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# Development of Comprehensive Performance Program for Beginner High Jump

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## Abstract

The comprehensive performance evaluation (CPE) is the most objectively, justly and reasonably overall evaluation in sport field.This study aim to find the factors related to the high jump performance, then designed the training program for beginner to compare the results of training between programs based on CPE and traditional experience.The research proceeded by explored the factors effecting the high jump performance with factor analysis to considered the factors and weights of them.After that designed the program based on CPE and then conduct two training programs.The entire research were mainly supported by the statistical methods: ICC, Spearman correlation, EFA, and t-test.The results were as follow:

1.There were 11 high quality indexes ($r > .5$) were selected and used to construct the final CPE by EFA.

2.The training and time allocation concentrated on the CPE evidence that physical fitness part of explosive power were 49.78% and technical part were 50.22%.

3.The CPE training program could improve the performance of beginner high jump better than the traditional training program.

**Key words** Comprehensive performance evaluation, beginner high jump, training program

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## Introduction

Any successful teaching, training, instruction were all started with accurate evaluation.The teacher, coach, and instructor should be able to select good test, administer them properly, and use the results to improve performance (Safri & Wood, 1995).In sport field, evaluation generally existed in every part, such as national physical fitness, teaching and coaching performance, performance-related physical fitness, and training effect.However, for evaluating the sports performance, at present, it was difficult to define the multi-factorial sport performance structure, due to the lack of consistent research and weak connecting between the different disciplines in sport science that support this kind of studies (Silva, A.J.et al, 2007).The evaluation method for exploring the factors that pertinent to the performance is the comprehensive evaluation.

Comprehensive evaluation is a complex process, which synthesizes the subjective and objective information together (Zhao, 2008; Su, 2000).In recent years, both of theory and application on comprehensive evaluation had a well development, and the related researches emerge in endless.Since 2001, there were more than 14 doctoral dissertations about the sport evaluation in China.In these works, many new methods applied, and the old methods were revised and improved.It changed from single and short methods of evaluation to be more complex by the mix used of mathematics, multidiscipline, and a common method.In general, the process of comprehensive evaluation include identify purpose, confirm the target and evaluator, build indexes system, select method and model, collect data and apply the evaluation.How to determine the weight coefficient and select appropriate model are the key parts.Normally, the frequently used linear methodology was PCA, and the Non-linear methodology was Artificial Neural Networks.

In practice, teacher or coach of track and field (TF) usually encountered the problems how to improve the performance, because they did not know the precise problems must be solved, so they just used their experience to design the training.Certainly, there were many researches about how to improve performance, but those researches are too narrow at present.Therefore, firstly the CPE should be conducted for figure out the key factors, which definitely determine the performance.However, there were very few studies employed the CPE methodology.This study selected the high jump as a point cut to practice the CPE program.

The objectives of this study were to develop a CPE training program for beginner high jump.It had three folds: (1) Identify the factors which are able to explain the performance; (2)

Construct a CPE indexes system and acquire the weight of the factors by the exploratory factor analysis (EFA); (3) Assess the training effect of CPE by designing, conducting and comparing the training program for the beginner high jump.

## Data collection

### Procedure

This study employed the methodology were divided into the following stages: (1) Literature review used to build the primary CPE indexes system; (2) Filtered the indexes by IOC and in-depth interview, and bivariate correlation between indexes and performance to delete the indexes less than 0.5; (3) EFA was used to ensure the CPE had construct validity, and meanwhile the weights were collected; (4) the CPE training program based on the weights and traditional training program were designed; (5) The experimental programs to compare the improvement between the two programs; (6) The data were analyzed by t-test to compare the training results.

### Statistical analyses

The K-S test and Levine's test performed to verify the normality of the distribution.The benchmark of ICC was Rxx>.7.Pearson's correlation coefficient was used to verify the correlation between CPE indexes and performance, and the indexes r<.5 were deleted.SPSS 13.0 was used to conduct the statistical analyses.

The PCA was used for factor extraction.KMO value (>.7) and Bartlett's test (<.05) were acceptable.For discriminant validity, in pattern matrix, variables should load significantly only on one factor means no "cross-loadings" exist, and in each components, the average loading value bigger than 0.7 means the acceptable convergent validity.Test reliability was to compute by Cronbach's $\alpha$ (>.7) for each factor.The independent sample t-test was used to test the difference between groups.The paired t test was employed to test the difference between the performance of pretest and posttest of the same group.

## Results

### The factors had significant correlation with the performance of beginner high jump

For figuring out the affecting factors of the performance, firstly the primary CPE indexes system collected totally 82 indexes, after IOC and in-depth expert interview 24 indexes were deleted.Then all the rest indexes were conducted by test-retest, the average ICC was 0.88 at 0.01

level.27 indexes without significant correlation less than 0.05 were cut in bivariate correlation stage.31 indexes had significant correlation with performance and 11 indexes bigger than 0.5.

**Table 1** Mean and SD of the 11 indexes ($r > .5$) that correlated with the performance (n=143)

| Domain | Variables | | Mean(±SD) | r |
|---|---|---|---|---|
| Physical fitness | Explosive power | Standing triple jump (STJ) (m) | 7.73±.397 | .804** |
| | | Standing long jump (SLJ) (m) | 2.61±.0.10 | .583** |
| | | 4 strides approach touch height jump (AVJ) (m) | 2.94±.15 | .668** |
| | | Absolute-Vertical jump (AVJ) (m) | 2.94±.11 | .602** |
| | | Relative-Vertical jump (RVJ) (m) | 0.66±.08 | .718** |
| | | Backward overhead throw (BOT) (m) | 12.70±.185 | .696** |
| Technique | CG height | H2 (m) | 1.63±.098 | .756** |
| | Velocity | V1Ls (m/s) | 5.23±.507 | .630** |
| | | V2Ls (m/s) | 5.59±.52 | .524** |
| | | TO Vv (m/s) | 3.48±.325 | .586** |
| | | TO V (m/s) | 4.70±.433 | .551** |

Note: ** means $p < 0.01$, TO is the take-off moment of toe; CG is the center of gravity; H2 is the highest CG height in flight phase; Vv is the vertical velocity; V is the 3d velocity; 1LS is the last step, 2LS is the penultimate step.

**The weights of the core effected factors of the performance**

In this stage, the EFA was employed to obtain the weights of the core effected factors which used for designing training program.Firstly, before conducted the EFA, the value of Cronbach's $\alpha$ (.903) meant the reliability of the CPE system was excellence, and the result of KMO (.832) and Bartlett's Test ($p < .01$) stated this evaluation system was suitable to conduct the factor analysis.

There were two components was extracted by the PCA, the weights and more detail category based on their characteristics (table 2).From statistics, STJ and H2 had weak validity that both could either be regarded as the components of explosive power or technique.Because they cannot clearly decided their component in structure matrix (loadings difference between two components less than 0.2).

**Table 2** Two components, weights and category of the CPE indexes

| Component | Items | Weights | Category (%) | |
|---|---|---|---|---|
| | | | Domains | Type |
| 1 | STJ | 0.10734 | Explosive Power | Horizontal jump |
| | SLJ | 0.07945 | 49.78 | 18.68 |
| | 4AJ | 0.06648 | | Vertical jump |
| | AVJ | 0.06658 | | 22.44 |
| | RVJ | 0.09134 | | |
| | BOT | 0.08664 | | Whole body coordination |
| | | | | 8.66 |
| 2 | H2 | 0.10362 | Technique | High jump ability |
| | | | 50.22 | 10.36 |
| | TOVv | 0.09203 | | Take-off velocity |
| | TOV | 0.09904 | | 19.11 |
| | V1Ls | 0.11252 | | Approach velocity |
| | V2Ls | 0.09495 | | 20.75 |

**The training program designed by the affecting factors and weights, and training result**

For verifying the whether the CPE have practical significance, two training programs were designed, respectively according to the traditional training experience and the evidences from CPE, and both of them follow the training principle.The training programs conducted for 8 weeks, two times per week, and 2 hours per time.According to the limited training schedule, the training cycles were telescope into two weeks cycles.Two training programs were divided into three phases include conditioning, preparation, and competition phases, except the first phase had two cycles, the others had one cycle.

The type and proportion of training include physical fitness (30%), technique (30%), and cross bar (40%).The content of training was different between traditional program (Control group) and CPE program (Experimental group), traditional program was designed according to the normal training procedure, and the CPE mainly depended on the weights from EFA.For physical training, CPE stressed to developing the explosive power with CG controlling and body coordination.As for the technique and cross bar, CPE focused on improving the preparation of take-off, coordination of pedaling-swing, and CG controlling technique in flight phase.

After 8 weeks, the result showed that the performance of CPE group was better than traditional group (increased performance CPE=14cm±6.4, Traditional group=8cm±4.1).Both of the two groups increased the performance at the very significant level ($p<.01$).But the independent sample t test showed the mean of posttest performance between two groups had significance difference (($p<.05$), while the pretest performance did not have.This value demonstrated the CPE training program was better than the traditional program.

**Discussion**

**Evidence from the weights of the core affecting factors**

In the structure matrix, STJ and H2 had the characteristics that could be classified as two components either.STJ was the indexes need well coordination, not just the explosive power, especially for the CG controlling.STJ was a great explosive plyometric exercise, and to control the body posture have great importance that is also the same for high jump (Schiffer, 2011).H2 was a technical index, but in essence, it depended on vertical jump ability.In correlation coefficient, STJ (.804) and H2 (.756) were the top two indexes.There were numerous literature employed STJ as

the important evaluation indexes, and the significant correlation with performance had been proved in previous researches (Wen.et al, 2013; Chen & Ye, 2003).

Two components have been categorized as explosive power and technique, from the view of weights, and they had the similar percent.This result back to the dualism rule of sport performance, performance depends on the physical fitness and the technique.The indexes have been further subdivided into six type.BOT and H2 had been divided into single type, which indexes can evaluate the explosive power of the whole body coordination.(Reiman & Manske, 2009).Some researchers have proved BOT had high correlation with the power indexes for the vertical jump ($r=.996$, $P<0.01$), and suggested BOT was a valid index for assessing power for whole body movement pattern (Mayhew.et al, 2005).

In the type of vertical jump, unquestionable RVJ had the biggest value with performance.However, the 4AJ and AVJ only had 9.1cm difference of the average value.During the test, the 4AJ of some subjects were even lower than vertical jump, and the correlation of 4AJ was less than AVJ.Therefore, this evidence implied beginner had weak combining capacity of running jumping.

For approach velocity, VlLs had the biggest weight, and total of the two CG velocity got the proportion of one fifth.This meant the approach technique of last two stride was very important for beginner.The reason of slower VlLs than V2Ls must be analyzed carefully.Combining with technical video and bivariate correlation, some evidence was revealed.The main mission of last stride was preparing for take-off.Swing technique of right arm had two actions.The first was forward swing with double or single arm in penultimate stride, then backward swing with double arm in last stride.For beginner, these actions were difficult, because they cannot fully control the technique.In video, the biggest problem was backward arm swing with exaggerated range, and this action directly caused slower V1Ls, meanwhile slower the swing velocity of the arm.In addition, the shorter last stride length and the negative correlation of the supporting time in last step were both proved the weak preparation technique.

TOVv and TOV were the basic indexes influencing of take-off effect.As mentioned in bivariate correlation, the slower swing velocity of elbow and smaller pedaling range of lower limb joint angle guided the training direction to improve the pedaling-swing technique.Normally the TOVv should be greater than V1Ls for the beginner, but the weight showed the importance of the

approach technique in last two stride.H2 also had the same situation as TOVv, because of poor take-off angle and CG control (body posture).

**Training program designing and comparing**

Mainly according to CPE, for developing the explosive power, the best training exercise for beginner high jump was to control CG and use the whole body coordination.CPE program designed the skip jump, hurdles bounding and depth jumping drill by hurdle as the exercise for improving the explosive power.For BOT, the power clean had the same movement structure that could improve the whole body power was inevitable included in the CPE program.

During the measurement of strength, many subjects conducted the back squat without the fully ankle stretching, and the ankle angle value have also demonstrated the beginners have weak pedaling consciousness.For making up this ability the loading calf raise and double foot sped take-off with touch height were employed to improve the pedaling ability.For improving the vertical jump, the 4 strides approach touch height and head touch height were used to improve the vertical jump ability.

For improving technique, in the approach part, two strides approach take-off with look mirror, two steps approach-take-off with look bar and two steps approach-cross bar were used to accelerate the approach velocity of the last two steps.Because the last two steps is the linking stages from approach to take-off, the preparation of take-off reflects the lowering of the CG and arm action during the last step and penultimate step, and this finally affects the approach velocity.

Three designed exercises were required for looking the bar.The reason was most of the beginner high jump beyond control their CG after take-off that could be observed in video.There were two obvious situations, first some of them had higher vertical velocity and lower horizontal velocity, and the second was on the contrary.If the subjects did not know the positon of bar, they cannot control their CG, and in flight the bar will produce an instinctive reaction by visual response that force the body to erect hip for clear the bar.

H2 was a very special index, for it was the result of combination from techniques and physical fitness.The approach take-off over mats and 4 steps head touch height were the exercises for the subjects to experience the highest CG.Therefore, both of the programs employed the standing cross-bar imitation, standing jump-cross bar imitation and standing jump-cross bar to

improve the experience of CG cross-bar, and two strides approach cross bar was the particular exercise for CPE program.

After statistical analysis, the expected result had been produced, and the average performance increased 0.15m from the descriptive of the post-test.If delete the top two values (0.34m and 0.25m) in CPE group, the difference will be smaller, and the same situation demonstrated in control group.The main reason existed in the training process.30 subjects in each group decreased the careful instruction time, meanwhile increased difficulty for controlling the training quality.

## Conclusion

It could conclude that the CPE training program developed in this study had effectively improved the performance of beginner high jump better than traditional program.It proved that the training program concentrated on explosive power with CG control and whole body coordination included with perfecting technique of accelerating approach velocity and preparation of last two steps, pedaling-swing coordination, and reasonably distributing the CG velocity in flight were very important training strategy.For future study, firstly, the other domains should enrich the CPE indexes system, such as the isokinetic, kinetics, and EMG, and the subjects should include all the level in high jump, as well the nonlinear model will be the very meaningful for constructing CPE.

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