



Research Article

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Tennis player physical health indicator evaluation system research based on AHP analysis

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ABSTRACT

With sports development, players call for higher competition performance, training strength also becomes larger, sports injury increases accordingly. To tennis players, sports injury is even quite universal. This paper establishes tennis player health evaluation system, with an aim to let tennis player understand its own conditions and make reasonable adjustment in training plan combining with such conditions. At first through questionnaire investigation of 100 tennis players, it gets that main sports injury body parts are waist, knee joint, ankle joint, thorax and abdomen, wrist, shoulder joint, thigh and shank. Then combine with medicine relative knowledge to make analysis of such 7 factors influence on human health, construct judgment matrix, apply analytic hierarchy process method to get each factor relative influence weight on human health, establish sports health evaluation system. And find out the most important body part to tennis player is waist and ankle joint, then analyze the two parts and make suggestions.

Key words: Sports injury, analytic hierarchy process, judgment matrix, sports medicine

INTRODUCTION

Tennis as one of Olympic Games events attracts more and more people's attention, and also more and more people regard it as their own fitness way. Tennis is a graceful but an intense sport, tennis sports injury is very universal. This paper makes research analysis of tennis sports injury combining with analytic hierarchy process method from perspective of sports medicine.

For tennis sports injury, many scholars has made lots of research and put forward their thoughts and suggestions, from which our country's tennis can rapidly develop. Among them, Gao Jing makes research on relations between Gansu province tennis players' forehand techniques and sports injury; points out that tennis player's sports injury are mainly concentrated on shoulder, elbow, wrist, knee, ankle and waist back etc. Most of sports injury is caused by errors in sports techniques, it needs to strengthen standardize technical motions in training [1]. Tao Quan Makes research on mass tennis injury causes and defense, points out that amateur tennis players injury causes are mainly blisters grinding out, sprain, cramp and muscle strain. Take sufficient warm-up. Amateur tennis players should reasonable control sports amount and choose rational sports apparatus in tennis training [2]. Han Qi Analyzes our country's modern tennis injury situation, pointed out from psychological perspective that psychological factors cause sport injury are arousal level, anxiety and attention as well as confidence. When players take training and attend competition with depression or rage, their attention and information acquiring ability would be greatly restrained lead to sports injury occurrence [3, 4].

This paper based on previous studies, analyzes each body part sports injury influences on players' health from medical perspective, utilizes analytic hierarchy process to establish tennis player health evaluation system, and points out the most important parts to tennis players are waist and ankle joint, researches on the two parts disease

mechanism and their effects from medical perspective, and make suggestion on their technical motions, with an aim to standardize technical motions and make contributions to tennis technical progress.

TENNIS PLAYER HEALTH INDICATOR EVALUATION SYSTEM ESTABLISHMENT

Tennis belongs to high risk movements; it is very common that players get injured. Many tennis players have injuries in all body parts, the slight would affect on their performance, while the serious would let them quit the competition because of injury or even end career in advance. It is huge loss to both country inputs and individual efforts. For tennis player sports health conditions, this paper from sports medicine perspective analyzes each part injury situations, adopts analytic hierarchy process to establish tennis players' sports health evaluation system.

Fundamentals of Analytic hierarchy process

To tennis players, one player tends to have injured in many areas of body, waist, knee joint, ankle joint, thorax and abdomen, wrist, shoulder joint, thigh and shank are vulnerable and also greatly health influences body parts to tennis players. How to quantitative define each factor influence degree on human health is the main usage of analytic hierarchy process in this paper. This paper applies analytic hierarchy process, defines each factor weight, establishes evaluate tennis players health evaluation system. Analytic hierarchy process is divided into 3 steps [5, 6].

- Construct hierarchical structure model
- Establish all judgment matrix in every layering
- Hierarchical single arrangement and consistency test

Construct hierarchical structure model

When applies analytic hierarchy process to analyze decisive problems, firstly it should organize and layer the problems, construct a hierarchical structure model. In this model, complicated problems are dissolved into element compositions. These elements form into some hierarchies according to their nature and relations. Regard last hierarchical element as criteria that plays a dominate role in next hierarchical relative elements.

- These hierarchies can be divided into 3 types.
- The top hierarchy: Only one element in this hierarchy, it normally is intended target or ideal result of analytic problems, therefore is also called target hierarchy.
- Middle hierarchy: In this hierarchy, it including intermediate links that get involved to fulfill targets, which can be composed of some hierarchies that including criteria, sub-criteria that required to consider, therefore it also called criteria hierarchy.

The bottom hierarchy: This hierarchy includes optional each measure, decision scheme and so on to fulfill targets, therefore it also called measure hierarchy or scheme hierarchy. Hierarchy numbers in hierarchical structure has something to do with problem's complicated degree as well as required analysis elaborate degree, normally it not limited. Each element in every hierarchy governs less than 9 elements. Because too many elements governing would bring difficulty to paired judgment. According to above principal, combine with this paper tennis injury situations, it can construct hierarchical structure figure as Figure 1 shows.

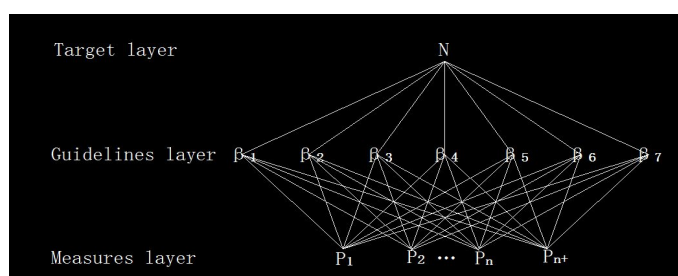


Figure 1: Hierarchical structure figure

Target hierarchy in Figure 1 is tennis players' health index. Criteria hierarchy, measure hierarchy, each variable are as below Table 1 shows.

Table 1: Figure 1 signs definitions table

Sign	Definition	Sign	Definition
β_1	waist	β_5	wrist
β_2	Knee joint	β_6	Shoulder joint
β_3	Ankle joint	β_7	Thigh and shank
β_4	Thorax and abdomen	$p_1 \cdots p_n$	player

Establish judgment matrix

Hierarchical structure reflects relations among elements, but a criterion hierarchy's every criteria weight in target measuring is not always the same that covers a certain proportion in the eyes of decision maker. Now, it needs to

compare 7 factors $\{\beta_1, \beta_2, \dots, \beta_7\}$ influence on element N, How to compare for providing reliable data? This paper quotes Saaty method, carries out comparison between two factors and establish paired comparison matrix.

Which takes two factors β_i and β_j every time, β_{ij} shows the influence ratio that β_i and β_j cover N, all comparison results use matrix $A = (\beta_{ij})_{n \times n}$ to express. Call A as judgment matrix (short of judgment matrix). It is easily found that if influence ratio that β_i and β_j to N is β_{ij} , then the influence ratio that β_j and β_i to N should be $\beta_{ji} = \frac{1}{\beta_{ij}}$.

With regard to β_{ij} value defining, this paper takes number 1 to 9 and their reciprocal as scale by quoting Sati's. As Table 2 shows.

Table 2: 1-9 Ratio scale table

Scale	Definition
1	Indicates two factors have equal importance by comparing
3	Indicates the former is slightly more important than the later by comparing two factors
5	Indicates the former is obviously more important than the later by comparing two factors
7	Indicates the former is intensely more important than the later by comparing two factors
9	Indicates the former is extremely more important than the later by comparing two factors
2,4,6,8	Indicates middle value of above adjacent judgment
Reciprocal	If importance ratio between element β_i and β_j is β_{ij} ; then importance ratio between β_j and β_i would be $\beta_{ji} = 1/\beta_{ij}$

According to Table 2, combine with medical relative knowledge to sort each element influences conditions on body health, define important degree. It can establish judgment matrix as Table 3 shows.

Table 3: Judgment matrix

	β_1	β_2	β_3	β_4	β_5	β_6	β_7
β_1	1	1/5	1/3	1/2	1/7	1/6	1/9
β_2	5	1	4	5	1/3	2	1/6
β_3	3	1/4	1	3	1/6	1/2	1/8
β_4	2	1/5	1/3	1	1/6	1/2	1/8
β_5	7	3	6	6	1	5	1/3
β_6	6	1/2	2	2	1/5	1	1/7
β_7	9	6	8	8	3	7	1

Hierarchical single arrangement and consistency test

Judgment matrix A (Table 3) corresponds maximum feature value λ_{\max} feature vector W , it is the priority weight of same hierarchy corresponding elements relative importance to last hierarchy some element after normalization, the process is called hierarchical single arrangement. Above paired comparison judgment matrix construction method though can reduce other factors inference, relatively make objective reflection of a couple of factors

influence difference, when integrate all comparison results, it is hard to avoid containing inconsistency to some extent. n Step positive reciprocal matrix A is consistent matrix, only when its maximum feature root $\lambda_{\max} = n$, and positive reciprocal matrix is not consistent, it would have conditions as $\lambda_{\max} > n$. Therefore we can test whether judgment matrix A is consistent matrix through defining whether λ_{\max} is equal to n . Due to feature root continuously relies on β_{ij} , so λ_{\max} is far bigger than n , A inconsistency degree would be more serious, λ_{\max} corresponding standardized feature vector would not really reflect $\beta = \{\beta_1, \beta_2, \dots, \beta_7\}$ ratios in element N influences. So, it is necessary to make one time consistency test on judgment matrix that provided by decision maker so as to decide whether it is acceptable or not.

Steps for judgment matrix consistency test are as following.

- 1) Calculate consistency indicator CI .
- 2)

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (1)$$

2) Look up corresponding average random consistency indicator RI . RI value is got in this way that construct 500 sample matrix by random method, random select numbers from 1 to 9 as well as its reciprocals to construct positive reciprocal matrix, and determine average value of maximum feature root λ'_{\max} , and define.

$$RI = \frac{\lambda'_{\max} - n}{n - 1} \quad (2)$$

For $n = 1 \dots 9$, this paper quotes RI value from Saaty, as Table 4 shows.

Table 4: 1-9 Step matrix average random consistency indicator

n	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

3) Calculate consistency proportion CR .

$$CR = \frac{CI}{RI} \quad (3)$$

When $CR < 0.10$, it is thought that judgment matrix consistency is acceptable, otherwise it should make proper correction to judgment matrix.

Through consistency indicator test on Table 3 judgment matrix by Matlab and combine with above principle, determine $CR = 0.05 < 0.10$, therefore can accept the matrix.

Therefore according to above principal and Matlab programming calculation of matrix A , it can define each factor weight as following Table 5.

Table 5: Each factor weight table

Factor	β_1	β_2	β_3	β_4	β_5	β_6	β_7
Weight	0.2724	0.0624	0.1854	0.2415	0.0457	0.1693	0.0233

According to relative medical knowledge, it can define that serious injury of each part is divided into 3 grades ϕ , no injury ϕ takes 0, slight injury ϕ takes 0.5, serious injury ϕ takes 1, and then tennis player health indicator computation formula is

$$N = \sum_{i=1}^n \beta_i \times \phi \quad (4)$$

Therefore, it can get player sports health indicator N , according to his injury conditions, N takes maximum value as 1, minimum value as 0, the smaller the N value indicates the higher player sports health degree would be.

IMPORTANT PARTS PROTECTION AND CONTROL SUGGESTIONS

Combine with above each factor influence degree on health, through questionnaire it can know each part injury distribution figure as Figure 2 shows.

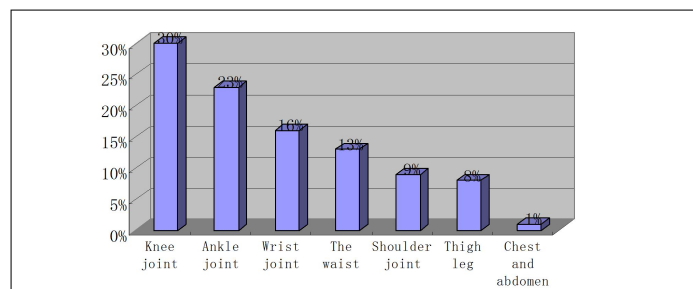


Figure 2: Sports injury parts distribution figure

From Figure 2, it can know that each part has different injury rate. To tennis player, it should strengthen protection of knee, because knee is prone to get injured, while though thorax and abdomen have great influences on human health (Table 5), their injury rate is quite low for tennis players and not prone to get injured, therefore can ignore strengthen protection of thorax and abdomen. So to tennis players, quantitative relations of each part protection should use weight in Table 5 multiply corresponding injury rate. Therefore, it can get Table 6.

Table 6: Each part protection quantitative corresponding relations table

Ankle joint	Waist	Knee joint	Shoulder joint	Wrist	Thorax and abdomen	Thigh and shank
4.2642	3.5412	1.872	1.5237	0.7312	0.2415	0.1864

From Table 6, it can know that to tennis players, body parts that should be strengthening protected are ankle joint and waist. This paper analyzes the two body parts injury mechanism and control is as following.

Control of ankle joint injury

According to human structure anatomy, it is known that ankle joint is composed of lower end of tibiofibula and talus of foot. To tennis, foot movements are fulfilled by subtler joint and ankle joint common movements. Due to ankle joint area is quite small, it is the smallest part of human movement cross section to whole human body. In tennis, players should make rapidly reaction, rush in or out, brings huge impact on ankle joint and so it bears huge force which is prone to get injured. Statistics of player ankle joint injury causes is as Table 7.

Table 7: Ankle joint injury causes statistics.

Causes	Numbers of people	%
Court not flat	12	6
lack of leg muscle strength	56	31
ankle joint partial under excessive heavy load	73	41
insufficient warm-up	39	22

From Table 7, it is known that ankle joint partial under excessive heavy load covers 41% of total ankle joint injury people, which is caused by stress concentration. Lack of leg muscle strength covers 31% of total ankle joint injury people, ankle joint muscle cannot supply enough strength to support that would strengthen ankle joint force burden, which leads to stress concentration and then gets injured. Court not flat is easier for ankle sprains, and insufficient warm-up would cause unreasonable ankle joint force and so gets injured.

Combine with above research analysis, this paper makes 2 suggestions from medical perspective to ankle joint protection as following.

Design reasonable and scientific training plan: In training process, it should make sufficient warm-up in advance,

design reasonable training plan, pay attention to training intensity, enable ankle joint to get enough rest, and avoid by all means blind pursuit of performance and so strengthen training intensity without considering consequences.

Strengthen leg muscle strength training: Increase muscle strength that let ankle joint muscle share ankle joint pressures so as to reduce ankle joint pressure burden.

Control of waist

In tennis, twist and bend is main sports form of spine; In forehand backswing stage, trunk twists and bend degree are gradually increasing, while they arrives at the maximum in backswing ending moment and form into body twist and lateral bow. Excessive twist and bend are prone to cause spine injury (Trunk twist angle is represented by shoulder hip twist angle). Through investigation and comparing of tennis players' shoulder hip twist angle range key technical parameters between waist injured player and no waist injured player can get Table 8.

Table 8: Tennis player shoulder hip twist angle technical parameters table

Types	Shoulder angle after backswing ending		Hip angle after backswing ending		Man/woman sit-up	
	Injured player	Uninjured player	Injured player	Uninjured player	Injured player	Uninjured player
Average value	83.34	84.18	28.09	61.01	29/30	35/37
Standard deviation	8.96	5.73	7.93	11.06	3.36/4.75	4.07/2.84
Maximum value	88.75	86.94	33.65	66.72	35/37	42/47
Minimum value	78.05	75.43	17.38	50.93	23/26	27/29

From Table 8, it is known that average difference between injured player and uninjured player after backswing ending is very small, but hip angle has big differences, uninjured player's hip angle is twice or more over injured players. Shoulder hip twist angle is shoulder angle minus hip angle. Therefore, injured players' shoulder hip twist angle is far bigger than that of uninjured players. Too small hip rotation angle leads to too big shoulder hip twist angle is one of waist injury causes. On the other hand, it can be known from Table 8 that waist injured players' waist and abdomen strength is obvious lower than that of uninjured players. When muscle bearing capacity is poor, joint protection capacity would be poor. In case muscle strength is not enough, players tend to increase elastic potential energy through increasing body shoulder hip twist angle so as to make up hitting strength. Therefore, poor waist muscle strength also is one of main causes to waist injury.

Accordingly this paper makes two suggestions on waist injury control. Improve waist technical motions when hitting, increase hip angle twist degrees. Through increase hip angle twist degrees to reduce shoulder hip twist angle. Avoid by all means increasing spin twist extent so as to increase hitting strength. Strengthen increase waist abdomen strength. The stronger waist abdomen strength is, the smaller shoulder hip twist angle would be required in the same hitting strength condition. Meanwhile, the stronger waist abdomen strength is, load bearing capacity would increase accordingly, the stronger joint protection capacity would get.

CONCLUSION

This paper established tennis player health indicator evaluation system with tennis player's health situations. Through the evaluation system, it can combine every tennis player injury conditions to define his own sports health degree; For each part injury influence extent on tennis human body, this paper utilized analytic hierarchy process quantitative find out each injury part influence extent on human health, and pointed out that ankle joint and waist are critical to tennis player and prone to get injured, it should strengthen protection to the two body parts.

For ankle joint, this paper analyzed its disease mechanism, and made suggestions that players were required to design reasonable and scientific training plan, strengthen leg muscle strength training; for waist protection, it suggested that waist technical motions should be improved and hip angle twist degrees should be increased when hitting. And strengthen improvement of waist abdomen muscle strength so as to increase waist abdomen load bearing capacity.

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