Basketball players ankle injury Pearson correlation test based on biomechanics

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ABSTRACT

Basketball is well received by the broad masses of the people due to its high speed, high combat as well as high techniques and high difficulties features. However, just because of such sports features, sports injury especially ankle joint injury is easily generated in sports process. To better and safely bring basketball into our life, this paper made principal component analysis and Pearson correlation analysis to ankle joint injury causes in basketball process, found out the top caused for ankle joint injury is technical motion mistake. According to biomechanical and dynamic analysis, achieve ankle joint injury prevention method in scientific and rational way, so that fundamentally reduce the probability of basketball ankle joint injury and also improve basketball athlete’s antagonism ability.

Key words: Biomechanics, basketball sports injury, principal component analysis, person correlation analysis

INTRODUCTION

Sunshine, air and water are indispensable substance for human surviving, while sports also is indispensable to life and health, sports to life and health is the same as water is the life source to fish. Basketball came into modern people life with its own charm, favored by the masses of people, become a symbol of social health progress. Basketball is a kind of comprehensive game that collective crowd confront in space, that has characteristics of intensive competitiveness and confrontational. By far, world series and American NBA are well known, their series of competition also let people enjoy the feast of eyes [1]. However, followed by development of world sports competition, it’s also common that basketball players get injury. Basketball players got injury not only let themselves suffers the pain as well as not able to attend physical training, but also let the whole basketball team to take the loss. How to avoid injury in training and competition is a inevitable important issue to basketball future development. Therefore, this paper takes basketball as an example, makes research and analysis to basketball injury causes and provides scientific prevention methods [2].

At present, some experts at home and abroad have made intensive studies on basketball injury mainly from two modules that are respectively the whole angle caused basketball injury and the concrete part of basketball injury (ankle joint, knee joint, wrist joint etc.). Chen Shangyue [3] made research on basketball player’s injury type and its causes, sports injury are mainly kneecap strain, meniscus strain, lumbar muscles strain and ankle joint strain so on, while reasons that caused these sports injury are generally excessive sports, high density, improper training arrangements, unscientific technical motions, players their own carelessness and ignorance as well as aggressiveness and so on [4]. There are various reasons that caused basketball players injury. So long as the most relevant factors are found, on which the correlation research be made together with scientific and rational prevention research plan be achieved, that not only can timely and scientifically cure basket players sports injury but also can fundamentally terminate basketball players sports injury [5].

According to experts’ at home and abroad biomechanical anatomy of basketball centers most vulnerable injured
parts, it can be seen that ankle joint is the most vulnerable part of basketball players. Ankle joint has serious influence on basketball players’ short term sports level playing and even players’ life. Basketball sports injury research is by far the urgent big problem so as to better improve our countries basketball level while also protect players’ body and make basketball really a best loved and most popular and safest sport [6].

Through studying and researching lots of relative information, this paper takes motions that caused ankle joint injury in basketball playing process as a physical process to study and analysis its acting force and force. And describe its whole force process according to dynamics principal, and then achieve scientific and rational motions to prevent ankle joint injury and improve basketball players’ antagonism ability to some extent.

ANALYSIS OF BASKETBALL PLAYERS’ COMMON INJURY
To analysis of basketball players common injury sites, this paper made comprehensive research through questionnaire surveying and interviewing. Totally 100 pieces of questionnaires were released to society and campus, withdrawn 95 pieces, the rate of withdrawing was 95%, among which 90 pieces questionnaires were valid.

Table 1: Common Injury investigation in Basketball

<table>
<thead>
<tr>
<th>Injured part</th>
<th>waist</th>
<th>knees</th>
<th>ankle</th>
<th>Shoulder</th>
<th>elbow</th>
<th>hand</th>
<th>leg</th>
<th>others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>quantity</td>
<td>5</td>
<td>10</td>
<td>28</td>
<td>1</td>
<td>3</td>
<td>20</td>
<td>7</td>
<td>16</td>
<td>90</td>
</tr>
<tr>
<td>proportion</td>
<td>6%</td>
<td>11%</td>
<td>31%</td>
<td>1%</td>
<td>3%</td>
<td>22%</td>
<td>8%</td>
<td>18%</td>
<td>100%</td>
</tr>
</tbody>
</table>

From Table 1, it can be seen that there are many and complicated basketball sports injury parts .Most of them is ankle injury that covers 31%.While others also cover a certain proportion, waist injury covers 6%, knees injury covers 11%, shoulder and elbow cover the little proportion are respectively 1% and 3%, palm and fingers injury are also more serious that cover 22%, leg injury covers 8%, others cover as high as 18%.It can be concluded that players in basketball should take special care of their ankle joint, palm and finger joint, knees joint and other body parts. There are different extends of injury in basketball, it including the occurrence of acute injury, chronic injury and coexisted old injury. No matter which body part injured, there will be great influence on its own learning, living and even health. Based on basketball its own features of high level technical, high antagonism ability, it has comprehensive and high requests for physical quality, to improve physical functions and technical level so that it has high incidence of injury and illness. Therefore, players should strengthen prevention and pay attention to make scientific technical motions and avoid causing unnecessary injury to themselves as well as others, especially for each joint part of body. Once these part injured that would lead to incurable effects, such serious pains would even let players suffer for life.

We learnt from research that ankle joint injury is very common and serious out of basketball injuries; therefore this paper would make injury mechanism and force research on ankle joint so that find out the best solution to protect ankle joint and prevent the concurrence of ankle joint sport injury.

Ankle joint injury mechanism analysis:
Ankle joint is a hinge joint mainly used to stretch and bent with nearly 70° activity range. Dorsiflexion is ankle bone with widely foot enters into mortise; tibia and fibula slightly take apart while close to each other in plantar flexion. Because of narrow distance ,ankle joint slightly becomes loose together with itself being the most force joint of completing weights when human standing ,it’s easily to get injured.

Reason for basketball well loved by broad youth is because of its own features of high speed, high combat as well as high techniques and high difficulties. Basketball is of extraordinary significance to human sports, that not only improve vitality but also propel to personality development, creativeness and improve analytical ability. It mainly composed of process motions like grab rebounds, hurdle, quick layup as well as takeoff, dribble, which not only strict with players all aspects of physical quality and techniques but also need mutual cooperation among players. It leads that basketball divides into some location as point guard, shooting guard, small forward, power forward and center so on. Every location player should perform its own functions, and adapt itself to the changing circumstance in techniques and cooperation according to competition development in the competition fields as well as pull together to fulfill the whole competition. Of course, competition is like war, conditions change quickly and accidents happened accordingly in such intensive high strength war fields that ankle joint injury is hard to avoid in basketball.

Factor analysis of ankle injury causes:
Basketball is a kind of complicated and changing physical force process at any moment, basketball players use force to complete superb technical motions both in competition fields and training ground, meanwhile players high speed sports ability also required. When basketball players get high speed, they also enlarge themselves joint bearings which also increasing their injury odds. And the main reasons lead to player ankle joint injure are: attending
competition or training with injury, insufficient warm-up, untimely injury curing in training or competition, technical motions mistakes, poor prevention awareness and excessive partial weight so on key factors.

Principal component analysis of basketball player’s ankle injury causes: In the research process of basketball players injury root cause analysis, our first work is confirm the major variable that caused ankle joint injury, but we can only find some variables with high correlativity out of these uncountable variables to replace other uncountable variables, these variables should reflect some information of other variables and be independent, uncorrelated. Through acknowledging of relative information, it can be seen that principal component analysis is a data handling process that enable to compress multiple correlation variables into some independent uncorrelated variables, use few data variables to replace multiple test data and utilize these variable indexes to reflect original data own information.

Select attending competition or training, insufficient warm-up, untimely injury cured in training or competition, technical motion mistakes, poor prevention awareness and excessive partial weight as linear combination $x_1, x_2, x_3, x_4, x_5, x_6$, linear combination selection is expressed as injury $Y$, use $Y = u_1x_1 + u_2x_2 + u_3x_3 + u_4x_4 + u_5x_5 + u_6x_6$ to represents relation formula between sport injury and its causes, while $u_1, u_2, u_3, u_4, u_5, u_6$ reflects the connection degree of relation between corresponding causes factor and ankle joint injury that expressed with variance. For instance, The larger $Var(x_i)$ is, the bigger influence of attending competition with injury to ankle joint injury would be, the more closer relation between the two, therefore, take the maximum variance from linear combination as the first principal component, when the first principal component cannot fully represent uncountable influence factors information, we should consider to use another principal component to fully efficiently reflect relations between influence factor and ankle joint injury, and that second principal component not only should make up for the missed information of first principal component but also be independent and uncorrelated to first principal component. It’s $\text{Cov}(x_i, x_j) = 0$ that should achieved between the two. If the second principal component still cannot fully represent enough information, then next influence factors should be taken into consideration, multiple influence factor can be found by parity of reasoning, till can represent all information of influence factors.

In actual practice, first should make data standardization to samples data. Since data index usually generates errors in the calculation of principal component analysis because of dimension differences, to do principal component analysis is the first step of eliminating data index dimensions, only data standardization can reduce errors occurrence. Data handling to influence factors would adopt minimum-maximum standardization, its formula as.

$$x_i = \frac{x_i - \min(x_i)}{\max(x_i) - \min(x_i)}$$  \hspace{1cm} (1)

Use SPSS software to do data analysis of standardized data, get significant correlation data of influence factors and ankle joint injury, as Table (2) shows.

<table>
<thead>
<tr>
<th>Influence factors and ankle joint injury significant correlation data</th>
<th>element</th>
</tr>
</thead>
<tbody>
<tr>
<td>attending competition with injury</td>
<td>0.996</td>
</tr>
<tr>
<td>insufficient warm-up</td>
<td>0.451</td>
</tr>
<tr>
<td>untimely injury curing in competition</td>
<td>0.978</td>
</tr>
<tr>
<td>technical motion mistake</td>
<td>0.983</td>
</tr>
<tr>
<td>Poor prevention awareness</td>
<td>0.901</td>
</tr>
<tr>
<td>Excessive partial weight</td>
<td>0.964</td>
</tr>
</tbody>
</table>

It can be seen from Table(2) that principal component analysis of 6 influence factors that caused basketball player ankle joint injury has chosen 5 principal component influence factors which are respectively attending competition with injury, untimely injury curing in competition, excessive partial weight, poor prevention awareness and technical motion mistakes. The significant correlations of such 5 influence factors all in the range of 0.8 to 1 all have bigger correlation to ankle joint injury, while correlation between insufficient warm-up and ankle joint injury only reaches 0.451 that indicates such influence factor has small correlation with ankle joint injury. Therefore, the other entire 5 influence factor can be regarded as major influence factor or the main effects that caused ankle joint injury.
Relative Pearson test on basketball player’s ankle joint injury causes:

Defined correlation index $r$ as:

$$
r = \frac{\sum x y - \frac{\sum x \sum y}{N}}{\sqrt{\left(\sum x^2 - \frac{\left(\sum x\right)^2}{N}\right)\left(\sum y^2 - \frac{\left(\sum y\right)^2}{N}\right)}}
$$

$N$ in the above formula is the numbers of major influence factors caused basketball player ankle joint injury; $\bar{x}, \bar{y}$ is the average value of influence factors, $\sigma_x, \sigma_y$ is the standard deviation of $x, y$. If correlation index $r$ be positive, it indicates the two are positive correlations, conversely, the two are negative correlations. If $r$ almost close to 0, it indicates that the two are uncorrelated; if $r$ closes to 1, it indicates the two have intensive linear correlations.

According to correlation analysis table’s analysis, when $0.8 < P \leq 1$, the two have strong correlations. It can be concluded that technical motion mistakes has the biggest correlations with basketball ankle joint injury, therefore technical motion mistakes is the main factors caused ankle joint injury.

**MECHANICAL ANALYSIS OF SPORTS TECHNICAL MOTIONS**

Make analysis of basketball technical motions with the examples of basketball’s step, stop, and jump shot motions. Basketball’s step, stop, jump shot motions can be divided into 5 segments as stop, takeoff, soar, off hands, land, while the impulse of the whole technical motion comes from each body joint. Best motion angle should be achieved in different moment of the whole process of basketball step, stop, and jump shot motion so as to achieve perfect technical motions and get better performance as well as avoid sports injury. Basketball step stop jump shot motions schematically diagram as Fig.1 shows.

![Fig.1: Stop jump shot motion schematically diagram](image)

For convenient research in mechanical angle, this paper makes corresponding simple schematic diagram by simplifying sports index as following. Knee angle-take knee as peak, the three point angle composed of hip joint, knee joint and ankle joint. Shank angle—included angle between connection line of knee joint and ankle joint and YZ plane.

Ground angle—included angle between connection line of knee joint and ankle joint and XY plane.

![Fig.2: Joint angle schematic diagram](image)

In the process of stop and jump shot, as Fig.2 shows, it’s mainly lower limb’s pedaling and stretching together with body lifting, enable whole body off the ground and has a initial liftoff speed, while at the same time ground also provides basketball players an acting force in the titled back direction, which greatly reduces horizontal reaction force in negative direction so as to reduce horizontal directions impulse. The takeoff process is to make players achieve more kinetic energy so as to arrive higher heights. A buffer action existing between stop and takeoff that influences on takeoff heights, it indicates that players should have sufficient buffer time when takeoff. Therefore,
player’s leg muscles explosive force and ground supporting force are required to improve speed and heights. Buffer stage is the important segment to connection the motion, motion in these segments has an influence on whole motions coherence. It can be acknowledged from relative data analysis results that players lower limbs are in slow angle changes in buffer stage. In buffer stage, player’s leg force increased so as to improve speed and increase heights. Ankle joint is easily injured if improper takeoff made. Therefore, lower hold posture should be kept in buffer and soar stage to increase leg muscle’s explosive force and reduce ankle joint force together with reduces grounds impulse.

![Diagram](image)

**Table 3:** Ankle joint angle features value

<table>
<thead>
<tr>
<th>No.</th>
<th>Angle (°)</th>
<th>Angle (°)</th>
<th>Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>119.70</td>
<td>110.41</td>
<td>9.29</td>
</tr>
<tr>
<td>2</td>
<td>127.98</td>
<td>107.18</td>
<td>20.80</td>
</tr>
<tr>
<td>3</td>
<td>139.28</td>
<td>116.25</td>
<td>23.03</td>
</tr>
<tr>
<td>4</td>
<td>118.89</td>
<td>105.05</td>
<td>13.84</td>
</tr>
<tr>
<td>5</td>
<td>121.10</td>
<td>109.30</td>
<td>11.80</td>
</tr>
<tr>
<td>6</td>
<td>107.14</td>
<td>90.67</td>
<td>16.47</td>
</tr>
<tr>
<td>7</td>
<td>109.63</td>
<td>113.12</td>
<td>3.49</td>
</tr>
<tr>
<td>8</td>
<td>83.18</td>
<td>105.82</td>
<td>22.64</td>
</tr>
<tr>
<td>9</td>
<td>122.00</td>
<td>118.09</td>
<td>3.91</td>
</tr>
<tr>
<td>10</td>
<td>134.54</td>
<td>109.83</td>
<td>24.71</td>
</tr>
</tbody>
</table>

It can be concluded from analysis of Table 3’s ankle joint angle feature values that left and right ankle joint angle in such stage are normally within the range from 109.10° to 127.20°, the maximum differences between players left and right ankle joint is 24.71°, the minimum of that is 3.49°, that indicates different angles existing between players landing posture and each body joint as well as players have different self-controlling ability which requires strengthen controlling training. In soaring , off hand process, players mainly proceed with free up casting uniform deceleration movements while make free falling uniform acceleration movements after body raised to top point. When take ball out off hands, wrist joint and finger joint bear force, they would be injured if improper motions makes.

Players force in landing moment as Fig.3 shows. Body gravity center falls from point a to point b when landing, gravity is G, ground supporting force is F, acting force in horizontal direction is f, downward inertial force is \( G_f \),forward inertial  force is \( G_q \),buffer heights is \( h_a \),momentous landing heights is \( h_b \), horizontal sports distance is \( S \).

\[
\sum l = 0 : (G_f + G)S - G_q h_a = 0
\]

(3)

From table (3), it can be seen that the bigger gravity landing’s heights \( h_a \) is, the bigger forward torque would be.

To keep balance when players landing without ankle joint injury , at the same time torque \( G_f S \) should be increased , that is also to increase players horizontal distance \( S \) in landing moment, if \( S \) is not in place, each force torque sum at point \( O \) would not reach 0,which lead to players imbalance landing at point \( O \) so that increase players ankle joint injury odds. When landing, front sole would first landing, lateral area of leg would support the
whole body balance; Ankle joint first bents and then make dorsiflexion, that ankle joint activity space enlarged when benting, together with inertial force torque in horizontal direction of gravity, imbalance landing would be caused, load of ankle joint lateral ligament and soft tissue increased, lateral ligament excessive stretching generated. Players should pay attention to adjust body in daily training and competition, for example, make muscle produce hedge distance through swing arm motions to offset dump torque. When make dorsiflexion, heel tendon bears greater force and pull led to such part got inflammation and breakage, therefore players should strengthen ankle joint heel tendon strength training.

No matter which levels players are, they all may not land with balance keeping because of unpredictable factors lead to different direction dump when landing. Therefore, players should constantly adjust legs lateral stretching angle and direction when tilting by side so as to well adjust landing site before landing and balanced landing reduce or eliminate sports injury caused by incorrect landing posture.

CONCLUSION

This paper acknowledged basketball players vulnerable injury part through questionnaires and communication, and put forward relative data analysis, clearly indicated that the most vulnerable part in basketball is ankle joint. This paper made further research on previous studies of causes for basketball ankle injury, use principal component analysis method and Pearson correlation analysis method, achieving the main reason caused ankle joint injury is technical motions mistakes. This paper provides most safest, scientific and rational technical motion suggestions according to biomechanics and dynamic theory, and present effective ankle joint protection methods and suggestions.

REFERENCES