19 sports are connected in the sports networks for Korea and the USA 19. On the other hand, only 13 sports connectivities in Japan. This implies that Japan tends to focus on smaller number of sports than Korea or the USA. We find that there is a strong relation between fitness and gymnastics in Japan, but their connection is not significant in Korea and the USA. This reveals that Japan tends to focus on a small number of sports that deal with basic training such as fitness or gymnastics. On the other hand, Korea and the USA tend deal with diverse advanced sports, compared to Japan.
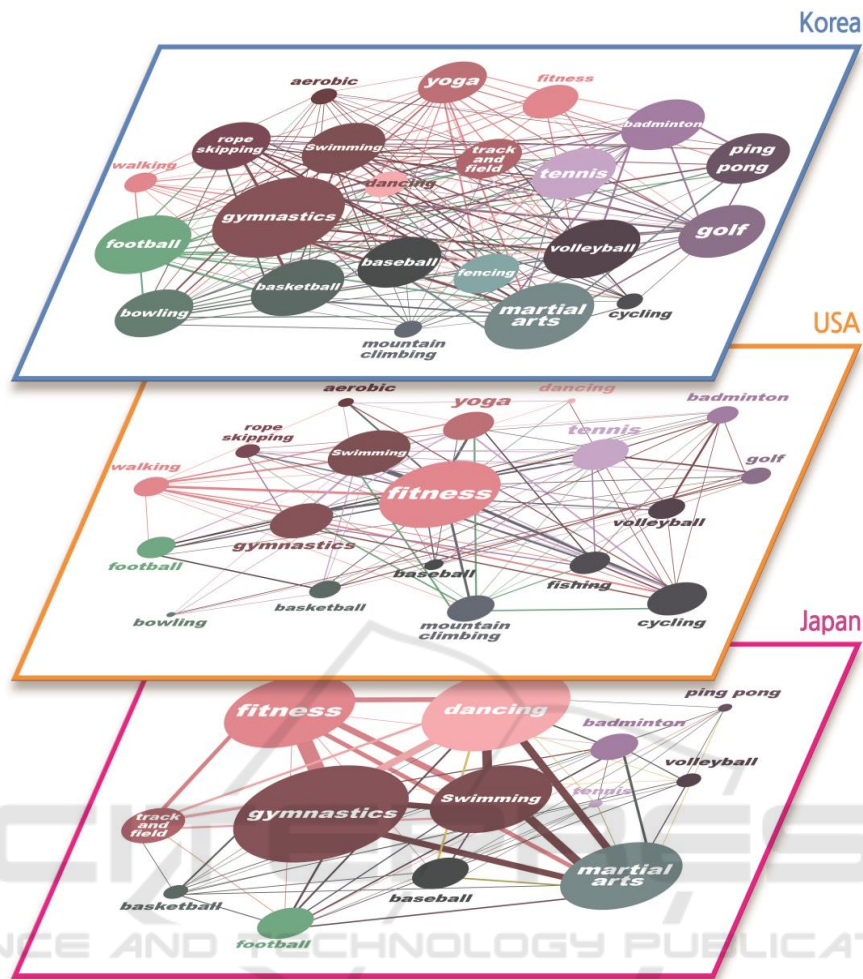
Figure 10: Three sports networks revealed through the K-12 Physical Education Systems are visualized.

## 4 CONCLUDING REMARKS

This study modeled and analyzed sports networks revealed through the K-12 Physical Education Systems in Korea, the USA, and Japan. We summarize four key implications as follows.

First, all three countries primarily focus on basic sports such as gymnastics and fitness. Korea and Japan teach swimming because it is required for the safety of students. Such effort on safety education is resulting in several large-scale accidents such as the 'Sinking of MV Sewol' or 'Shun Maru disaster' (Wikipedia, 2019a; Wikipedia, 2019b).

Second, many students in Korea and Japan take up Taekwondo and Judo, respectively, as traditional sports. This leads martial arts to become an important part of the physical education curriculums in these countries.

Third, it was found that Japan focuses more on basic movement sports, compared with Korea and the USA. It may be due to the characteristics of living areas in Japan.

Lastly, the study showed that physical education courses have had a certain effect on the life-long sports. Therefore, during school, the sports curriculum provides various experiences from a variety of sports. Also, education of basic movement sports is essential. However, from the educational perspective, it is not easy to educate students who are not interested in those movement sports (Myeong-Soo, Kim., 2017). To remedy this issue, there have been a number of proposals offered to the academic community on physical education (Song, Ji-Hyun·Choi, Won-Seok., 2018; Jeong-Hyun, Lee., et al., 2017; Ho-Cheol, Lee., 2016; Yang-Ok, Ahn., Min-Cheol, Cha., 2016; Jeong-Jun, Park., 2017).

The development of new sports and the need of more enjoyment (e.g., through extreme sports) are one of the important trends of the modern sports (Kyeun Woo, Park., and Seong Kyu, Ro., 2012). One of the main reasons of learning sports is to know how to have fun and how to increase our physical condition. In order to achieve this goal, another study is required to closely analyze the curriculum of primary and secondary schools, which can guide how to balance the different experiences of various sports and training in basic sports.

## ACKNOWLEDGEMENTS

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