THE IMPROVEMENT OF PCA ALGORITHM AND ITS APPLICATION IN THE PREDICTION OF ELBOW KNEE JOINT INJURY

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O APRIMORAMENTO DO ALGORITMO PCA E SUA APLICAÇÃO NA PREDIÇÃO DE LESÃO DA ARTICULAÇÃO DO COTOVELO E DO JOELHO

LA MEJORA DEL ALGORITMO PCA Y SU APLICACIÓN EN LA PREDICCIÓN DE LA LESIÓN DE LA ARTICULACIÓN DEL CODO Y LA RODILLA

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ABSTRACT

Objective: There were many constraints produced by training time and joint injury to analyze the influence of the training intensity on the elbow and knee joints of athletes during the training process. Methods: An improved algorithm-based master component analysis (PCA) modeling method is proposed .1 4 4 athletes were selected in xxx and compared in three groups. Results: The improved PCA models for injury prediction were applied to athletes from group A, the traditional injury models for prediction were adopted for athletes from group B, and athletes from group C received the hospital physical examinations. The results showed that the accuracy of elbow injury in group A due to excessive exercise was 66.86%, the accuracy of hospital physical examination in group C was 67%, and the accuracy of the traditional algorithm in group B was 50%, finding that the accuracy of group A was obviously different from group B ($P < 0.05$). Compared with other injuries caused by excessive friction, the detection accuracy of knee injuries caused by excessive friction in group A was 62%, that in group B was 44%, and that in group C was 63%. There was a statistically marked difference between groups A and B ($P < 0.05$). Conclusions: A PCA - based model of athletes' overtraining injury has high accuracy and adaptability, predicting elbow injury. ***Level of evidence II; Therapeutic studies - investigation of treatment results.***

Keywords: Elbow joint; Wounds and injuries; Athlete.

RESUMO

Objetivo: Houve uma grande quantidade de restrições produzidas pelo tempo de treinamento e lesão articular a fim de analisar a influência da intensidade do treinamento nas articulações do cotovelo e joelho dos atletas durante o processo de treinamento. Métodos: É proposto um método de modelagem aprimorado de análise de componentes mestre (PCA) baseado em algoritmo .1 4 4 atletas foram selecionados em xxx e comparados em três grupos. Resultados: Os modelos aprimorados de PCA para previsão de lesões foram aplicados a atletas do grupo A, os modelos tradicionais de lesões para previsão foram adotados para atletas do grupo B e os atletas do grupo C receberam os exames físicos hospitalares. Os resultados mostraram que a acurácia da lesão de cotovelo no grupo A devido ao exercício excessivo foi de 66,86%, a acurácia do exame físico hospitalar no grupo C foi de 67% e a acurácia do algoritmo tradicional no grupo B foi de 50%, achando que a acurácia do grupo A era obviamente diferente do grupo B (P <0,05). Em comparação com outras lesões causadas por atrito excessivo, a precisão de detecção de lesões no joelho causadas por atrito excessivo no grupo A foi de 62%, no grupo B foi de 44% e no grupo C foi de 63%. Houve uma diferença estatisticamente marcada entre os grupos A e B (P <0,05). Conclusões: Um modelo baseado na PCA de lesão por overtraining em atletas tem alta precisão e adaptabilidade, o que pode prever lesões de cotovelo. ***Nível de evidência II; Estudos terapêuticos- investigação dos resultados do tratamento.***

Descritores: *Articulação do cotovelo; Ferimentos e lesões; Atleta.*

RESUMEN

Objetivo: Hubo una gran cantidad de restricciones producidas por el tiempo de entrenamiento y la lesión articular para analizar la influencia de la intensidad del entrenamiento en las articulaciones del codo y la rodilla de los atletas durante el proceso de entrenamiento. Métodos: Se propone un método mejorado de modelado de análisis de componentes maestros (PCA) basado en algoritmos .1 4 Se seleccionaron 4 atletas en xxx y se compararon en tres grupos. Resultados: Los modelos mejorados de PCA para la predicción de lesiones se aplicaron a los atletas del grupo A, los modelos tradicionales de predicción de lesiones se adoptaron para los atletas del grupo B y los atletas del grupo C recibieron los exámenes físicos hospitalarios. Los resultados mostraron que la precisión de la lesión del codo en el grupo A por ejercicio excesivo fue del 66,86%, la precisión

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del examen físico hospitalario en el grupo C fue del 67% y la precisión del algoritmo tradicional en el grupo B fue del 50%, encontrando que la precisión del grupo A fue obviamente diferente del grupo B (P <0.05). En comparación con otras lesiones causadas por fricción excesiva, la precisión de detección de las lesiones de rodilla causadas por fricción excesiva en el grupo A fue del 62%, en el grupo B del 44% y en el grupo C del 63%. Hubo una diferencia estadísticamente marcada entre el grupo A y B (P <0.05). Conclusiones: Un modelo basado en PCA de la lesión por sobreentrenamiento de los atletas tiene una alta precisión y adaptabilidad, lo que puede predecir la lesión del codo. ***Nivel de evidencia II; Estudios terapéuticos- investigación de los resultados del tratamiento.***

Descriptores: *Articulación del codo; Heridas y lesiones; Atleta.*

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INTRODUCTION

The elbow joint is one of the best apposition joints in the human body, which is composed of the lower end of the humerus and the upper end of the ulna and radius. Besides, it is the connection point of the shoulder joint and the wrist joint, and plays a critical role in the upper limb function.[1-4] The biomechanics of the elbow joint during exercise has direct guiding significance for the prevention of elbow arthritis and sports injuries.[5] Thus, the elbow joint instability has now become a more common injury . The maintenance of the normal function of the elbow joint in the human body mainly depends on its stability.[6,7] Only when the elbow joint is normal, it can carry out activities or exercises of different amplitudes to meet the healthy survival needs of humans.[8,9]

Nowadays, there are higher requirements for athletes in sports skills, so that there are more and more elbow and knee injuries in their training process. This will have a more serious impact on the training and competition of athletes. Furthermore, the modeling method for elbow and knee injuries caused by athletes' excessive exercise can effectively solve this problem.[10-12]

METHODS

Selection of research samples

In this study, 144 athletes in the xxx District during the training period from January 20, 2019 to February 15, 2020 were selected as the research objects, and were grouped into group A, B, and C according to the different detection schemes, with 48 cases in each group. The principal component analysis algorithm was adopted to athletes from group A for modeling experiments to elbow joint injury caused by overtraining. The traditional algorithm and retrograde test were applied to athletes from group B, and group C were detected by hospital physical examination.

The criteria for inclusion were defined to include athletes who were professional, received routine training, and had clear consciousness to ensure that the experiment could be completed.[13-14]

The criteria for exclusion were defined to include athletes who suffered from psychiatric diseases, had major joint injury diseases, and withdrew from the experiment due to their own reasons.[15]

PCA algorithm construction process

Based on this, the specific modeling was as follows. Assuming $T = \{T_X, = 123...,X\} \in L^q$ was represented a vector set of athletes' overtraining and elbow joint injuries,G(*T*) stood for the mathematical expectation of X and K meant the covariance matrix of X. Then, the equation (1) could be applied to establish the change matrix of athlete's overtraining and elbow joint injuries.

$$\begin{aligned} A_{\mathrm{x}} &= YT_{\mathrm{x}} \\ T_{\mathrm{x}} &= Y^{\mathrm{i}} A_{\mathrm{x}} \end{aligned} \qquad (1)$$

Based on the above-established injury vector set, it was assumed that β(*T*) expressed the variance vector of the athlete's overtraining elbow joint injury vector set X in the process of optimizing the modeling of elbow joint injuries caused by athlete overtraining, the equation (2) could be obtained.

$$\beta(T))\in \mathrm{j} \quad \frac{1}{2}\sum_{x-1}^{X}[T_x(j)-T(j)]^2 \qquad (2)$$

In the above optimization modeling process, the equation (3) and (4) could can be obtained according to the above equation.

$$T = G(T) = \frac{1}{x}\sum_{x=1}^{X} T_x \qquad (3)$$

$$f(\mathrm{T}) = \left\|\beta(T)\right\|^2 = \sum_{l=1}^{e}[\beta(T)(\mathrm{l})]^2 \qquad (4)$$

In the process of optimizing the modeling of elbow joint injuries caused by athlete's overtraining, W stood for the orthogonal change matrix of elbow joint injuries caused by excessive exercise of athletes. What's more, the following equation was adopted to define the change code gain of W.

$$H_{ZX}(W) = \frac{f(\mathrm{WT})}{\exp \mathrm{M}(\mathrm{WT})} \qquad (5)$$

$$M(\mathrm{T})^{\xi} = \frac{1}{e}\sum_{x=1}^{e}\log\beta(T)(\mathrm{j}) \qquad (6)$$

In the process of optimizing the modeling of elbow joint injuries caused by overtraining of athletes, the above equation was used as a set of optimal vectors selected by the packet, and the equation (7) was employed to calculate all vectors in the vector set T.

$$\beta_{zx}^2(T)(\mathrm{A}) = \frac{1}{\mathrm{e}}\sum_{x=1}^{e}\left(\lambda_{zx}^{(n)}(\mathrm{A})\right)^2 \qquad (7)$$

In the optimization modeling process of this model, the equation (8) was applied to calculate the cost function $Q(K_{2X})$ of factors that affected the elbow joint injuries of basketball players.

$$Q(K_{zx}) = \sum_{o=1}^{d/2^s} \beta_{zx}(T)(A) \quad (8)$$

PCA was adopted in this study to model the athlete's elbow joint injuries caused by overtraining, and C represented a constant vector that should affect the elbow joint injury factor of athletes.[16] Under constrained conditions of $C_i'C_i$, $i = 1, 2, ...n$, the equation (9) was employed to establish the linearity change matrix of the athlete's elbow joint injury factor.

$$\begin{cases} L_1 = C'_1 T = i_{11}T_1 + I_{n1}TA \\ L_2 = C''_2 T = i_{12}T_1 + I_{n2}TA \\ L_p = C'_P T = i_{IP}T_1 + I_{np}TA \end{cases} \quad (9)$$

In the modeling process, the i-th principal component of Y had to meet $Y_i = C'_i$. Besides, C_i meant the relationship between the overtraining of athletes and the factors affecting their elbow joint injuries. Then, the sample matrix of the athletes' overtraining elbow joint injury was obtained from the equation (10).

$$T = (T_1, T_2, \cdots T_n) \quad (10)$$

The correlation matrix of athletes' elbow joint injuries was obtained, as shown in the equation (11).

$$\mathrm{R} = \frac{1}{n-1} T'T \quad (11)$$

Finally, the elbow joint injury model caused by athletes' overtraining was established according to the equation (12).

$$L_1 = ail\frac{T_1 - \bar{T}_1}{Y_1} + ai2\frac{T_1 - \bar{T}_1}{Y_1} + aip\frac{T_p - \bar{T}_p}{Y_p} \quad (12)$$

Statistical methods

The data collected in this study were sorted by Excel and analyzed with SPSS22.0 statistical software. Measurement data were expressed as mean ± standard deviation (x ± s), and count data were represented by percentage (%). The analysis of variance was used for pairwise comparison. In addition, P < 0.05 meant that the difference was statistically substantial.

RESULTS

Comparison on basic information of research objects

There were 100 males and 44 females among the 144 research objects collected. The average age of the 48 cases in group A was 27.5±3.78 years, the average weight was 73.9±10.27 kg, and the average height was 182.23± 5.68 cm. The average age, weight, and height of 48 cases in group B was 26.52±5.79 years, 72.63±8.98 kg, and 177.12±8.83 cm, respectively. As for group C, they were 27.09±4.88 years old on average, with an average weight of 70.78±11.73 kg and an average height of 179.67±6.99 cm. Based on the above numerical comparison, the research objects from the three groups had no marked differences in age, height, and weight (P > 0.05), which could be used for statistical analysis. (Figures 1 and 2)

Test results of athletes from the three groups

Figure 3 indicated the elbow joint injuries, knee joint injuries, and other injuries of athletes from the three groups, which were caused by excessive exercise. It was found that the detection accuracy of elbow joint injuries caused by excessive exercise in group A was 66.86%, the detection accuracy of hospital physical examination in group C was 67%, and the detection accuracy of the traditional algorithm in group B was 50%. What's more, the detection accuracy of knee joint injuries and other joint injuries in group A was also dramatically higher than that of group B. Therefore, there were statistically substantial differences in group A and B (P < 0.05).

Figure 4 showed the elbow joint injuries, knee joint injuries, and other injuries caused by excessive friction of the three groups under investigation. The detection accuracy of knee joint injuries caused by

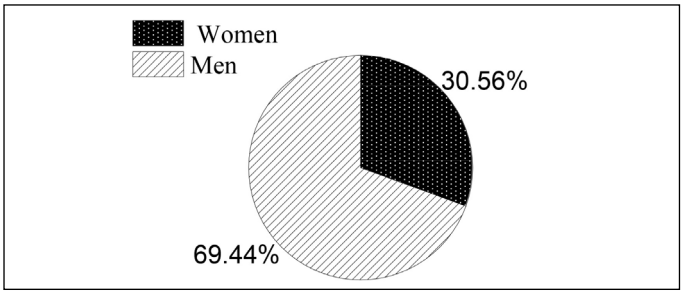

Figure 1. The gender ratio of all the research objects.

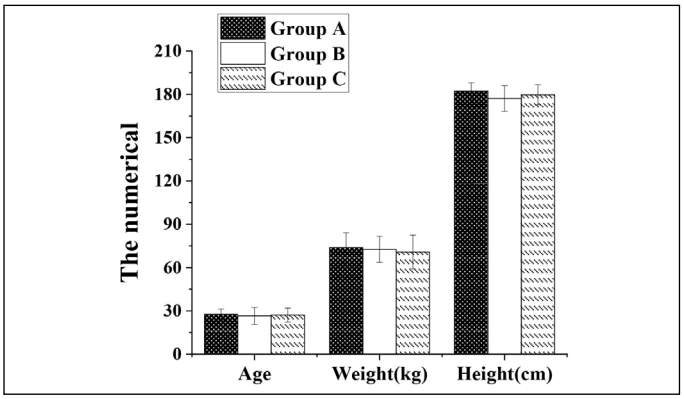

Figure 2. Comparison on the basic physical indicators of athletes from the three groups.

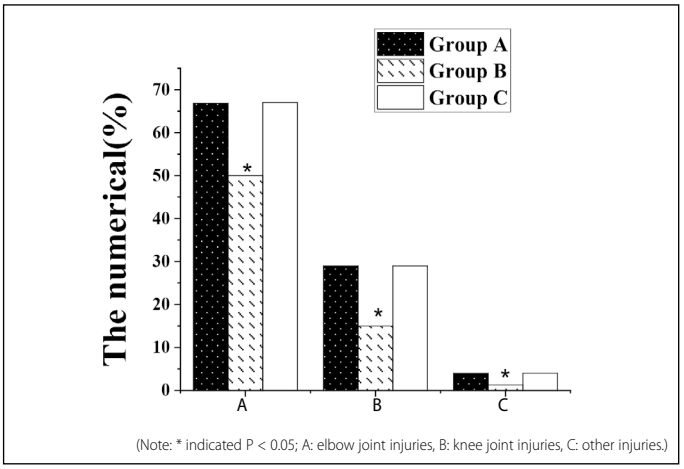

Figure 3. Comparison on joint injuries caused by excessive exercise in athletes from the three groups.

excessive friction in athletes from group A, B, and C was 62%, 44%, and 63% in turn. Thus, the detection accuracy of knee joint injuries caused by excessive friction in group A increased obviously in contrast to the accuracy of group B ($P < 0.05$).

The elbow joint injuries, knee joint injuries, and other injuries of athletes from the three groups were compared due to unreasonable exercise and poor mental state, as shown in Figure 5 and 6 in sequence. It revealed that the detection accuracy of knee joint injuries in group A was 62%, which was compared with group B, indicating that there were statistically obvious differences both in unreasonable exercise and poor mental state ($P < 0.05$).

The accuracy of joint injury examination caused by poor physical condition of the three groups was compared, and the results were presented in Figure 7. In the detection of knee joint injuries and other joint injuries, the accuracy of athletes from group A was markedly higher than that of group B ($P < 0.05$).

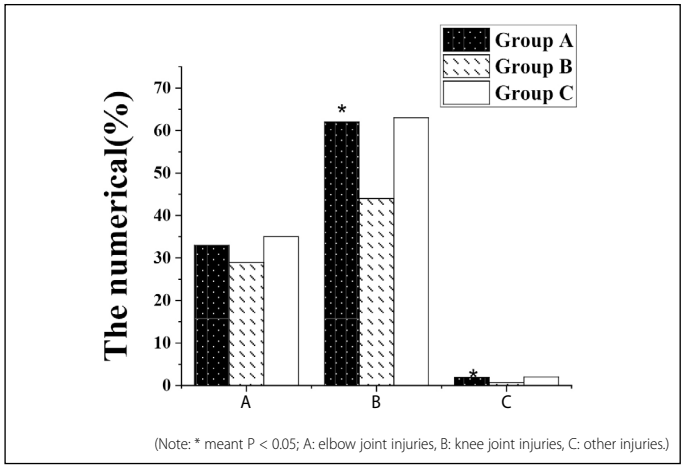

Figure 4. Comparison on joint injuries caused by excessive friction of athletes from the three groups.

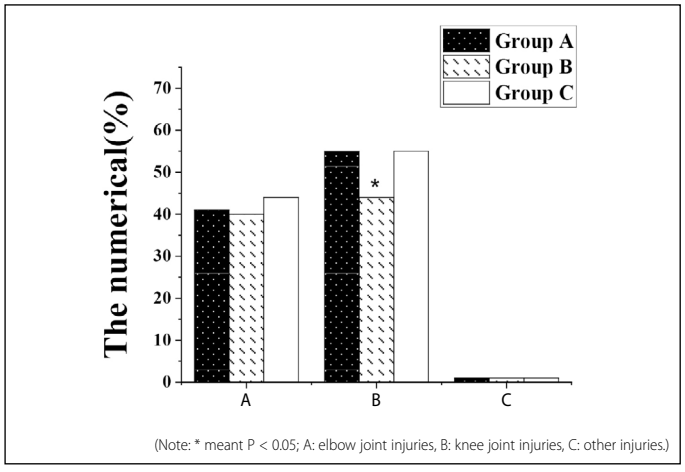

Figure 5. Comparison on joint injuries caused by unreasonable exercise in the research objects from the three groups.

DISCUSSION

The test results indicated that the detection accuracy of elbow joint injuries in group A due to excessive exercise was 66.86%, the accuracy of hospital physical examinations in group C was 67%, the accuracy of traditional algorithms in group B was 50%. Thus, there was a statistically huge

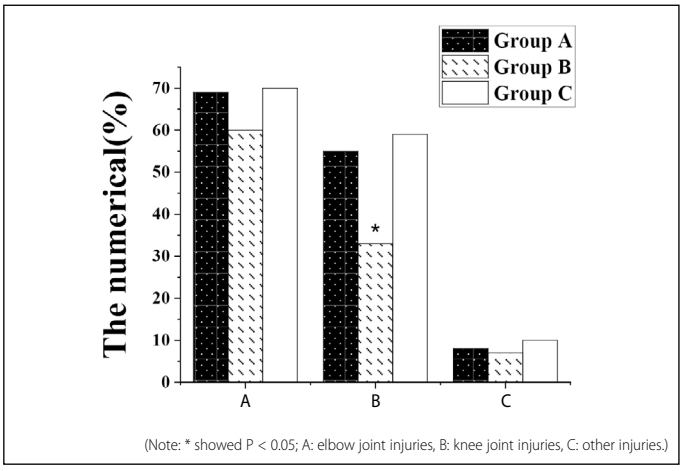

Figure 6. Comparison on joint injuries caused by poor mental state in athletes from group A, B, and C.

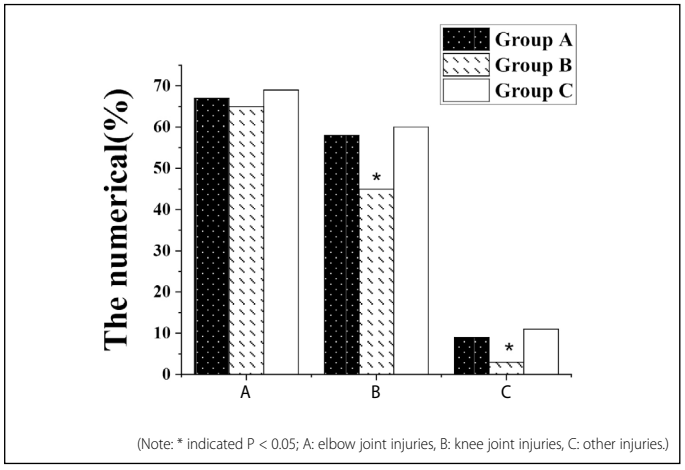

Figure 7. Comparison on joint injuries caused by poor physical condition of the three groups.

difference in group A and B ($P < 0.05$). As for knee joint injuries caused by excessive friction, the detection accuracy of group A, B, and C was 62%, 44%, and 63% in sequence, suggesting that the accuracy of group A was greatly higher than that of group B ($P < 0.05$). The results of elbow and knee joint injuries and other injuries caused by unreasonable exercise, poor mental state, and poor physical condition also showed that the detection accuracy of group A was hugely higher than that of group B, so the improved PCA algorithm had a more accurate joint injury detection effect.[17]

CONCLUSION

The model of elbow joint injuries caused by athletes' overtraining based on the PCA algorithm had higher accuracy and adaptability, which could be applied to the prediction of elbow joint injuries. The shortcomings of this study are that the sample size selected in this study is small, which may have some impact on the results. Besides, the athlete's elbow joint injury model is mainly discussed in this study, which has a small scope of application. In the future research, the size of samples will be increased and the scope of investigation will be further expanded, so as to explore the clinical application value of the PCA algorithm.

The author declare no potential conflict of interest related to this article

AUTHORS' CONTRIBUTIONS: Zhenhua Liu analyzed and explained the impact of training intensity on athletes' elbow and knee joints during training. Training time and joint damage will cause a lot of constraints. A new modeling method based on an improved principal component analysis (PCA) algorithm is proposed, which is used to simulate and study the elbow and knee injuries of overtrained athletes in parallel. And is the main contributor to the writing of the manuscript.

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