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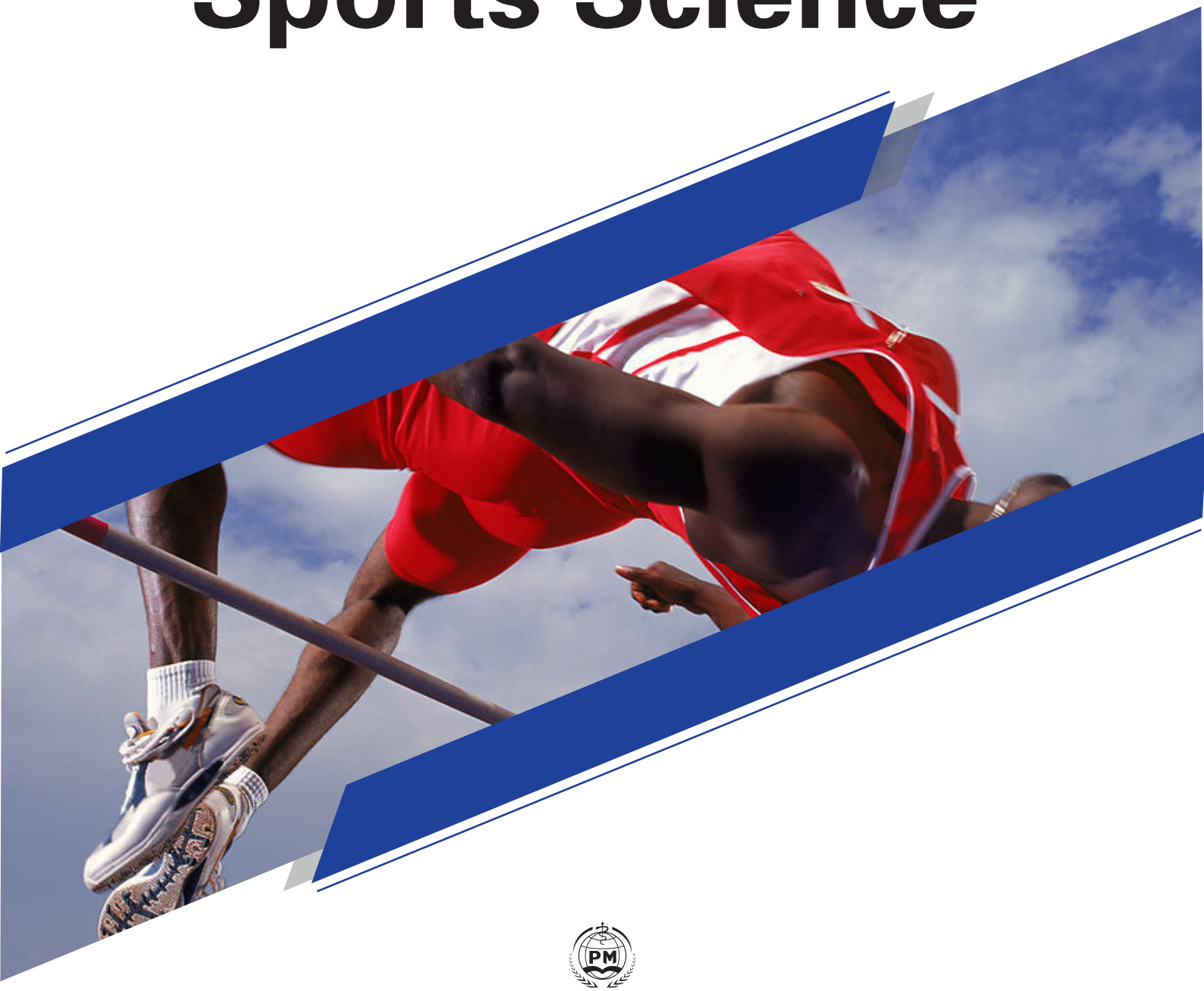

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Original Research Articles

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Original Research Article

Tactical Analysis Through Objective Data in Football

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Abstract: Tactical analysis in football has rarely been conducted using a mathematical model with numerical data (although tactical analysis through objective data has been used more often). Therefore, this study establishes principles for tactical analysis in team sports using numerical data, through a mathematical model based on the location of the players and the ball. A competitive match between Sanfrecce Hiroshima (home) and Ehime FC (away) in the third round of the Japanese Emperor's Cup 2011 was filmed and used for the match analysis. Observations were made by a team analyst as well as extracted from official match records. The main procedure in the research flow was to establish a mathematical offence/defence model based on tactical concepts in football, which was applied for the location of players, which, in turn, was quantified from video images in order to categorise a team's tactical performance (in relation to attacking or defending). Furthermore, the authors focused on attacking categories and identified different types of passes during a specific period, as well as comparing these findings with an actual match video. The results obtained from the numerical data derived from applying the offence/defence model led to the same overview as the tactical analysis produced by a team analyst. In addition, the results when categorising types of passes (as extracted through the mathematical model) again mirrored those retrieved from an actual match video. This leads to the conclusion that the offence/defence model could provide relevant insight into types of attacks. The data revealed that football tactical analysis can be successfully performed using a numerical model, which might possibly enable automatic tactical analysis of football games without a match analyst.

Keywords: Football Tactics; Numerical Data; Mathematical Model; Team Sports

1. Introduction

In order to improve a team's performance and results in football, logical and effective training is required to prepare players so that they can perform to the best of their ability[1]. It is important to analyse one's own tactics and

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those employed by opposing teams in order to establish logical and effective training. Indeed, this study builds on the premise that tactical analysis of one's own team and opposing teams is an essential element to improve a team's performances and results in football. Particularly in training of team sports, including football, it is crucial for a team to have purposeful and logical criteria in order to gain a mutual understanding of a game's situation[2]. Therefore, using objective data such as numerical location data for players and the ball during a match could be useful as one of the resources to create such criteria and to ensure an objective tactical understanding of a football game.

The adoption of information technology in team sports has increased significantly in recent years, and the use of objective data has become common in sports at the highest levels[3]. Particularly in football, the usage of objective data by professional teams for tactical analysis has expanded in various ways[4,5], which is influenced by business elements[6]. One example entails setting up cameras at a stadium to create a tracking system*[1], which involves capturing the players' movement as location information, for the purpose of improving players' performance[7]. Furthermore, such data is also used to produce valuable information for fans and spectators[8]. The use of such numerical data has an impact on sports analysis and its implications for training and performance[9].

In the analysis of a football game, everything occurring in the play can be translated into numerical data by considering ''who'' and ''where'' in terms of three-dimensional spatial coordinates and adding the ball's location[10]. In recent years, a framework has been established to objectively analyse and evaluate players' physical performance[11]. However, the usage of this data can be further developed to improve game analysis[12]. Furthermore, the interpretation of numerical data has been entrusted to analysts with expert football knowledge. This data has, for the most part, been used to analyse players' physical performance, but rarely for the tactical analysis of games[13]. When it has been used for the tactical side of game analysis, such objective data has frequently been used together with the match record and video.

Therefore, the current research aimed to establish the foundations of an analytical method for football tactics using numerical location data and a mathematical model. To achieve this purpose, the authors attempted to establish a method to analyse a football match, attuned to tactical elements, with numerical data on the three-dimensional location coordinates of the players in relation to the ball. The objectives of this research were 1) to develop better-structured tactical concepts in football and 2) to establish a mathematical model based on such concepts and applicable to numerical data.

2. Method

2.1 Participants

The sample match used for this study was the encounter between Sanfrecce Hiroshima (home) and Ehime FC (away) at EDION Stadium, Hiroshima on 11 November 2011, in the third round of the Japanese Emperor's Cup 2011. Ehime FC won the match 1-0 (0-0 at half-time). Only the first half, which lasted 45 minutes and 27 seconds, was subject to analysis.

The Ehime University Research Ethics Committee approved the use of human subjects in this research for the purpose of collecting and statistically analysing data, according to the Declaration of Helsinki. The authors obtained permission from the Hiroshima Prefectural Football Association and the J.League, as well as Sanfrecce Hiroshima and Ehime FC.

2.2 Equipment and instruments

The match was filmed using two SONY DCR-TRV70 video cameras, in full HD (1,920 × 1,080) and at 30 frames per second (fps). The tracking data was obtained at 5fps. The two video cameras were synchronised using an LED-type synchroniser (DKH, PTS-110), and three-dimensional analytical software (MP Japan, Tomoko-VM) was used to obtain the coordinate data of the 22 players and the ball.

[1] Tracking is a data coding mechanism for players, referees and the ball making use of a special camera and computer software.

2.3 Procedures

The main procedure in this research was to establish a mathematical ‘‘offence/defence model’’ based on tactical concepts in football. This involved conducting basic game analysis with numerical data in order to determine the team’s situation (attacking or defending)[14].

First, an interpretation of tactical concepts in football was identified with a view to establishing an appropriate mathematical model. Second, tactical analysis in relation to possession of the ball was considered. Third, an offence/defence model was established. Finally, tactical game analysis using the offence/defence model was compared to the results from manual input completed by an individual observing the match in relation to the following metrics: total attacking time, average duration of attack, number of attacks and maximum and minimum duration of attack. The research flow is detailed in **Figure 1**.

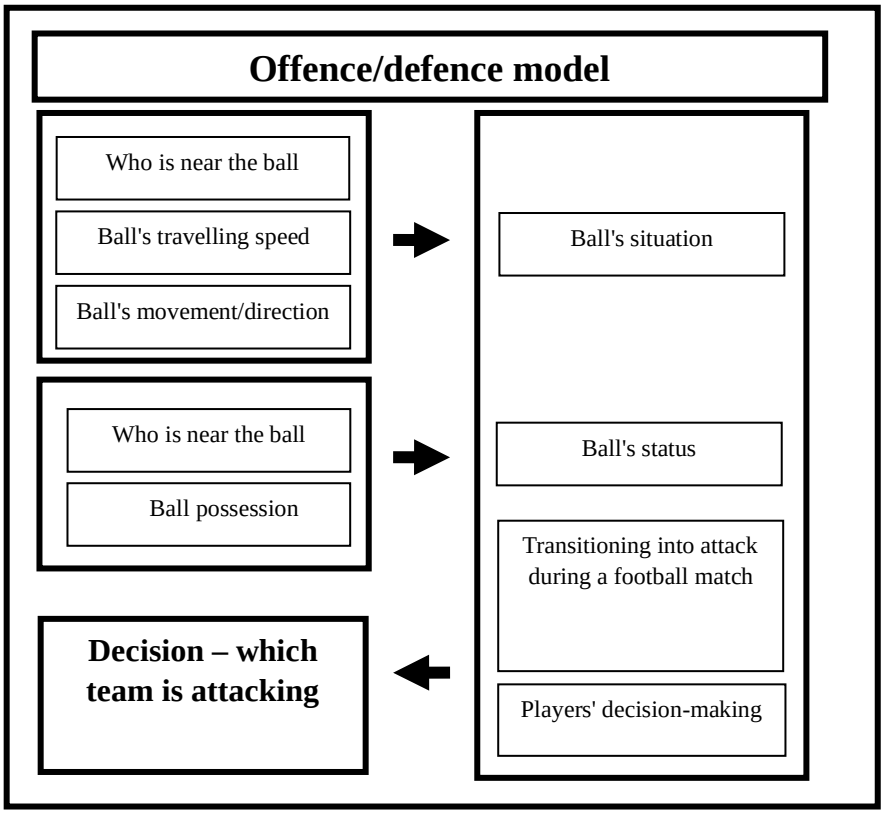

Figure 1. Research flow.

2.3.1 Interpretation and mathematical modelling of tactical concepts in football

This study focused on team tactics in football, covering both the offensive and defensive phases of the game. It explored tactical precepts as logical concepts based on the interpretation below.

In the long history of football tactics, principles of attack and defence have been established through years of analysis and play. In other words, the essence of the game can be said to be the relationship between attacking and defending[15], and it can be considered that tactical concepts in football have developed dialectically through playing experiences[16].

Data is presented numerically and represents the (dynamically changing) locations of players and the ball in the spatial coordinates (configuration space) at certain moments in the match. To structure such data by the team values tactically, tactical concepts must be converted into a mathematical model capable of analysing numerical data. This study aimed to optimise a mathematical way of thinking, such as modelling, to expand logical thinking for tactical concepts, and to provide a framework for the tactical analysis of games.

2.3.2 A framework for tactical game analysis and interpretation of ball possession

Wade[17] showed the team playing principle by capturing the situation in attack and defence on a pitch from a team's tactical point of view (see **Figure 2**).

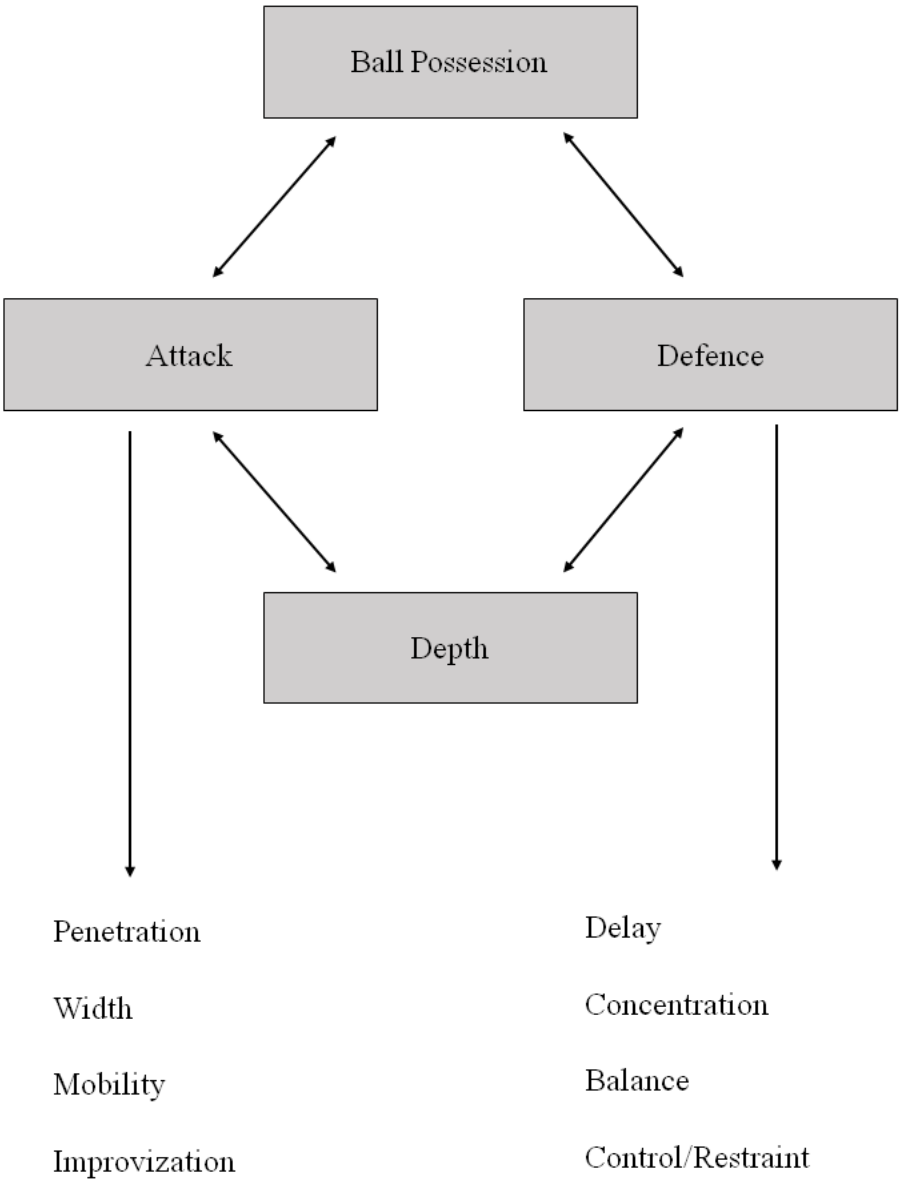

Figure 2. Depth in attack and defence[17].

Worthington[18] provided an overview of the playing principle and players' functions from a collective tactical point of view (see **Figure 3**).

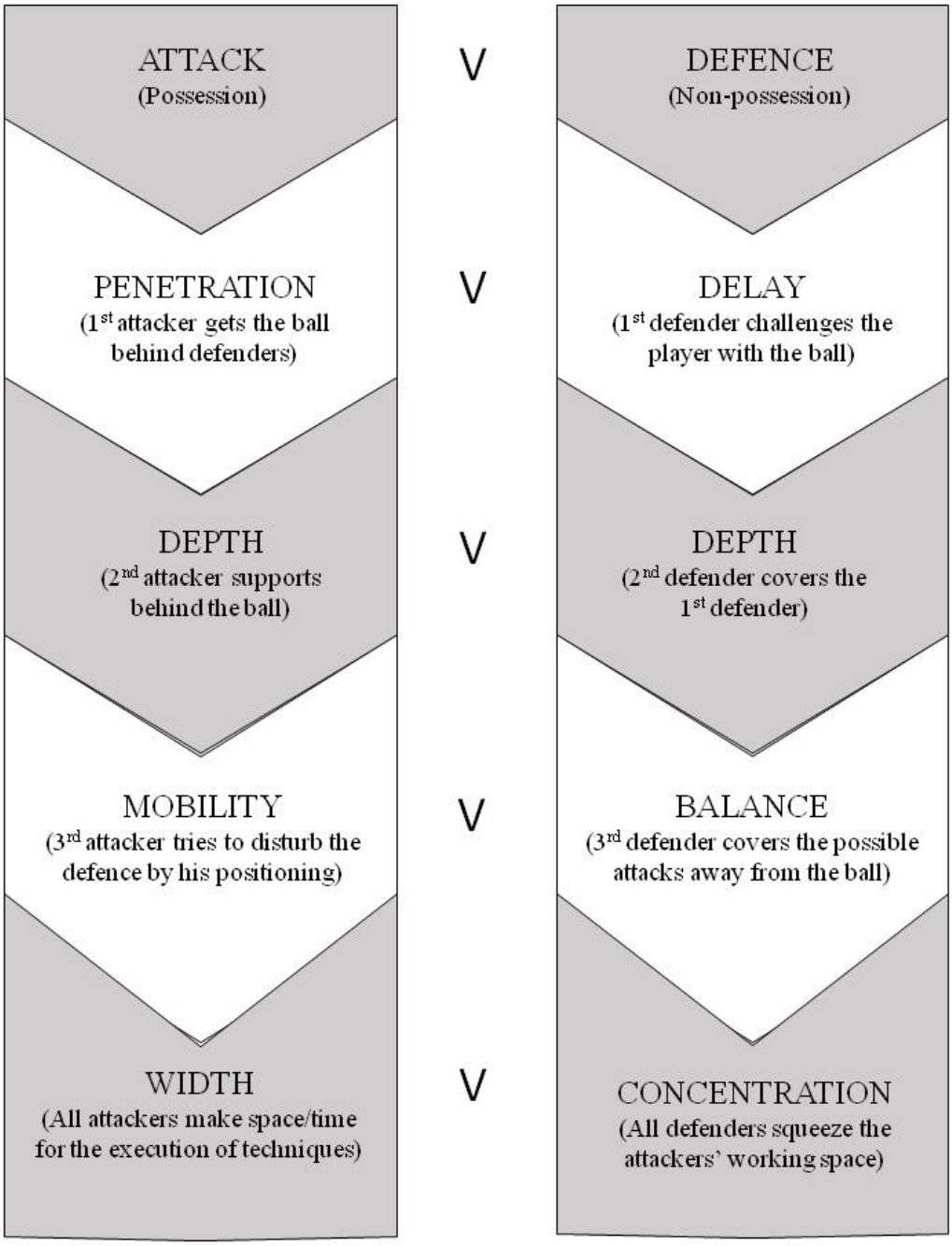

Figure 3. The principle of play and summary of the main functions of players[18].

Similarly, Takii[15] explained that football can ultimately be boiled down to two situations, attacking or defending, which are defined by possession of the ball. Wade and Worthington concluded, as outlined in the models above, that attacking and defending principles revolve around what players should do once in possession of the ball and what defending players should do after losing the ball, with a tactical decision being made depending on the team in possession.

In other words, in conducting tactical analysis, ball possession could be the basic information to predict players' tactical movement. The main factor determining players' movement is whether a team is attacking or defending, and players should strive to efficiently break the lines or to prevent the opposition from doing so in order to score goals or defend the goal.

When conducting a tactical analysis of a match, a team analyst usually watches the match, judges when a team is attacking or defending, and divides the match into spells of attacking or defending, breaking down the duration of each attack. Moreover, the team analyst often analyses the tactics based on the team's playing style and long-term coaching

plan. A key part of the team analyst's task involves attempting to clearly identify which team is in possession of the ball. Therefore, it could be anticipated that the team analyst intuitively understands the ball's movement and the situation around the ball. This means that the analyst assesses players' tactical movement on the pitch by gauging the ball's movement and the situation around the ball, and judging whether teams are attacking or defending.

Accordingly, the authors attempted to establish a method to analyse game tactics in football, starting by mapping the ball's movement and the situation around the ball, emulating the tactical game analysis conducted by a team analyst intuitively. The authors then proceeded to interpret ball possession from the viewpoint of ''which player on which team the ball can be attributed to'', rather than ''which player on which team is in control of the ball''.

2.3.3 Filming methodology

The match was filmed by two cameras using the direct linear transformation (DLT) method to obtain the location information of players and the ball during the match. The two cameras were stationed in the stands of the stadium, with a 70° filming angle, and filmed the whole match at 30Hz. Each camera was positioned so as to be able to film the same reference points, such as the goals and the intersection of the touchline and goal line (see **Figure 4**).

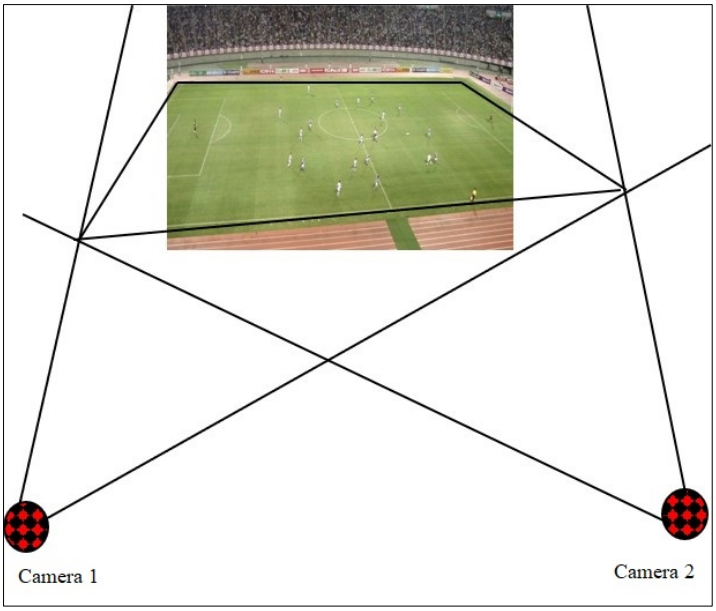

Figure 4. Cameras' angle.

The images were converted from 30fps to 5fps. The tracking data (numerical data) was obtained using video editing software and by manually clicking the location of players and the ball on a screen for each frame. The data is different from usual tracking data, in that it includes the location data of not only players but also the ball. Usually, the location data for the ball involves where the ball is when the players have it under control. However, the data used in this current research could contribute to furthering tactical game analysis using numerical data by making it possible to 1) analyse the locations of the ball when it is in motion and 2) convert the locations of the ball into numerical data, to be applied to tactical analysis.

2.3.4 Capturing objective data (location data)

The images recorded by the two digital cameras were digitalised per 0.25 seconds and transferred to a computer. The coordinated data for 22 players and the ball (x, y, z) was obtained using the three-dimensional analytical software. In the process, a point on players' waist was digitalised. The three-dimensional coordinates were set with the x-axis being parallel to a touchline, the y-axis being parallel to a goal line and the z-axis being the vertical direction. For calibration purposes, the intersection points of the touchlines and goal lines, and 5m-high calibration poles set on the intersection points, were used as the coordinate points. The measurement error for the DLT method was 0.01m on the x-axis,

0.02m on the y-axis and 0.02m on the z-axis.

2.3.5 Data obtained through observation

The same match was observed to manually judge attacking or defending and to calculate the total attacking time, average duration of attack, number of attacks and maximum and minimum duration of attack in the first half of the match. The data in **Table 1** was manually recorded by a team analyst. He determined which team was attacking or defending based on the video of the match. **Table 2** shows a sample of the team analyst's event-tagging notes, with data being recorded on a second-by-second basis in accordance with convention for official matches.

Attacking time	Sanfrecce Hiroshima	Ehime FC
Total	18:21	12:04
Average duration	00:10	00:07
Number of attacks	106	101
Maximum duration	00:48	00:36
Minimum duration	00:00	00:00

Table 1. The data determined manually

	H/A	Start	Time	Close	Time	Outcome	Duration
1	H (Ehime)	KO	00:12		00:18		00:06
2	A (Hiroshima)		00:18		00:20		00:02
3	H (Ehime)		00:20		00:22		00:02
4	A (Hiroshima)		00:22		00:26		00:04
5	H (Ehime)		00:26		00:37		00:11
6	A (Hiroshima)		00:37	Throw	00:41		00:04
7	H (Ehime)	Throw	00:48		00:52		00:04
8	A (Hiroshima)		00:52		00:59		00:07
9	H (Ehime)		00:59	Throw	01:07		00:08
10	A (Hiroshima)	Throw	01:21	Throw	01:28		00:07
11	A (Hiroshima)		01:34		02:01		00:27
12	H (Ehime)		02:01		02:21		00:20
13	A (Hiroshima)		02:21	Throw	02:29		00:08
14	H (Ehime)	Throw	02:42	Throw	02:45		00:03
15	H (Ehime)	Throw	02:52		02:56		00:04
16	A (Hiroshima)		02:56		03:20		00:24
17	H (Ehime)		03:20		03:23		00:03
18	A (Hiroshima)		03:23		03:25		00:02
19	H (Ehime)		03:25		03:27		00:02
20	A (Hiroshima)		03:27	GK	03:33	SH	00:06
21	H (Ehime)	GK	03:58		04:04		00:06
22	A (Hiroshima)		04:04		04:24		00:20
23	H (Ehime)		04:24		04:47		00:23
24	A (Hiroshima)		04:47		05:27		00:40
25	H (Ehime)		05:27		05:29		00:02
26	A (Hiroshima)		05:29		05:33		00:04
27	H (Ehime)		05:33		05:50		00:17
28	A (Hiroshima)		05:50	Throw	05:53		00:03
29	H (Ehime)	Throw	05:53		06:19		00:26
30	A (Hiroshima)		06:19		06:43		00:24

Table 2. Sample of the team analyst's manual tagging notes

The events that triggered the start of an attack (kick-off: KO; throw-in: throw; goal kick: GK; free kick: FK) were labelled ''Start''. The events that finished an attack were labelled ''Close''. The time difference between ''Start'' and ''Close'' was calculated as the duration of the attack. The outcomes of the attacks – a shot (SH) and a goal (GOAL) – were noted in the relevant column.

2.4 Statistical analysis

The offence/defence model was applied to the data obtained, with the objective of determining which team was attacking or defending during the match. The authors attempted to provide an overview of the match with the results from the collected data for the above-mentioned metrics: total attacking time, average duration of attack, number of attacks, maximum duration of attack and minimum duration of attack.

The outcome was analysed using the game summary which was drawn up, along with the official match record and comments from the respective head coaches. Furthermore, the results derived from the offence/defence model were

compared with those yielded through observation in terms of the tactical overview.

2.5 Constants and variables

By applying the offence/defence model to the obtained location data, the total attacking time, average duration of attack, number of attacks, maximum duration of attack and minimum duration of attack were calculated. In the calculation, the constant ''shot_b'' was set as 7.0m/s and the ''angle_b'' was set as 30°. The vicinity of the ball was set as a circle with a radius of 2m because the average height of football players in the Japanese top division (J.League 1) is 1.782m according to the official J.League website[20].

2.5.1 The offence/defence model

Location data was produced at every moment throughout the match, with attacking or defending expressed according to the constantly changing dynamics of the game. Therefore, a model was structured in the following order: 1) first, which team had the ball was determined using location data at a certain moment and 2) next, whether a team was attacking or defending was decided using the information on which team had the ball at a certain moment.

2.5.1.1 Extraction of ball possession at a certain moment

Ball possession was determined based on a combination of 1) the ball's moving speed and changing direction and 2) the number of players within a 2m radius of the ball (*i.e.* in the ball's vicinity) at certain moments. In this research, the ball's situation, $BC(k)$, at the time k was set as follows:

$$BC(k) = \begin{cases} shot & \left(v_b \geq shot_b \wedge \left|\theta_b\right| \leq \text{angle}_b\right) \\ keep & \left(\neg shot \wedge \left|X\right| = 1\right) \\ mix\text{–}up & \left(\neg shot \wedge \left|X\right| > 1\right) \\ others & \left(\neg shot \wedge \left|X\right| = 0\right) \end{cases}$$

	Game situation
→	Shot and pass
→	Dribble
→	1v1 situation
→	Ball free

The radius of 2m, as a constant denoting the vicinity of the ball, was set to reflect the range where a player is able to move within one second while in possession of the ball (*i.e.* dribble). In reality, it will be easier for a player to move in certain directions depending on his/her orientation and the situation around the ball. However, in this study, we did not have data on players' direction, for which reason it was decided to use the aforementioned radius as the vicinity of the ball.

Based on previous research[19], we decided to set the constant for ''shot_b'' at over 7.0m/s and for ''angle_b'' at 30°, taking into consideration the common phenomena occurring on the pitch. X represents a player near the ball, and $|X|$ denotes the actual number of the players around the ball.

$$BA(k) = \begin{cases} Own(\alpha) & \left(BC(k) \neq shot \wedge \varnothing \neq X \subseteq \alpha\right) \\ Own(\beta) & \left(BC(k) \neq shot \wedge \varnothing \neq X \subseteq \beta\right) \\ Own(\varnothing) & \left(BC(k) \neq shot \wedge o.w.\right) \\ BA(k-1) & \left(BC(k) = shot\right) \end{cases}$$

Next, possession of the ball, *i.e.* which team (α, β) has possession of the ball at the time k, was defined as $BA(k)$ as follows, including the less clear-cut situations.

Per the above formula, possession was determined when the ball's situation was not ''shot''. The possession was classified as ''own (α)'' when the ball's situation was not ''shot'' and all the players around the ball were from Team α. On the other hand, the possession was ''own (β)'' if all the players around the ball were from Team β. The possession became ''own (∅)'' if there were players from both teams, or no players, around the ball.

However, the above definition does not attribute the ball possession when the ball's situation is ''shot''. Therefore, in such a situation, the possession was determined by going back to the game footage.

In football, attacks can last for sustained periods of time, during which the ball's situation changes through passes between players and through dribbles. Therefore, based on these definitions, we can determine which team is attack-

ing and defending. In the next section, we define the game's situation, attacking or defending, and a team's ''attacking scope'' in dynamically changing circumstances based on the ball's situation and attribution at every moment.

2.5.1.2 Acquisition of attacking scope amid dynamic action

An attacking transition could be determined based on the ball possession at the moment of a player kicking and receiving the ball. However, it cannot be simply determined from the information at each moment due to possible situations when the ball possession is not clear. Therefore, when the ball possession is clear, it is simply determined that the team with the ball is attacking. In cases when the ball possession is not clear, however, the team that is attacking is determined by looking ahead to the next moment when the ball possession is clear.

$$isOff(k)=\begin{cases} \alpha off & \left(\begin{array}{c} BA(k)=Own(\alpha) \\ \vee \left(\begin{array}{c} BA(k)=Own(\varnothing) \\ \wedge\ BA(k+m)=Own(\alpha) \end{array} \right) \end{array} \right) \\ \beta off & \left(\begin{array}{c} BA(k)=Own(\beta) \\ \vee \left(\begin{array}{c} BA(k)=Own(\varnothing) \\ \wedge\ BA(k+n)=Own(\beta) \end{array} \right) \end{array} \right) \end{cases}$$

In the above definition, *m* and *n* represent the minimum natural numbers of the future moment when the ball possession could be clear. The relationship between *BA*(*k*) and *isOff*(*k*) is shown in **Figure 5**.

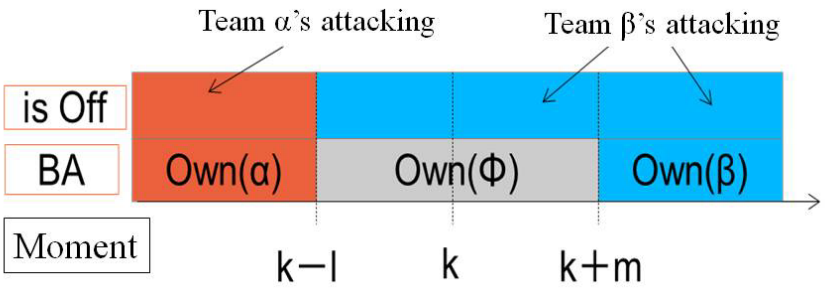

Figure 5. Determination of attacking scope using the offence/defence model.

3. Results and discussion

The offence/defence model yielded the following results for Sanfrecce Hiroshima: 18 minutes 45 seconds for the total attacking time, nine seconds for the average duration of attack, 114 for the number of attacks, 48 seconds for the maximum duration of attack and zero seconds for the minimum duration of attack. The results for Ehime FC were a total attacking time of 12 minutes, an average duration of attack of six seconds, 103 for the number of attacks, a maximum duration of attack of 34 seconds and a minimum duration of attack of zero seconds.

On the other hand, the results that were manually compiled by a team analyst were 18 minutes 21 seconds for the total attacking time, ten seconds for the average duration of attack, 106 for the number of attacks, 48 seconds for the maximum duration of attack and zero seconds for the minimum duration of attack for Sanfrecce Hiroshima. The results for Ehime FC were 12 minutes four seconds for the total attacking time, eight seconds for the average duration of attack, 101 for the number of attacks, 36 seconds for the maximum duration of attack and zero seconds for the minimum duration of attack. These results are shown in **Table 3**.

Attacking time	Sanfrecce Hiroshima		Ehime FC	
	Manual	Model	Manual	Model
Total	18:21	18:45	12:04	12:00
Average duration	00:10	00:09	00:08	00:06
Number of attacks	106	114	101	103
Maximum duration	00:48	00:48	00:36	00:34
Minimum duration	00:00	00:00	00:00	00:00

Table 3. Comparison of the attacking time as determined by the offence/defence model and manually by the team analyst

3.1 Attacking time

In this section, the attacking time obtained using the offence/defence model will be discussed. Sanfrecce Hiroshima's total attacking time was 18 minutes 45 seconds, while Ehime FC's was exactly 12 minutes. The sum of both teams' attacking time was therefore 30 minutes 45 seconds. As the first half lasted 45 minutes 27 seconds, this suggests that about 14 minutes of the half – *i.e.* the difference between the two teams' combined attacking time and the half's duration – involved no attacking action and consisted of what is known in football as ''ball-out-of-play'' situations. These include when the ball is off the pitch and the time until play restarts after a foul or offence is committed. Furthermore, when one team's attacking scope has been established, this confirms that the other team was defending: in other words, one team's attacking time equates to the other team's defending time. The results showed that Sanfrecce Hiroshima attacked for about six minutes more than Ehime FC, which means that the former accounted for 60% of the total attacking time and the latter for 40%. Consistent with the team analyst's findings, the results bore out that Sanfrecce Hiroshima took the initiative and dominated ball possession in the game.

However, Ehime FC won the match by a 1-0 scoreline, demonstrating that having the upper hand when it comes to ball possession during a match does not always lead a team to win. According to the Technical Report for the 2018 FIFA World Cup Russia[21], this point was exemplified by 2018 World Cup winners France, whose average ball possession over the course of the tournament was 48% (20th out of the 32 participating teams).

3.2 Average duration of attack and number of attacks

According to the data obtained through the offence/defence model, Sanfrecce Hiroshima's average duration of attack was nine seconds, while Ehime FC's was six seconds, meaning that, on average, Sanfrecce Hiroshima's attacks lasted three seconds longer.

In terms of number of attacks, Sanfrecce Hiroshima outstripped Ehime FC by 11 (114 to 103). Furthermore, according to the official match record[22], Sanfrecce Hiroshima took 14 shots in the first half, whereas Ehime FC only registered three. This means that Sanfrecce Hiroshima averaged a shot roughly every eight attacks (8.1), compared to Ehime FC's roughly 34 attacks (34.3) per shot. This information supports the conclusion that Sanfrecce Hiroshima took the initiative during the game.

3.3 Comparison with the official match record, coach reactions and other statistics

On the basis of the official match record[22], we can conclude that Sanfrecce Hiroshima took the initiative in the game, having outshot Ehime FC by 23 to 11. Likewise, the Sanfrecce Hiroshima head coach mentioned after the match that his team had taken the initiative and controlled the game, while Ehime FC had focused more on defending and looking to execute their attacking plan by capitalising on their very few opportunities[23].

In addition, the official J.League statistics for 2011 further show that Sanfrecce Hiroshima were successful in taking the initiative in this particular game, having exceeded both their own average number of shots taken per match (13.1)[24] and the average number of shots that Ehime FC faced that season (11.6)[25]. One could therefore consider, without relying on the offence/defence model, that this evidence—the official records and the comments from the Sanfrecce Hiroshima head coach—suggests that Sanfrecce dominated the game.

3.4 Comparison with the results from the observation (manual input)

In the previous sections, the possibility was mooted that the tactical analysis to estimate a game overview could be performed by using data determined by the offence/defence model. In this section, the results respectively obtained using the offence/defence model and manually determined by the team analyst are compared and discussed in terms of attacking time.

Every analyst can hardly be expected to have exactly the same criteria for determining attacking or defending because they make decisions based on football knowledge gained through their own experiences. In other words, each observer interprets football tactics based on his/her distinctive background. Therefore, when comparing the results from the offence/defence model, it was taken into account that the outcomes from the team analyst may be subject to particular trends and a certain amount of bias.

The comparison of the results is shown in **Table 3**. For example, the discrepancy between the total attacking time was 24 seconds for Sanfrecce Hiroshima and four seconds for Ehime FC. Meanwhile, the difference in the average duration of attack was one second for Sanfrecce Hiroshima and two seconds for Ehime FC, and when it comes to the number of attacks, the disparity was eight attacks for Sanfrecce and two for Ehime FC. The results for the maximum duration of attack were the same for Sanfrecce Hiroshima, but there was a difference of two seconds for Ehime FC. There was no divergence for either team in regard to the minimum duration of attack. In sum, there was very little difference in most categories, with the exception of Sanfrecce's total attacking time and number of attacks.

Overall, both game analytic results showed that Sanfrecce Hiroshima took the initiative in the game. Furthermore, the attacking data obtained from the offence/defence model had similar conclusions to those of the team analyst. However, there was a significant difference in the respective figures produced by the team analyst and the offence/defence model for the number of attacks racked up by Sanfrecce Hiroshima.

3.5 Examination of the attacking patterns

As noted, similar numerical data on attacking time was obtained from the offence/defence model and the team analyst. This showed that both methods can potentially provide a similar overview as part of tactical game analysis. However, considering the actual game, we should be able to analyse what shape attacks take at certain times during the game, with reference to the numerical data obtained from the game. Therefore, in this section, the researchers attempted to examine the attacking patterns by picking certain attacks and capturing ''Pass'' during the periods when a team was clearly in possession of the ball. As explained in the previous section, the situation was defined as ''Pass'' if the situation during the team's attack was determined as ''$shot_b$'' (understood as any kick of the ball) by the offence/defence model[26,27]. **Figure 6** shows the movement of the ball during an attack consisting of a string of consecutive passes, to support understanding of the image when comparing the results from the model and the actual video footage.

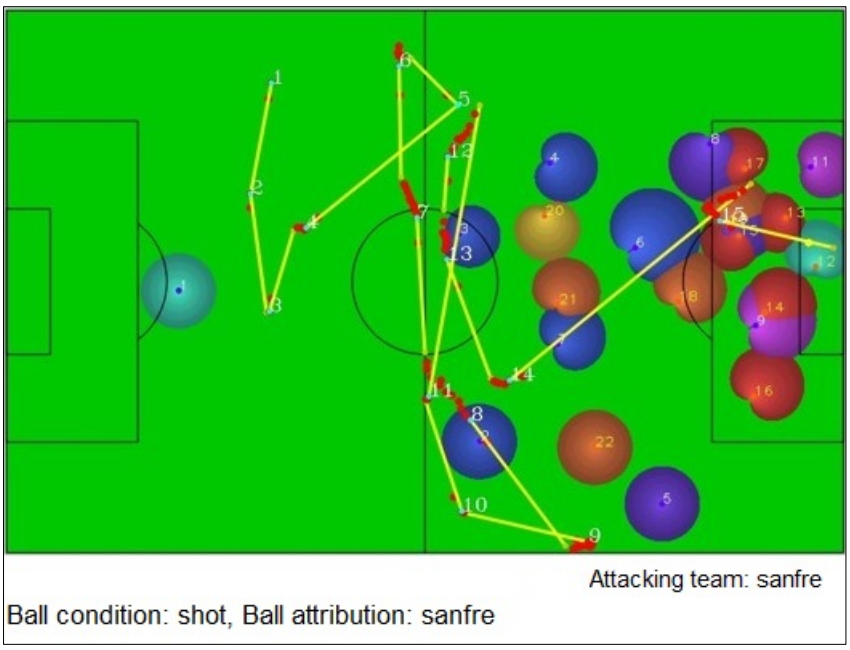

Figure 6. Diagram of passes during 39-second attacking sequence.

Sanfrecce Hiroshima's attack, which lasted 39 seconds, was mapped for the purpose of determining the patterns of ''Pass''. **Figure 6** shows the sequence of passes put together by Sanfrecce during those 39 seconds. The yellow lines represent the passes, the numbers at the starting point indicate the order of the passes and the red dots denote the movement of the ball that is not considered ''Pass''. ''Which team is attacking'', as determined by the offence/defence model, is shown in the top right, and the ball's situation and attribution are displayed in the bottom left-hand corner. Lastly, the players' locations and the predominant area with time limitation[*2] evidence the final moment of the attack. Through a comparison between the videos and **Figure 6**, the ball's movement as expressed by the yellow lines was confirmed as ''Pass''. Therefore, the results suggest that it is possible to apply the offence/defence model to interpret ''Pass'' as a type of attack.

In conclusion, captured attacks were determined by defining the team in possession of the ball and performing the action ''Pass''. According to the results, it is reasonable to assert that ''which team is attacking'' as defined by the offence/defence model could possibly determine the attacking patterns.

4. Conclusion

4.1 Conclusion

From this study, we learned that our mathematical model, the offence/defence model, can produce similar analytical data to the findings of a team analyst. Using numerical data from the location of players and the ball, based on key tactical principles, the authors were able to generate similar information to the team analyst, which also mirrored the official match record. It can therefore be considered that the information obtained using the offence/defence model is sufficient to capture an overview of the tactical analysis of a football game.

It was also found that the numerical data on attacking time respectively obtained by the team analyst and by the offence/defence model showed a similar overview. Furthermore, examining the attacking patterns by capturing ''Pass'' at a certain moment yielded the same results for the ball's movement in a passing sequence as through observation of a video. ''Which team is attacking'' can be identified through the offence/defence model and could also be an appropriate

[2] In football game analysis based on players' location, a predominant area diagram applying the computational geometry concept of the Voronoi diagram is used. Although it is considered that the player's predominant area should be reflected by the territory closer to the player's performance area, rather than the Voronoi area, such an area could be too big to obtain the information on the player's defending area. Therefore, to obtain such information, a time limitation was set for the predominant area.

way to determine attacking patterns.

4.2 Further research

The above-mentioned results show that it is possible to establish a basic framework for tactical game analysis in football by applying the offence/defence model to the objective numerical location data of players and the ball. However, some features of our model could be improved. They include 1) evaluation of entire games by applying the offence/defence model, 2) clarification of the constants in the offence/defence model and 3) incorporation of numerical data from several football games.

On the first front, the evaluation in this study was only conducted for the attacks at certain moments of the game. This needs to be extended throughout a game, and to several games, in the future. As for the constants, or the range of constants, these need to be clarified by applying the model to the data from several games. With regard to the third point, the challenge is that there is currently only a limited amount of publicly available open data, because most of the relevant data is guarded as a proprietary asset for the purpose of sports business.

4.3 Implications for practice

During this research, coaches and researchers worked together to establish a mathematical model based on a concept of football tactics. The researchers who established the mathematical model subsequently attempted to analyse a football match using a sample video. A lack of playing experience would traditionally have been seen as limiting a person's ability to analyse a game. However, the researchers realised that this research led to an opportunity for such people to get involved in the area of tactical game analysis. Indeed, during this research, we discovered that using this kind of model could help people with minimal experience to learn how to analyse the game.

In today's game, game analysis is of the utmost importance for improving and developing better athletes. It is hoped that this study will contribute to the promotion of numerical data as a tool to enhance analysis and potentially help to create a new community.

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Original Research Article

Study of Body Posture in Latin Dance and Its Important Significance

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Abstract: In this fast-developing era of the 21st century, the spread of culture is far beyond people's imagination. Since it was introduced into China, Latin dance has developed rapidly and now entered colleges and universities as a novel major. The focus of the education of Latin dance has gradually turned from popularization to cultivating specialized Latin dancer. Professional physical colleges and dance schools have also established art departments or dance departments one after another to ensure more students to obtain corresponding qualifications through theoretical and practical learning professionally and systematically, and pursue the artistic temperament and enthusiasm brought by dance. However, in the development process of modern Latin dance in China, there are some defects in universities' Latin dance courses. It is especially important to understand the importance of body posture in Latin dance. This paper introduces the requirements of five kinds of Latin dances on body posture. By using the methods of literature, induction and analysis, interview and investigation, combined with the characteristics of Latin dance, this paper explores and analyzes body posture in Latin dance and its important significance. Then the practice methods of body posture in Latin dance and its influence on Latin dance practice in the future are obtained.

Keywords: Body Posture; Latin Dance; Important Significance; Practice Method

1. Introduction

With the rapid development of the world economy in recent years, people have had a higher pursuit of beauty in daily life, in the context of which, Latin dance has become a good choice for fitness and entertainment. At the same time, more and more students like and begin to learn Latin dance. Latin dance can not only cultivate students' graceful posture, but also cultivate their unique dancing temperament. Nowadays, many colleges and universities have set up Latin dance courses one after another. However, in the development process of contemporary Latin dance, many Latin dancers in China now have wrong body posture, misunderstanding Latin dance as a dance with great swings and twists. In order to correct their wrong ideas on Latin dance and improve the dancers' understanding of the significance of body posture, the research of this paper is carried out to enable Latin dancers to dance with correct posture.

2. Body posture exercise: the key of shaping Latin dancers' good body shape

Good body posture is the basic requirement to display perfect dance style and elegant dance steps. A perfect Latin dance performance is a combination of movement and emotion. Body posture has become an important factor to judge dancers in Latin dance competitions. Long-term Latin dance training can promote learners to develop body muscle

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strength and form straight figure. Correspondingly, good body posture will help the dancers' movements more elegant, with stronger expression and appeal on the stage or in the competition. Therefore, body posture exercise is quite important in Latin dance training[1].

3. Body posture exercise: the premise of cultivating dancers' unique dance temperament

Good body posture has an important influence on dancers' temperament. The difference between professional Latin dancers and amateur Latin dancers is obvious, among which, the biggest advantage of the professional group is that the overall posture of the dancer is much straighter. As good body posture can show the dancer's perfect dance style, the audience can be moved by the atmosphere created by of professional dancers. The elegance of the dance is reflected in the gestures. It is also known that students who learn dance from an early age possessing a unique temperament compared with ordinary students. Therefore, body posture exercise can cultivate dancers' unique dance temperament[2].

4. Good body posture: the basis of high-quality dance movements

One of the main criteria for evaluation in many large-scale sports dance competitions is the player's body posture. Especially in the final round, body posture evaluation is the most important. Because most players will be relaxed when they run out of strength after several matches in a row, they may lose control on their body. However, the professional dancers are still at their best in the final round, who recover from the competition and effectively control their body posture from top to toe. Therefore, the dance quality of professional dancers can be well expressed through their perfect body posture[3]. That is to say, the body posture is also the core of the dance quality.

5. Body posture exercise: an important factor to reflect artistic beauty

Outstanding dancers will describe the scenes of the dance from three aspects, namely their faces, posture and emotions. The combination of graceful dancing and beautiful music perfectly presents the cultural connotation of music, which is based on good body posture. The beauty of art is demonstrated in every movement of body posture. For example, there are strict requirements on the posture of the head, trunk and limbs of Latin dancers, which requires Latin dancers to be strict with themselves in their movements, then fully express their emotions through the combination of dance and music, thus perfectly presenting the beauty of art[4].

6. Key points of body posture in Latin dance

Perfect dance is bound up to diligent practice. However, in many cases there are some students who practice particularly hard, turning out to have inelegant dance posture and little progress. Therefore, the correct practice method is important to dance. As a very important and indispensable part of Latin dance practice, body posture exercise is directly related to the future performance of dance[5].

6.1 Raise the head and tuck the jaw gently

In daily practice of Latin dance, looking down at the floor should be forbidden, nor raising the jaw which seems arrogant and destroys the beauty. In all dance movements, it is better to tuck the jaw gently unless it is necessary to raise the jaw in some movements, so as to lengthen the head and neck lines.

6.2 Lengthen the neck and sink the shoulder

Lengthening the neck means lengthening the cervical spine at the back of the neck. At the same time, combining with sinking the shoulder instead of shrugging can perfectly express the noble temperament of the dancers.

6.3 Hold out the chest, retract the ribs and keep the spine straight

Holding out the chest instead of retracting it refers to slightly retracting the ribs on both sides on the basis of holding out the chest. The spine should be kept straight instead of bending left and right or back and forth. In this way, the

upright but not rigid posture from the head to the chest and back can improve the overall appearance of the dancers.

6.4 Pull the stomach in and lift the hip

Pulling the stomach in is also called tightening the middle section or the abdominal muscles, while hip muscles should also be tightened inward. Hip lifting isn't holding up the hip or collapsing the waist.

6.5 Tighten the legs and brace the foot

The muscles on the inner side of thighs should be tightened to ensure that the legs are powerful and the body can be turned into a straight line when rotating. Excellent Latin dancers have tight inner thigh muscles. No matter standing or exercising, the instep of Latin dancers should be as straight as possible so as to improve the beauty of feet[6].

7. The practice method of body posture in Latin dance

Correct body posture practice in daily Latin dance training will double the training effect for dancers to learn dance skills. Based on the interviews with school teachers and the author's own teaching experience, the factors that affect body posture of Latin dance can be divided into two categories, one is the exercise of various parts of the body, the other is the exercise of dancers' ideological body posture[7].

7.1 Training points of body posture in Latin dance

(1) The method of circling or turning left and right with positioning eyes can be employed to practice the head's speed and flexibility. In the process of practice, the head should be controlled as far as possible to be perpendicular to the spine, and always be upright and straight.

(2) Shoulder fixation can be achieved by shoulder weight-bearing exercises so that the shoulder is fixed and will not shake with the movement of the body. In order to maximize the shoulder's extension, shoulder pressing and shoulder winding can be applied for practice.

(3) The exercises of the middle part (waist and abdomen) can adopt sit-ups, push-ups and plank to promote the core strength, thus enhancing the control of the body.

(4) As for the lower limb training, squat can be employed to improve strength of the thigh. Meanwhile, in order to prevent the formation of muscle legs due to excessive lactic acid accumulation, the muscles should be fully stretched after the exercise to relax the thigh, which can not only improve strength of the leg but also stretch the leg lines[8].

7.2 Training of dancers' ideological body posture

In Latin dance, the training of dancers' ideology is a long-term process. Good ideological body posture will be displayed from the dancers' gestures. Only when dancers possess the correct ideology can they show the beautiful body posture. Investigations and interviews indicate that Latin dancers' ideological body posture can be cultivated from the following aspects.

7.2.1 To understand the historical and cultural background of various dances and improve dancers' self-cultivation

In order to enable dancers to master the correct body posture of various dances, it is necessary to understand the cultural background and historical sources of various dances, accurately express the cultural information contained in them, and understand the respective style and characteristics of each dance, so as to add vitality and elements of each dance into the body[9].

No matter it is the hot samba, the tender rumba, the witty cha-cha-cha, the cheerful cowboy dance or the passionate bullfighting, each dance requires dancers to understand it attentively, to feel his experience, his growth and his emotion. While understanding each dance, it is also promoting the dancers' self-cultivation. Understanding the connotation of the dance enables dances to make the proper dance posture. In addition, male Latin dancers show a gentlemanly manner and masculinity, with softness and strength at the same time, while female Latin dancers show ladylike manners. Both of them need to improve their self-cultivation and show their perfect posture.

7.2.2 To strengthen the dancers' self-consciousness

The body posture should be fully stretched in the vertical direction from head to foot. The consciousness of stretching the body originates from the dancer's mind. It is necessary to deeply understand the space consciousness and the position on the stage, so that audience can feel the unique temperament and see the proper posture of the dancer. Latin dancers should form good habits, let their body posture be released subconsciously, and keep the consciousness of setting up a good posture in each movement[10].

8. Recommendation

8.1 Pay attention to the special exercises of body posture

Teachers are advised to use posture exercises as warm-up exercises in every Latin dance class, so that students can warm up and take posture exercises at the same time, thus avoiding boring classes when posture is separately exercised in the later class. Moreover, taking body posture exercise as the early stage of each class can help students gradually develop the habit of keeping good posture in daily life.

8.2 Pay attention to body exercises

Body exercises and body ideology exercises are two important factors affecting body posture in Latin dance. Therefore, body exercises can improve the aesthetic appearance of dancers' body posture, while good physical quality can improve the control of dancers' body posture. Correct ideology can reflect the level of Latin dancers. To sum up, an excellent dancer must have a good body posture, which is closely related to body exercises and physical exercises.

8.3 Attach importance to the ideology in body posture

Dance is a movement art of time and space. Latin dancers should integrate themselves into the practice when practicing body posture. They should add the style and characteristics of this dance into every movement and try to feel the artistic conception of the dance. The cultivation of self-consciousness is a long-term process of accumulation, practice and correction. With dance ideology, elegant dance posture of dancers will be reflected in each gesture[11].

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Original Research Article

Cultivation Methods of Students' Lifelong Physical Education Consciousness in High School Physical Education

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Abstract: In recent years, under the reform of new curriculum education and teaching in China, students' learning pressure in cultural courses is getting bigger and bigger, especially in senior high schools. Due to the increasing learning pressure of cultural courses, students' physical fitness is neglected in education, which makes students' physical fitness decline, thus directly affecting the learning state of senior high school students. Therefore, in the education of senior high school students, attention should be paid to physical education methods, students' lifelong sports awareness should be cultivated, and the quality of physical education methods should be enhanced so that students' physical fitness can be improved and their full physical and mental state can be put into study.

Keywords: Lifelong Sports Consciousness; High School Physical Education; Teaching Strategies; Status Quo; Culture Method

1. Introduction

The teaching goal of high school physical education is to improve the physical quality of high school students, and to develop them morally, intellectually, physically and aesthetically. But in fact, in the past high school teaching, due to the old teaching methods and teaching concepts, high school students' sports awareness training has not been taken seriously at all. With the continuous improvement of the new curriculum standards, people pay more attention to themselves and their children's health. Under such circumstances, the cultivation of senior high school students' lifelong sports awareness has become increasingly important. From this point of view, it is very important for senior high school physical education teachers to cultivate lifelong physical education consciousness.

2. The importance of cultivating students' lifelong sports awareness in high school physical education

2.1 Reduce the learning pressure of high school students

Cultivating senior high school students' awareness of lifelong physical education in senior high school physical education can help senior high school students reduce their learning pressure. Students in senior high school have great learning pressure, and the ease of physical education in senior high school can help senior high school students release their learning pressure effectively, which is of great help to their healthy development. It can be seen from this that in high school physical education, the cultivation of lifelong physical education awareness by high school physical education teachers can help high school students relax and reduce learning pressure, so as to help high school students improve their learning ability and realize the healthy development of high school students.

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2.2 Improve the physical quality of senior high school students

Physical education in senior high school can be said to be for the purpose of training students' health and improving their physical quality[2]. Establishing high school students' lifelong sports awareness can make high school students understand the importance of sports, so that they can exercise physically in the process of learning, so as to realize the combination of work and rest for high school students. In fact, it can be seen that cultivating students' lifelong sports awareness in the process of high school physical education can help high school students to exercise and improve their physical fitness, thus strengthening their physical functions and helping them grow up healthily.

2.3 Improve high school students' innovative thinking and practical ability

In fact, the high school stage is an important stage in the development of high school students. In this stage, high school students can not only learn a lot of theoretical knowledge and practical knowledge, but also help high school students form good thinking habits, thus effectively promoting the improvement of high school students' thinking ability. At this stage, carrying out physical education and cultivating lifelong sports consciousness for senior high school students can not only exercise their physical quality and help them form a healthy body, but also make senior high school students directly feel the infinite charm brought by sports in the process of actually participating in sports activities, and even make senior high school students promote their practical sports ability by participating in high school sports activities. Therefore, it can help high school students improve their innovative thinking ability and practical ability, and then achieve the goal of comprehensive training of high school students.

3. The current situation of high school students' lifelong sports awareness

First, senior high school students do not have a correct and sufficient understanding of lifelong sports consciousness. At present, high school students in China only have a superficial understanding of sports, and most of them think that sports are just for keeping healthy, but they don't fully understand its true value and significance, and the related sports knowledge they have learned and mastered is even less, and their understanding of lifelong sports is rarely touched. There are many reasons for this situation, such as inadequate publicity, too much emphasis on cultural achievements, etc., the latter reason is the most important, which leads to the students' lifelong sports awareness cannot be effectively cultivated in physical education.

Second, high school students lack the habit of long-term exercise. High school students basically do not form good exercise habits. In high school, students have great pressure to study in college and enter higher schools. Under the current exam-oriented teaching, students have to pay attention to the study of cultural courses in order to better enter higher schools, and they also review cultural knowledge after class. Therefore, students' physical exercise is basically carried out on the physical education class every week, so it is difficult to effectively form the habit of lifelong exercise and sports awareness.

4. Measures to effectively cultivate students' lifelong sports awareness in high school physical education

4.1 Create a good sports learning atmosphere

Physical education teachers create a good sports atmosphere, thus effectively enhancing students' interest in participating in sports. Schools can effectively create physical education learning conditions according to students' hobbies, age and personality, such as setting up health education classes and physical education festivals. In addition, besides sports games, students can also carry out various sports activities to better release their learning pressure and further exercise their bodies; Schools can also increase the publicity of sports, such as radio and campus publicity columns, and organize students to watch international sports competitions. In addition, the school can also organize some teachers and workers to participate in sports activities, teachers set an example for students, and fully stimulate students' interest in sports; Finally, the school can also organize more physical education lectures, so that students can establish a good

sense of lifelong physical education and correctly recognize the importance of physical exercise.

4.2 Enrich the teaching forms

Usually, physical education class is carried out in the campus or playground, so teachers don't have to pay too much attention to one teaching method in the teaching process, and can adopt various teaching methods, which may yield unexpected results. When teachers arrange the teaching content, they should choose the items that students are interested in as much as possible, and then add health education for senior high school students to carry out various forms of teaching for students.

For example, teachers can explain the connection between sports and health to students by means of film and television, and then present the picture vividly through multimedia, so that students can identify with it in their hearts and gradually form subjective consciousness. Teachers can also play some competition highlights and replays to students, such as NBA, Rio Olympic Games in 2016, etc., and explain relevant theoretical knowledge to students, so that students can have more interest in watching.

At present, in physical education, sports events are basically unified, and teachers also use unified standards to assess students' sports achievements, so that most high school students will have coping psychology and lose their initiative consciousness of participating in sports events slowly. When carrying out physical education on campus, teachers should teach students in accordance with their aptitude, select sports events according to the interests and hobbies of all students, and formulate the teaching objectives and assessment standards of sports events together with students. For example, some students have a high enthusiasm for skipping rope, but they lack strong arm strength. Teachers can let students set their own standards, or how many jumps per minute will pass. In this way, students are more motivated to participate in their favorite sports. When students become interested in a sport, they will have the idea and consciousness of participating frequently for a long time, so that they will participate in the sport for life, and then form a good lifelong sports consciousness.

4.3 Assist students to establish the concept of lifelong sports

When cultivating students' lifelong sports awareness, physical education teachers should help students effectively establish the concept of lifelong sports. At the same time, teachers should constantly improve their professional quality and skills, and effectively combine sports knowledge with psychological knowledge in the teaching process, so as to provide students with more scientific teaching programs. In actual teaching, physical education teachers should first demonstrate sports action standards to students. If sports are difficult, teachers can guide students on the spot, and find out the problems in students' practice in time and solve them effectively. In addition, physical education teachers can fully understand students' interests and hobbies, and then choose appropriate teaching methods, so that students can discover their own sports advantages and effectively cultivate their lifelong sports awareness.

4.4 Cultivate students' lifelong sports awareness in teaching practice

In high school physical education, sports are usually carried out on the playground, and students have a larger activity area. In this way, students can't learn sports knowledge effectively. In view of this situation, teachers can explain knowledge in a class and the first half of the class in the classroom. The content is mainly sporting that students can generally accept, such as teaching Taijiquan and gymnastics, so that students can get better exercise and lay the foundation for subsequent sports. Teachers can apply the competition teaching method to students' free learning, and launch a small competition for the sports they practice.

For example, in basketball teaching, the "three to three" street basketball method can be applied, and students take turns to compete. This method can not only effectively cultivate students' sports consciousness, but also further improve their team ability and cooperation ability, and students will make more efforts for their own team. In addition, from the perspective of competition, students will maximize their potential to win. In this process, students' sports consciousness is greatly stimulated. At the same time, students can learn sports skills from each other in the process of competition, so as to improve their mastery of sports skills and establish a strong sense of lifelong sports.

Senior PE teachers should not ask students some mandatory requirements in the specific teaching process. For example, students must master several skills within 45 minutes, so that students will have greater pressure and their spirit will always be in a tight state, which will not only improve learning efficiency, but also lead to a decline in learning enthusiasm. Therefore, high school physical education teachers should let students learn physical education in a relaxed and pleasant atmosphere, and effectively stimulate their lifelong physical education consciousness.

4.5 Strengthen the construction of stadiums and facilities

In order to further cultivate students' good lifelong sports consciousness, a very important link in high school is to increase investment, build better sports venues and buy more sports equipment. First of all, schools should strengthen the construction of sports venues to provide better space for students' exercise. Secondly, to buy a certain amount of equipment and facilities, teachers should teach students the correct use of these equipment, so that students can master more exercise skills. Finally, the equipment management system is formulated effectively. Students can rent the equipment from the equipment management office, increase extracurricular activities, and further improve students' awareness of physical exercise.

5. Conclusion

To sum up, in the teaching of high school physical education, great importance should be attached to physical education methods, and the quality of physical education methods need to be enhanced. It is also necessary to improve students' physical quality, make students pay attention to the study of physical education courses, and gradually cultivate students' lifelong sports awareness, so that students can have better development in the future.

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Original Research Article

Analysis on the Influence of Physical Education in Secondary Vocational Schools on Students' Mental Health

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Abstract: For physical exercise, it can not only enhance students' physical quality, but also benefit their mental health. Students studying in secondary vocational schools are generally between 15 and 18 years old. Judging from the age of students, their ideas are gradually maturing and their understanding of the whole society is becoming more and more comprehensive. However, students are also very prone to problems at this age, which are not only prone to differences with mainstream ideas, but also prone to psychological problems. Therefore, this paper makes a brief analysis of the influence of sports activities on students' mental health in secondary vocational schools, and puts forward relevant suggestions, hoping to benefit the teaching in secondary vocational schools.

Keywords: Secondary Vocational Sports; Mental Health; Strengthen Countermeasures

1. Introduction

As a secondary vocational school, its training focuses on students' vocational skills, so the quality of students' learning directly determines students' future work level and salary. This makes many students' study pressure too great, and even have psychological problems. In addition, for those students in secondary vocational schools, their thoughts are not yet mature. If students find that their ideas and correct values are deviated, they can easily make some radical behaviors, which will have an impact on their mental health. Therefore, in the process of educating students in secondary vocational schools, teachers can help students solve psychological problems through sports activities.

2. The psychological status of secondary vocational school students and its causes

2.1 Psychological status of secondary vocational school students

At present, many students in secondary vocational schools lack the sense of cooperation, are often self-centered, are difficult to integrate into the collective, and are prone to anxiety, loneliness and loneliness. Moreover, their adaptability is poor, they lack the sense of group, and they are easy to rely on their parents. If these psychological problems of secondary vocational school students are not solved for a long time, it will be difficult for students to form correct values, and their growth will be seriously hurt, which will easily make students give up and feel inferior, and seriously affect their mental health. Once the secondary vocational school students can't meet the needs of the society, they will become useless people in the society, which will not only affect the students' character, but also make the students' thoughts distorted and difficult to adjust.

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2.2 The causes of psychological problems of secondary vocational school students

For students, they are in a changeable and complex environment, which is influenced not only by family and school, but also by social environment. In the social environment, students will inevitably be affected by various dangerous factors. In the family environment, students are greatly influenced by their parents, and domestic violence and parents' divorce will cause students' mental health problems. At school, students are also prone to campus violence due to personality differences. These factors often impact students' outlook on life and values. Once it cannot be guided correctly, it will further affect students' mental health.

3. The impact of physical education on students' mental health

3.1 To help students form good will quality

In the process of sports activities, students can not only keep a relaxed and happy state of mind, but also effectively cultivate students' good moral character, making them more witty and agile and more collectivist. If we want to cultivate students' strong will as much as possible, it is necessary to help students complete related tasks through games, bring them the pleasure of winning, and encourage them to build confidence. In addition, for those students with poor adaptability and learning ability, they can also appropriately reduce their requirements. In the actual teaching process, it is important to help students get the pleasure of solving difficulties in learning by build up their confidence by setting reasonable goals that students can accomplish through certain efforts. At the same time, it can also improve students' will quality unconsciously, stimulate students' courage to overcome difficulties to the maximum extent, and enhance their interest in learning. In addition, in specific teaching, teachers should pay attention to the improvement of learning methods. For sports, it has the characteristics of strong competition, fierce confrontation and hardship. Therefore, in order to cultivate students will power and bring better emotional experience to students, it is necessary to cultivate students will quality through various learning modes.

3.2 To help students improve their interpersonal relationships and enhance their sense of teamwork

For sports, its positive effects on students are mainly reflected in further improving students' interpersonal relationships, changing students' behaviors, and effectively releasing students' bad emotions. Only through sports can the students effectively establish good interpersonal relationships, thus enhancing the communication between teachers and students, and making students feel the strength of unity and the joy of victory. By making full use of sports activities, students can get short-term happiness and further release their negative emotions. At the same time, they can realize the meaning of unity in cooperation and gain precious friendship in an environment of mutual help and mutual assistance. Making full use of students' herd mentality can help students grow up in a collective environment and gradually overcome their self-awareness. In addition, by organizing sports activities, the communication between students is fully enhanced, making them a team and creating a good learning atmosphere for them.

3.3 To help students promote the development and utilization of the brain

In the process of sports activities, it is not only conducive to the development of students' intelligence, but also can fully stimulate students' potential. Gymnastics can relax students' muscles; volleyball can fully train students' reaction ability; track and field sports can make students understand the significance of persistence; basketball shooting training can improve students' team consciousness. Sports can further enhance the flexibility of students' nervous system and improve their sensory system, auditory system and visual system. Sports can also effectively promote people's intellectual development. Using sports activities can make students' thinking more divergent, imagination more abundant and memory gradually enhanced. Students can improve their cognitive ability as much as possible through sports activities after a long period of mental work.

3.4 To help students improve their ability to resist negative psychology and induce positive thinking and emotion

Through sports activities, students can effectively relieve negative emotions such as stress, confusion and anxiety, and promote them to have positive thoughts and emotions. Students can effectively treat psychological diseases in the process of sports activities, and long-term sports activities can effectively release students' positive emotions. At the same time, anaerobic exercise can greatly reduce the fluctuation of depression. According to the current medical research, for those patients with mild depression, physical exercise is the most effective auxiliary means to treat depression patients. In addition, in the process of physical activities, physical health and balance are conducive to the healthy development of students' psychology. For example, the rise and fall of body temperature, the contraction of blood vessels, the speed of metabolism and the beating of pulse will enhance people's control over the movement of certain nervous systems and organs.

3.5 To help students build self-confidence and strengthen self-efficacy

For secondary vocational school students, scientific sports activities can enhance their self-confidence. When carrying out activities, setting reasonable goals according to students' own abilities can enhance students' consciousness, thus fully mobilizing each student's participation enthusiasm, and the joy of success can further stimulate students' desire to seek higher goals. After a long period of accumulation, students can continue to gain successful experiences in sports activities. Teachers should be good at discovering students' advantages and strengths in the teaching process, such as some students strong jumping ability, some students strong speed or strength, and some students quick learning of technical movements, which are students' unique advantages. Only by giving full play to their specialties can students interest in sports activities be truly stimulated.

4. The strengthening strategy of the influence of physical education on students' mental health

4.1 To increase the penetration of mental health education

In the promotion of quality education, secondary vocational education should not only improve students' learning ability, but also strengthen students' psychological quality. Physical education in secondary vocational schools has become an effective way to carry out psychological education in secondary vocational schools because of its advantages in sports skills and sports spirit. Physical education classes in secondary vocational schools should uphold the student-oriented educational philosophy and strengthen the penetration of mental health in physical education teaching. Physical education teachers should lead by example and guide students to study with a good attitude through their own words and deeds. When infiltrating mental health education in secondary vocational sports, rich and interesting sports contents and forms should be used according to the physical characteristics of secondary vocational students, so as to attract students to participate in sports and love sports, thus laying the foundation for psychological health infiltration.

For example, in secondary vocational physical education, besides training students' sports skills, psychological games can also be introduced into sports events. P.E. teachers can organize students to compete in groups. Students should not only complete the sports actions specified by the P.E. teachers, but also guard against the obstacles and influences of each other in the confrontation. In this combination of sports and psychological strengthening, the psychological training of secondary vocational school students can be well realized.

4.2 To strengthen the cultivation of psychological education skills of physical education teachers

The combination of physical education and psychological education in secondary vocational schools is realized through the teaching of physical education teachers. Therefore, the concept and level of psychological health education of physical education teachers in secondary vocational schools have a direct impact on the effect of guiding students' psychological health in secondary vocational schools. Secondary vocational schools should strengthen the training of physical education teachers' mental health education ability, and improve the teaching level of secondary vocational physical education teachers through professional and comprehensive training channels.

Traditional physical education in secondary vocational schools only trains and assesses physical education teachers' physical skills, but neglects the cultivation of their mental health education ability, which requires the joint efforts of secondary vocational schools and normal colleges. First of all, normal colleges should add mental health education to the education of physical education students, so as to deliver high-quality physical education talents to the society. Secondly, secondary vocational schools should strengthen the training of in-service physical education teachers. They can hire professional mental health education experts at home and abroad to give lectures for professional training. They also need to actively cooperate and exchange with other institutions, learn from each other and learn from relevant educational experiences, and broaden the vision of mental health education for secondary vocational physical education teachers.

4.3 To constantly improve physical education textbooks

Physical education textbooks in secondary vocational schools are the key for physical education teachers to design teaching content, and mental health education should be integrated into the compilation of physical education textbooks in secondary vocational schools. For sports content that secondary vocational school students like better, such as volleyball, basketball, football, badminton, swimming, sprint and so on. Secondary vocational physical education textbooks can enhance students' psychological experience by combining mental health education with teaching content.

For example, the content of swimming events in physical education textbooks of secondary vocational schools can be based on the traditional knowledge of swimming skills, and quick judgments and solutions in the face of drowning, body cramps and other dangerous situations can be added to help secondary vocational students not only achieve the purpose of improving their physical fitness in physical education, but also cultivate students' calm mentality in the face of difficulties and dangers.

4.4 To optimize the physical education teaching environment

Physical education teaching environment in secondary vocational schools is also an important factor affecting students' mental health, so secondary vocational schools should pay attention to the continuous optimization of physical education teaching environment to create conditions for cultivating students' good psychological quality. Secondary vocational schools should provide students with convenient ways of physical exercise through scientific and reasonable layout of sports venues, replace and repair old sports equipment in time, so that every student can participate in physical exercise with peace of mind, and strengthen the soft environment construction of physical education, and stimulate the enthusiasm of secondary vocational students to participate in physical exercise by creating a harmonious and democratic sports atmosphere.

Good physical education teaching environment can make students devote themselves to physical education, cultivate students' perfect personality and healthy psychology, strengthen their own sports spirit, and truly realize the unity of body and mind in physical education.

5. Conclusion

In the process of knowledge education, secondary vocational schools should pay attention to the guidance of students' mental health, and actively use secondary vocational physical education to create a positive learning atmosphere for students, so as to improve the psychological quality of secondary vocational students.

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Original Research Article

On the Application of Outward Bound Training in Junior Middle School Physical Education

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Abstract: With the development of the new curriculum reform, physical education teaching methods in junior middle schools have changed, but the traditional physical education teaching mode still occupies a dominant position, and the teaching mode is single and the content is tedious, which makes it difficult to arouse students' interest. Outward bound training is a brand-new form of sports, which can greatly enhance students' participation and train students' collective consciousness, and is widely used in physical education. This paper mainly introduces the characteristics of outward bound training, tells the necessity of outward bound training in junior high school physical education, and briefly describes the specific application strategies of outward bound training in physical education.

Keywords: Junior High School Physical Education; Outward Bound Training; Apply

1. Introduction

Under the background of the new curriculum reform, physical education class is one of the core courses in quality education in primary schools, which plays an important role in ensuring the healthy development of students' body and mind. However, the traditional physical education class teaching content is less, which can not only arouse students' interest in learning sports knowledge, but also affect students' actual learning effect. At this time, if effective outward bound training on the basis of innovating the concept and mode of physical education teaching can be actively carried out, then students' physical education knowledge in class can be consolidated and the effectiveness of physical education teaching can be enhanced.

2. The characteristics of outward bound training

Outward bound training is a kind of training method introduced into China from the West, which is used in physical education in China, and is conducive to improving students' sense of unity and cooperation, and also helps to temper students' personal will. Quality development training has higher requirements for students' physical quality and flexible ability of mind, and has been more and more quoted in physical education in China. Outward bound training has the incomparable characteristics of traditional physical education teaching mode.

(1) It can increase the degree of students' participation. Individual projects in outward bound training can greatly increase students' participation, stimulate students' interest and stimulate students' personal potential.

(2) It can enhance students' sense of teamwork. In group training in outward bound training, everyone needs to actively participate. Only by doing their best and taking care of each other can we achieve the final results. Therefore, outward bound training can effectively enhance students' sense of group cooperation, enhance students' trust and bene-

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fit the unity of classes.

(3) It can enhance students' satisfaction. Compared with conventional physical training, outward bound training is challenging. Students can overcome difficulties in the process of participating in outward bound training. Students will succeed after all kinds of difficulties, which can greatly enhance their satisfaction.

(4) It can review and summarize, and sublimate the theme. In sports development training, physical education teachers usually distribute tasks and students complete them independently. After the activity, the teacher will lead the students to review and summarize, and tell everyone the purpose of outward bound training, which can sublimate the theme of the activity and make the students understand some truth.

3. The necessity of expanding training

3.1 To enhance students' physique

Strengthening students' physique is an important goal of quality development training. In the traditional junior high school physical education teaching mode, students' participation in sports events is not high, and students are not interested in sports, whether organized by students or teachers. Because of the low training intensity, it cannot improve students' physique. The use of outward bound training in junior high school physical education has a relatively strong training intensity and a high degree of students' participation, which can effectively exercise students' physique and enhance their physical fitness. Because the outward bound training is competitive and requires the whole class to participate, it greatly improves the students' participation degree and enthusiasm, and can improve the physical quality of the whole class.

3.2 To improve students' thinking level

Outward bound training components can not only strengthen students' physique, but also train students' thinking level. To a certain extent, outward bound training can make students think fully. It can enable students to quickly analyze the conditions that help them, train students to grasp the completion of tasks, enable students to effectively analyze the advantages and disadvantages, exercise students' mental thinking, and improve students' thinking level.

3.3 To strengthen students' sense of group

Outward bound training is mostly group training, which can enhance students' group consciousness. In the process of outward bound training, it is inevitable that there will be students who can't keep up with their physical quality, and accidents will happen from time to time. In the face of this situation, teachers generally choose to leave it to the students themselves, which can enhance the students' feelings of sharing weal and woe and increase the emotional connection between students. In the process of outward bound training, students share weal and woe as a whole, and solve problems together, which can shorten the distance between students, enhance the trust between students, and make students trust each other.

3.4 To meet the requirements of physical education reform

In recent years, with the reform of education, the reform of teaching philosophy is in full swing in various subjects. In the Curriculum Standard of Physical Education and Health issued by the Ministry of Education, the first guiding ideology is health. The emergence of outward bound training meets the requirements of physical education reform, which can improve students' physical quality and provide a good physical foundation for students to learn other subjects.

2.5 Conform to the concept of modern curriculum

With the changes of people's living standards, people's ideological level has been effectively improved, and the requirements for education have gradually changed to quality education, and students have become the main body of education. Outward bound training can effectively improve students' learning and thinking ability, improve students' personal qualities, make students have good moral character, enhance students' sense of unity, help students improve their comprehensive quality, conform to the concept of modern curriculum, and promote students' all-round develop-

ment.

3. The specific application strategy of outward bound training

3.1 To renew teaching philosophy and improve teachers' development quality

Under the background of core literacy teaching reform, the cultivation of students' ability has become an important content of subject education. The application of new teaching mode requires improving teaching skills and renewing teaching concepts. Solid teaching basic skills and sports literacy are the basic guarantee for optimizing and expanding training. In the actual outward bound teaching of junior middle school physical education, teachers should optimize the design according to the students' physical and mental development process and the cultivation content of will spirit. The most important thing is to stimulate students' interest in training based on their physical condition. Facing all kinds of situations in junior middle school during outward bound training, teachers should consider in place and prepare emergency plans to strengthen guidance. Junior middle school physical education teachers should assume their own teaching functions, and constantly optimize the outward bound training according to the scientific theory to improve the teaching level.

For example, updating teaching concept is the premise of expanding training optimization design, and making careful preparation with all teaching resources is conducive to improving classroom efficiency. Junior high school students have distinct group characteristics and are in the golden stage of adolescent physical and mental development. In view of students' interest in physical education and the process of physical development, innovative development training needs to be guided by scientific training methods, and physical education teachers should update and integrate into the student group to guide and organize specific activities in development training. Learning the representative teaching methods of outward bound training is a prerequisite for PE teachers to continuously improve their teaching level, which is conducive to enhancing the scientific and orderly development of outward bound training.

3.2 To innovate teaching forms and guide students to actively participate

Giving full play to students' dominant position is the core guiding ideology of junior middle school physical education outward bound training teaching. Creating positive teaching situations needs to be linked with physical education classroom contents and students' interests, especially the rational use of game teaching situations is conducive to enhancing students' participation enthusiasm in challenging themselves. Games are the most interesting teaching activities for primary and secondary school students. The integration of outward bound training and game teaching mode is beneficial to cultivate students' sports interest and team consciousness. Teachers should design interesting teaching activities according to the physical and mental development characteristics of adolescent students, pay attention to the improvement of students' physique and physical fitness, and ensure safety and efficiency. As an effective teaching activity, game teaching needs teachers to grasp the teaching opportunity and introduce it. Innovative outward-looking training that meets the physical and mental needs of junior middle school students is conducive to enhancing enthusiasm and sports literacy.

For example, teachers can design sports activities that are practical and conducive to giving full play to students' enthusiasm in junior high school sports development training, and attaching importance to the interest principle enhances the value of game teaching. Athletics is an important teaching content of junior high school physical education, including 100 m, 1000 m and 4 *100 m, which are common test and assessment contents. Junior high school students often introduce game teaching because of poor performance due to physical problems, which is conducive to stimulating students' enthusiasm for outward training. For example, teachers can divide the game activity groups to carry out relay race activities. According to students' physique, the groups should pay attention to collocation and ability to formulate fair and objective competition rules, stimulate competition awareness and improve the quality of junior high school development training.

3.3 To optimize the teaching content and stimulate the positive emotion of sports

Different from other disciplines, physical education attaches importance to students' participation in sports activities and the guidance of their psychological state, and stimulating positive academic emotions is conducive to promoting the all-round development of students' morality, intelligence, physique and beauty. Combining with physical education teaching content, grasping the degree and amount of outward bound training is conducive to enhancing the innovation and guiding of the training content. Junior high school students' psychological and physical qualities have personalized characteristics. The characteristics of outward bound activities facing most students make teaching optimization design an important content. In the outward bound training teaching, it is necessary not only to teach sports skills and sports spirit, but also to promote the healthy development of sports mental health and change students' attitude towards sports subjects so as to enhance and establish lifelong sports consciousness. The integration of outward bound training and physical education class is beneficial to sharpen students' will and improve their physical quality, especially to stimulate positive psychological experience, which makes students face study and life objectively and positively.

For example, the optimized design of outward bound training meets the needs of team activities and arouses students' training enthusiasm. For example, in team development activities, teachers can design interesting projects, and tests students' reaction ability and agility when applied to classroom teaching content, which can stimulate students' participation in training. First, teachers can divide students into several development groups to specify the number of people in each round of games. In games, teachers should stop music as the beginning of competition until the last one sits on the stool, which is the winner. It is important to pay attention to students' development training and play team games to enhance students' sense of cooperation and improve the overall teaching quality of development training.

3.4 To carry out extra-curricular development training to improve students' training effect

In order to further improve the effect of outreach training for junior high school students, it is far from enough to rely solely on the objectives and contents of conventional physical education textbooks. It is necessary to scientifically design some extracurricular outreach training practice activities for junior high school students according to their physical and mental development characteristics, so that they can improve their comprehensive physical education quality in practice activities. Considering that the current junior high school students are Z generation, and most of them are only children, they are loved by their parents at ordinary times, and have developed a strong dependence psychology, and their psychological quality and self-care ability are weak, so they cannot cope with the increasingly complex social environment. Therefore, in the actual development training, it is necessary to train students' ability to solve problems.

For example, in the usual holidays, teachers can organize students to carry out some extracurricular activities such as winter camp or summer camp, and organize them to actively carry out outdoor training and practice activities such as "looking for treasure", and set up some treasure hiding points for students in advance in outdoor venues, and set some treasure hunting routes and tips for students, so that students can find treasure hiding places faster than others or groups. With the help of this kind of extracurricular outward bound training activities, it can not only increase students' interest in outward bound training, but also help students improve their overall physical quality in practical training.

4. Conclusion

In a word, junior middle school physical education should be paid attention to as an important content of students' physical education theory and intensive training. Teachers should combine physical education knowledge and skills teaching to carry out outward bound training, and put forward targeted outward bound training teaching methods according to students' actual situation, which is beneficial for students to actively participate in training activities to enhance their physical literacy.

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Original Research Article

Data Analyses of European Soccer

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Abstract: Using European soccer data sets, which contain data related to common European soccer leagues, players basic information, and teams' goals, etc., this paper analyzes the characteristics of European soccer and players, explores data visualization regarding European soccer, and makes predictions of results of matches. Based on Python 3 and some of the packages inside, such as numpy, the author improves the data set to make it clear and user-friendly. Visualizations of data and basic statistics, including Poisson Distribution, are then utilized to determine the results. Finally, this paper analyzes the attacking and defending abilities of different leagues and teams in Europe, ascertains distributions of players' attributes, and predicts match results by using Poisson distribution and Skellam Distribution. Generally, this paper analyzes data from leagues to matches to players. All these analyses are meaningful for the public to understand the characteristics of European soccer and the world behind the numbers.

Keywords: Soccer; Data Analytics; Python; Statistics

1. Introduction

Scholars and experts have tried hard to explore data in the sports arena. Python 3 has been gaining a tremendous amount of popularity over the past few years, and is the language of choice for many data scientists across the world. It is no accident that the language is also gaining popularity amongst sports scientists, who have to work with a lot of data on a day-to-day basis.

Data visualization is a significant part of analyzing data. Data visualization is a graphical representation of information and data. By using visual elements like charts, graphs, and maps, data visualization tools provide an accessible way to see and understand trends, outliers, and patterns in data[1]. With the help of data visualization, we have the chance to analyze several characteristics of European soccer, such as a comparison of players and their abilities, a comparison of the different leagues, and the relative age effect.

The relative age effect in soccer is manifested by early educators and trainers, who group their players by chronological age to ensure equal opportunities for success. As we know, age-related cut-off dates are put into place to determine the age-range of our children's sports leagues as well as their classrooms. The idea here is to cordon-off groups of adolescents based on similar levels of physical and mental development. A result of these cut-off periods is a phenomenon known as "the relative age effect"[2]. Previous findings of skewed birth date distributions among sports professionals have been interpreted as evidence for systematic discrimination against children born shortly before the cut-off date for each age grouping[3]. By using Python 3, the author could explore the age distribution of European soccer players and find the potential rules for this distribution.

Predicting match results is also a hot topic around the world. One way of doing predicting matches is by using Pio-

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sson Distribution, which is a discrete probability distribution that expresses the probability of a given number of events occurring in a fixed interval of time or space if these events occur with a known constant mean rate and independently of the time since the last event[4]. Based on European soccer data of the past 30 years from the database, the author calculates the possibility of a specific number of goals and thus predicts the match results by comparing goal differentials (to be precise, we use Skellam Distribution, which is the distribution of the differences between two Poisson Distribution plots).

2. Methods

2.1 Data visualization

The author connects the database 'soccer_database.sqlite', and extracts some of the data that are essential to the data analyses in the next steps, such as players, leagues, countries, etc. The following step is to process the data to make sure that it is clear, and that it can be perfectly fitted in models the author creates. Then, the author needs to get the different numbers of players corresponding to the characteristics that the author is going to analyze. At this time, groupby and count() method is needed to determine the times that the corresponding data appears. Finally, based on matplotlib.pyplot package, the author illustrates plots of distributions.

2.2 Match results prediction of home teams and away teams

The essential technique that the author needs to predict the match result based on data of past matches is Poisson Distribution and Skellam Distribution. The probability function of Poisson distribution is:

$$P(X = k) = \frac{\lambda^k}{k!} e^{-\lambda}, k = 0,1, \ldots$$

The Poisson distribution is suitable for describing the number of random events occurring per unit time. The expectation and variance of the Poisson distribution are λ, in which the parameter refers to the average number of random events per unit time (or unit area). The eigenfunction is

$$\psi(t) = exp\{\lambda(e^{it} - 1)\}$$[5]

The first step is quite similar to that of data visualization: extracting data that is essential to the next-step analyses. Then the data needs to be clear and well-formed, which ensures that the data can be fitted in the model the author is going to use. To predict the results by Poisson Distribution, first the author imports package poisson from scipy.stats. Getting the average number of goals is quite significant if we want to predict match results through Poisson Distribution. So the author needs the average number, lambda. The final step is to use the packages imported previously, as well as matplotlib.pyplot package, to get the plot of the Poisson distribution of the goal differences. If we want to gain the prediction result, we can find the probability that the goal difference is larger than 0, equal to 0, or less than 0, which signifies whether the home teams win, the two teams drew, or the home teams lose.

3. Experiments

3.1 Data visualization

3.1.1 Top ten defensive and offensive leagues/teams

The author imports several packages, including numpy, matplotlib.pyplot, pandas, seaborn, and sqlite. To elicit the specific data, the author extracts league, country, team and match data by using the sqlite method. Since these data sets are given in separate columns, they need merging for a complete form. So merge method is used at this time. The merged form is called "match". Inside "match", the author finds the total goals (home team goals plus away team goals), which is an important indicator of the defensive abilities of a league. For example, if the number of total goals of a league is very large compared to that of other leagues, this league has relatively poor defensive ability (or good offensive ability). So, the author picks up columns "home_team_goals" and "away_team_goals", and gets the column "total_goal". The following step is to g*et al*l league names from the form "match", and use the names as ordinates. Thus, the author uses a for-loop to loop over the league names. By now, the author has already obtained all essential data: goal

differences and league names. Then, by using matplotlib.pyplot and seaborn, the author obtains the bar-plot. Finally, the author provides a visualization of the data, which makes it clear to see which league has the best defending ability.

The process of getting the plot of the best ten defensive and offensive teams is roughly the same as that of getting the plot of the best ten defensive leagues. But there are some subtle differences. In order to obtain the best ten defensive and offensive home/away teams, the data about goals per game is quite important. First, the author gets the average home team stats and away team stats, such as the home team goals, away team goals, total goals and goal difference by using the method sort_values, which sorts the data the author needs. Then the author calculates goals per game, including goals scored and goals conceded per game. By using matplotlib.pyplot package, the author can gain the bar-plot of the top ten defensive/offensive teams.

3.1.2 Relative age effect

	birthday	id	player_api_id	player_name	player_fifa_api_id	height	weight
3596	1989-03-02 00:00:00	10	10	10	10	10	10
3919	1990-03-27 00:00:00	8	8	8	8	8	8
3855	1990-01-13 00:00:00	8	8	8	8	8	8
3441	1988-08-31 00:00:00	8	8	8	8	8	8
3679	1989-06-09 00:00:00	7	7	7	7	7	7
3010	1987-04-16 00:00:00	7	7	7	7	7	7
3372	1988-06-12 00:00:00	7	7	7	7	7	7
3809	1989-11-14 00:00:00	7	7	7	7	7	7
4347	1991-08-19 00:00:00	7	7	7	7	7	7
2953	1987-02-14 00:00:00	7	7	7	7	7	7

Figure 1

The process is quite similar to that mentioned previously. First, the author extracts the columns that contain information on players' birthdays, and makes them clear and well-fitted in drawing plots. Later, the author gets the months of players' birthdays, and uses group_by method to make sure that the data is grouped by months, and count() method to obtain the corresponding occurrence times of each month. Then a for-loop is used to get the names of all the months. Finally, by using matplotlib.pyplot package, the author draws a subplot of the distribution of the months of the players' birthdays.

3.1.3 Players' abilities comparison

To get clear comparisons, the author needs to use bar plots. First, as previously described, the author uses a for-loop to get all the relevant characteristics of the players. Then the author writes a function, for which there are two parameters—player 1 and player 2. The data that corresponds to the characters are grouped by players' names. Then the author obtains the average values of players' abilities. Finally, by using matplotlib.pyplot package, the author elicits a comparison bar plot of the two players' various abilities.

3.2 Match result prediction of home teams and away teams

First, the author extracts all the goals scored by using a previously described method to select specific columns: home team goals and away team goals. Since the database 'soccer_database.sqlite' is huge, containing data from all aspects of European soccer of the past few decades, it meets the conditions of Poisson Distribution, particularly that the total occurrences in relevant matches is extremely large. Next, by using method mean(), the author calculates the average goals of home teams and away teams, and saves them separately into "lambda_home" and "lambda_away". Additionally, "total_lambda", which represents the total average goals of all teams, is calculated.

Finally, by using matplotlib.pyplot and poisson, the author derives different plots. The author obtains the Poisson Distribution of home team goals, away team goals, and total goals. Most significantly, the author obtains the Skellam Distribution of the goal difference of home teams and away teams, which is used to predict the probability of winning, drawing, or losing.

4. Conclusion

4.1 Data visualization

The author deduced several conclusions pertaining to leagues and teams. **Figures 2** & **3** illustrate that home teams and away teams score the most goals in the Dutch Eredivisie than any other teams in the other ten leagues during the 2008/09 season to the 2015/16 season. Home teams in France's Ligue 1 and Poland's Ekstraklasa score the least goals compared to any other league during the 2008/09 season to the 2015/16 season. Also, the number of goals that home teams score is larger than that of goals that away teams score in all eleven leagues in Europe. Thus, we can connect these results to home advantages and away advantages. Home advantage is the psychological and physiological advantage that the home team has over the visiting team and it is prevalent in all sports, including soccer[6].We can properly speculate that home teams and away teams in Netherlands Eredivisie has more home or away advantage (Bundesliga also had an away advantage). Home teams and away teams in Poland Ekstraklasa and France Ligue 1 have the worst home or away advantage. Plus, these two figures demonstrate that the home team has a clear advantage during any given match.

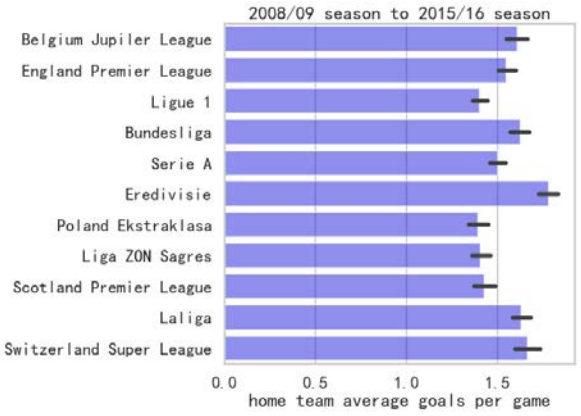

Figure 2

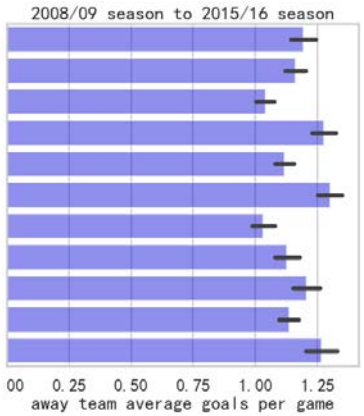

Figure 3

The distribution of total goals in the 11 leagues in Europe indicates that teams in the Netherlands Eredivisie have more goals than any other league. On the contrary, France Ligue 1 and Poland Ekstraklasa have the least total of goals than all other leagues in Europe. Therefore, we can draw the conclusion that teams have the best attacking ability in the Dutch Eredivisie, and teams have the worst attacking ability in France's Ligue 1 and Poland's Ekstraklasa. Admittedly, the conclusion may have some flaws and it may be due to defensive abilities rather than offensive abilities. But the method and the trends are accurate with significant approximation.

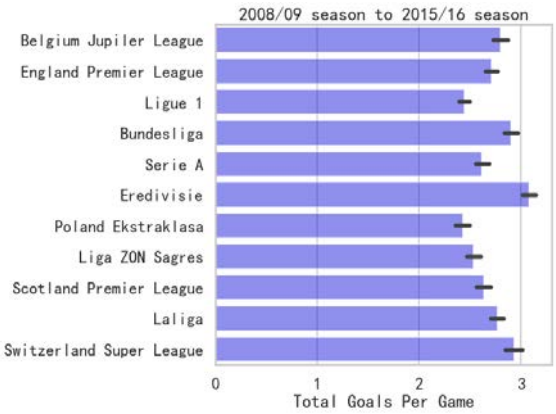

Figure 4

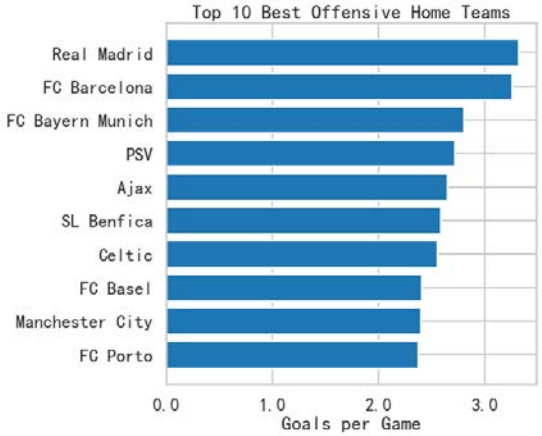

Figure 5

The author can also draw conclusions on the top 10 home/away teams which have the best attacking or defensive abilities. According to **Figures 5**, **6**, **7**, and **8**, Real Madrid is the home team that has the best offensive ability, whereas FC Barcelona is the away team that has the best offensive ability[6]. Meanwhile Glasgow Rangers is the away team that has the best defensive ability; and FC Porto is the home team that has best defensive ability.

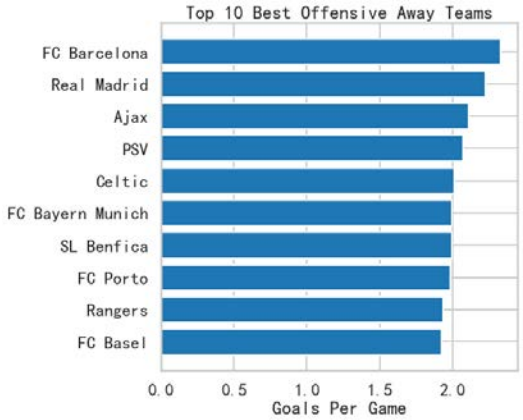

Figure 6

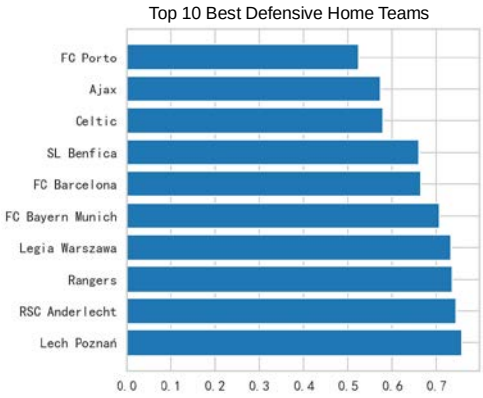

Figure 7

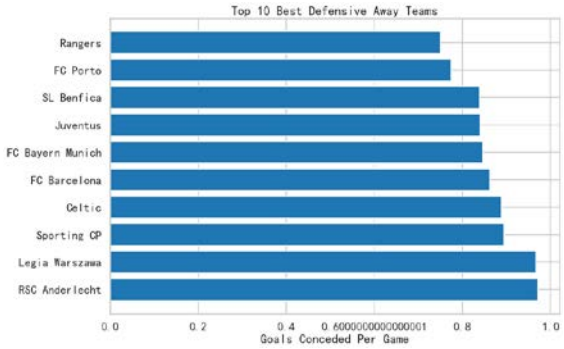

Figure 8

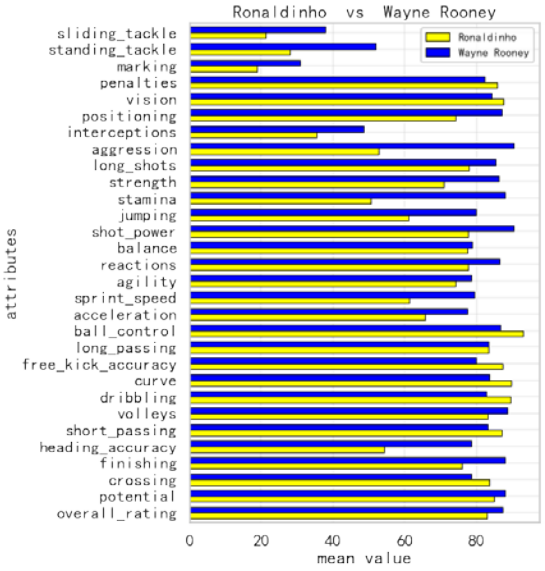

Figure 9

The author then focused on the abilities of individual players and how they compare with others. From the figure below, we can see the radar charts of different players, which show their abilities, their versatility, and the pattern of different characteristics. For example, from radar charts of eight famous play-makers, they all tend to have weaknesses in slide-tackling and intercepting ability. For most of the player-makers, they have weaknesses in heading accuracy and jumping ability (except Cristiano Ronaldo). And these eight players generally have competitive advantages in agility and shooting. Also, we find that Lionel Messi and Cristiano Ronaldo have the most extraordinary attacking abilities, such as ball control and agility; Wayne Rooney is relatively versatile in all aspects as well. Thus, we can properly determine that player-makers are generally weak in defending, such as successful tackles and interceptions, but they excel

at ball control, speed, and reaction. If coaches want to train player-makers to make them more complete players, then they would do best to improve their defensive abilities.

If we want to compare two players closely, we can refer to the bar plot. For example, **Figure 10** compare the ability values of Ronaldinho and Wayne Rooney, two of the best players in the world.

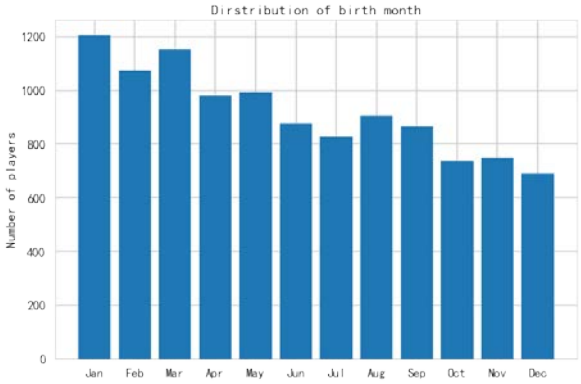

Figure 10

Generally, Ronaldinho is better at ball control, curve, dribbling, and other aspects of the game needing finetuned and intricate techniques. Wayne Rooney is better at aspects related to power and shooting such as slide tackling, standing tackling, aggression, jumping, and so on[7]. Thus, by comparing two different players through a bar plot, we can clearly see strengths and weaknesses, and how the values of pertaining to different abilities vary.

The relative age effect is also covered in the author's research. According to **Figure 12**, there are more players born in the beginning months of the calendar year than the middle or last months. This can be attributed to a requirement for players to join a club: they must be under 18 by January 1 of that year.

Thus, players born in the beginning months of the year, who meet the requirements and are the closest to 18, would be more likely to join in the club since they are physically more advantaged than other players who compete with them. Thus, the conclusion drawn from the plot of the distribution of players' birth months accurately confirms the relative age effect.

4.2 Match result prediction of home teams and away teams

Figure 11

Figure 12

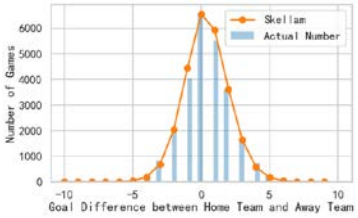

Figure 13

The author uses Poisson Distributions to obtain the distributions of number of goals that home teams or away teams could make. According to **Figures 11** & **12** above, the distributions of both home teams and away teams are roughly the same in that they are both skewed to the right, and their summits are both at one goal. However, these two figures also indicate that home teams can score more goals than away teams, which confirms the conclusion the author deduced previously: home teams have an advantage in scoring goals over away teams.

Looking at the distributions of goals scored by home teams and away teams can predict the match result by referring to the probability of various goal differences[8]. **Figure 15** demonstrates that the Skellam distribution of home teams and away teams' goal differences is more or less normal. Thus, the most probable match result is that both teams would tie. However, a closer look shows that the area of number of goals larger than 0 is larger than that of goals smaller than 0. This indicated that home teams have a greater probability of winning the game even though the probability is only a little greater than that of losing the match. Thus, these results further consolidate the theory that home teams, indeed, have a greater chance of winning the game compared to away teams.

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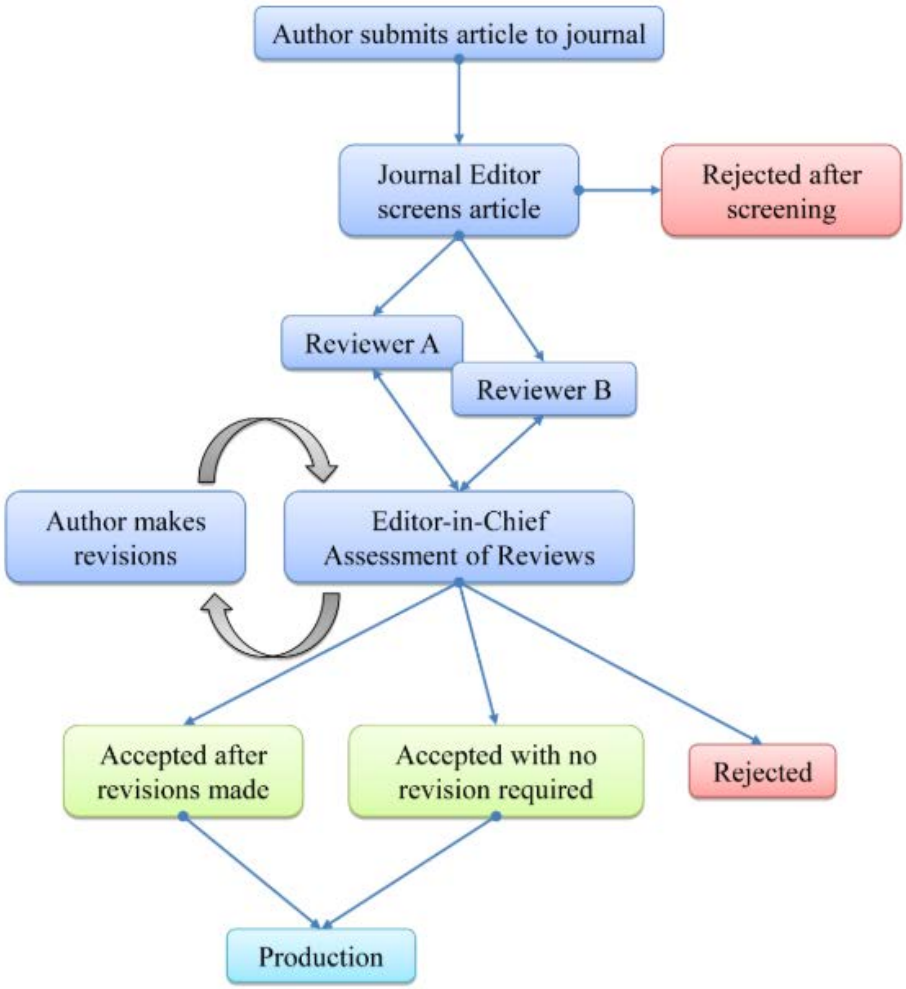

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