SHOT PUT TECHNIQUE ANALYSIS USING ANN AMT MODEL

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The purpose of this study was to analyze the technique of female shot put athletes. In this paper the ANN Analysis Model of sport Technique (ANNAMT) was applied to the data. It was shown that there were three possible ways to use this technique. The first was to reveal the general principles underlying an activity. The second method was to determine what differences exist between elite and other athletes and finally to achieve an individual technique diagnosis for direction in training. This study demonstrates the potential of the system that was developed previously for this purpose. It has the ability to standardize and program the technique analysis course, to some extent overcoming subjective decisions. This study suggests that ANNAMT could be used to establish sports training programs if the database was made available, compiled from performances of elite athletes.

KEY WORDS: biomechanics, sport technique analysis, artificial neural networks, shot put

INTRODUCTION: Sports technique analysis (or technique investigation) includes three phases: data collecting, data analysis, and decision-making (Sprigings, 1987; McPherson, 1996). As sport science gradually has gained recognition, the computer and other modern technologies have enhanced the phases of data collection and analysis. In relative terms, the third phase lags behind and has remained focused on subjective diagnosis and experience based decision-making.

Recently, artificial neural network (ANN) has been proposed as an alternative tool to comprehensive decision-making (Lapham & Bartlett, 1995). One of major advantages of this method is that ANN model makes no assumptions about the underlying relationship between all the technique parameters. This can be obtained from the data. In other words decision-making is achieved by carrying out data transformation. In this paper the ANN Analysis Model of sport Technique (ANNAMT), has been used to investigate the techniques used by Chinese elite female shot-put athletes. The merits of this method were established by previous research. Possible applications and the decision-making capacities of the ANNAMT were also explored.

METHODS: Subjects and experimental design**.** All 31 subjects selected for this study were members of 1981-1997 Chinese national team. In official competitions 3-D video or cinematography was used (Photosonic 1PL16mm and JVC KY-19E, SVHS; 50-100 frames/sec.) and the kinematics data of 155 trials from these 31 female shot putt athletes were collected. The range of official results is between 21.78-15.10m. The distance distribution of all the trials was shown in Figure1. The average number of trials digitized for each subject was 5 (TYF-2 digitizer and PEAK5).

Hierarchy analysis and the selection of technique parameters. In theory, the throwing distance is definitely determined by the release velocity, angle and height, thus these three release parameters are the effect variables of shot put. Considering an individual release height changes little with the throw distances. For simplification, the horizontal velocity and vertical velocity of shot release (match to release velocity and angle) were taken as effect variables. The hierarchy analysis of

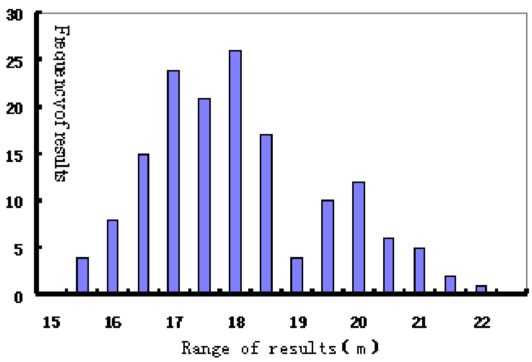

Fig1. The distance distribution of all 155 trials to be analyzed

shot-put techniques was shown in Figure 2.

Evaluation and analysis. In order to evaluate the technique importance denoted by the technique parameters, the relative change rates of the effect variables were introduced which is expressed as following:

This expression means that one unit change of technique parameters may bring about the

$$Rate_{rel}(\%) = \frac{value_{eff}(5\%) - value_{eff}(-5\%)}{value_{eff}(0\%)} \times 10\% \times 100\% \qquad (1)$$

possible change of the effect variable on the present training and physical conditions. ±5%. Simulating change of the technique parameter could not only avoid the influence of the data errors, but also keep the property of local change.

RESULTS AND DISCUSSION:

By using the relative change rates of the effect variables the present training, importance of different technique factors were compared on the same base. Table1 lists the ten dominating overall parameters (OP). Table2 lists the analysis results of the local parameters (LP) model calculation. By simple analysis, the present existing technique principles (Grgalka, 1981) were quantitatively verified and amended where necessary.

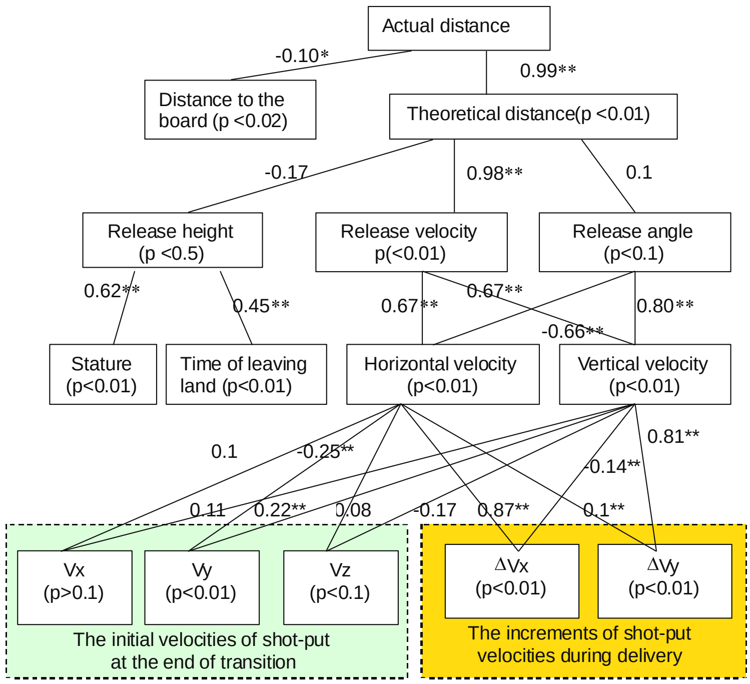

Fig.2 The hierarchy technique model of the delivery in shotput throwing. *: significantly(p<0.05); **: very significantly (p<0.01)

Table 1 Ten Selected Dominating OP Delivery Technique Parameters* which Significantly Influence Each Release Variable or Shot Put Distance

Parameter Rank	Release variables				Shot-put distance
	Vx	Vy	Vr	θ	
1	X14(37.74)	x13(42.01)	x14(24.89)	x13(37.36)	x14(40.48)
2	x10(-22.29)	x15(31.75)	x12(15.00)	x15(28.33)	x12(26.70)
3	x12(14.72)	x12(15.47)	x10(-14.13)	x14(-24.99)	x13(23.53)
4	x11(11.20)	x17(-12.00)	x13(10.26)	x10(15.86)	x10(-22.78)
5	x13(-8.95)	x16(-9.78)	x15(7.67)	x11(-10.57)	x15(17.63)
6	x19(-8.33)	x19(5.87)	x11(5.77)	x19(10.41)	x17(-9.80)
7	x15(-6.90)	x20(-4.94)	x17(-4.82)	x17(-8.44)	x11(8.71)
8	x3(5.59)	x8(-4.20)	x5(3.30)	x16(-7.99)	x16(-6.44)
9	x6(-4.75)	x3(-3.84)	x6(-3.13)	x3(-6.91)	x5(5.53)
10	x5(4.47)	x14(3.65)	x16(-2.99)	x20(-5.00)	x6(-5.13)

Notes:

*: These can lead the shot-putting result to above 5% absolute relative change rate (in bracket).
X14: the horizontal average acceleration of shot in the period of power delivery;
X12: the horizontal displacement of shot in the period of the power-start to release;
X13: the angle of shot resultant displacement relative to the horizontal plane;
X10: the time from the end of transition to power start;
X15: the vertical average acceleration of shot in the period of power delivery;
X17: the support pace width at the power delivery;
X11: the horizontal displacement from the end of transition to the power start;
X16: the angle between the support pace and the release direction on the horizontal plane;
X5: the width rate of support-pace to glide-pace;
X6: the height of human gravity center at the end of transition;
X3: the vertical velocity of the human gravity center at the release;
X8: the time of the maximum transverse displacement of shot relative to the end of transition;
X19: the vertical velocity of shot at the end of transition;
X20: the horizontal velocity of shot at the end of transition.

Table 2 The Analysis Results of ANNAMT for LP Parameters

Joint angle	Technique parameters	The effect on release variables and shot-put distance					Implying significance for training
		Vx	Vy	Vr	ϑ	S	
Ebow angle	$\omega_{max.}$	↔	↑**	↔	↑**	↔	Keep the shot speed
	The angle at ω_{max}	↔	↓**	↔	↓*	↓*	As early as possible to attain the ω_{max}.
Shoulder-hip angle	Angle at release	↓**	↑**	↓*	↑**	↔	Control the exertion direction
	time to reach ω_{max}	↔	↑**	↔	↑*	↑**	Prolong the exertion time
Shoulder-arm angle	Angle at release	↓**	↔	↓*	↔	↓**	Increase the chest adduction force
Angle of shoulder axis	Angle at the end of transition (yz plane)	↔	↓**	↓*	↑*	↓**	Totally keep the back towards the release direction
	Time to reach ϑmax (yz plane)	↔	↓**	↔	↓*	↓*	Shorten the time of power preparation
	$\lvert\omega max\rvert$ (yz plane)	↔	↓**	↔	↓*	↓**	Speediness helps the reverse flap
	Angle at the end of transition (xy plane)	↔	↓**	↓*	↓**	↓**	Reducing the angle leads to the addition of side-bow
Angle of trunk Angle of coax axis	Time at ϑmax	↑*	↓**	↓*	↓**	↓**	rapid power ability
	Time at ωmax	↔	↑*	↔	↔	↑*	Persistence acceleration ability
	ϖ: ϑmax to release (minus)	↑*	↔	↑*	↔	↑**	Approaching to zero stands by the high efficiency of energy transformation
	The max. angle near the tran. end (xz plane)	↓*	↓*	↓*	↔	↓**	Right knee flexes over; little support stride
	Max. angle(yz plane)	↑*	↓**	↔	↓**	↔	In favor of the horizontal turn of coax axis
	Release angle (minus, xy plane)	↓**	↑**	↔	↑**	↔	Horizontal turn significantly
	ϖ?minus, xy plane?	↑**	↓**	↔	↓**	↔	Shift from hor.plane to ver.plane
Angle of right knee	Time at ϑmax	↔	↓**	↓*	↓*	↓**	Influencing the shot vertical velocity
	ϖ: ϑmax to release?minus?	↑*	↔	↔	↓*	↑*	No fast leave the land
R. calf angle	The angle at the transition end	↔	↔	↔	↔	↓*	Increase the double support stride
	Min. Angle	↓*	↔	↔	↑*	↔	increase the Vy in the sacrifice of Vx
L. knee angle	Extending speed	↔	↑**	↔	↑**	↑*	Increase Vy
L.calf angle	Angle at the tran. end	↑*	↔	↑*	↔	↑**	Left calf must root in the land at the delivery
	Angle at leaving land	↔	↓**	↓*	↓*	↓**	

Notes:

↔: Hardly any influence on the effect factor; ↑: positive influence, i.e. the effect factor increases as the technique variable increases; ↓:negative influence, i.e. the effect factor decreases as the technique variable increases; *: the relative change rate is great than 1%, but less than 5%; **:the relative change rate is greater than 5%.

This method also can be applied to individual technique analysis. The analysis procedures could be summed up as first, averaging all the technique parameter values of several-time measurements in a relatively short training period. This is followed by construction of the individual's technique analysis ANN model on the base of overall-sample model previously determined. Subsequently, input of the parameters of similar-style elite athlete to the individual model. Separation of the technique differences from comparison of the corresponding technique parameters of analyzed subject and the elite athlete. Finally, finding the technique advantages and drawbacks of the analyzed individual from the ANN network output, which could provide direction for future training. Table3 lists the analysis results of a certain individual (YJ) ANN model. The individual model was built up on 8 trials (result range: 17.61-18.36m). The athlete selected for comparison of elite shot-putter was HZH, whose trial result was 21.53m. From the data in Table 3 it could be concluded that (YJ) skill style differed from the HZH's. The primary technique factors currently restricting the individual's throwing distance increase were as follows. The horizontal acceleration ability (x14; 9.26%), vertical acceleration ability (x15; 5.93%), horizontal displacement of shot during the period of the transition end to acceleration start (x11; 3.62%), double support stride width (x17; 3.58%), the height of human gravity center at the end of transition (x6; 1.54%) and the time of the shot, maximum transverse displacement (x8; 1.29%). In addition to all the analysis results, the training suggestions for YJ were as follows. Reinforcement of power ability training, reduction of the stride width and the height of gravity center in the end of transition, extension of the left leg in the glide period, appropriately adding length to the support stride, and diminishing the preparatory time before delivery.

Table 3 The Analysis Results of YJ Individual ANN Model

Influencing factors and its values				The relative change rates of effect factors				
Tech. Factors	YJ value	HZH value	Change rate(%)	Vx	Vy	Vr	θ	Dist.
x1	6.30	-1.57	-27.01	-0.30	0.58	0.02	0.65	0.15
x2	0.83	0.78	-5.04	-0.15	0.00	-0.10	0.11	-0.15
x3	0.84	1.41	30.48	1.70	-1.03	0.71	-2.01	0.90
x4	-0.28	0.23	42.02	-0.43	0.11	-0.23	0.40	-0.34
x5	1.21	1.39	12.90	0.58	0.35	0.49	-0.17	0.85
x6	0.83	0.75	-28.15	1.57	-0.05	0.98	-1.19	1.54
x7	0.83	0.75	-18.75	-1.02	-0.98	-1.01	0.03	-1.77
x8	0.25	0.12	-40.31	0.90	0.50	0.75	-0.29	1.29
x9	0.12	0.09	-15.00	-0.79	-0.31	-0.61	0.36	-1.02
x10	0.08	0.11	18.33	-4.04	-0.16	-2.60	2.95	-4.15
x11	0.21	0.38	31.09	3.98	-0.45	2.38	-3.20	3.62
x12	1.03	0.92	-17.50	-2.72	-3.02	-2.83	-0.23	-4.98
x13	39.39	38.79	-2.85	0.21	-1.48	-0.41	-1.25	-0.93
x14	43.87	63.82	58.81	12.83	-4.12	6.93	-11.76	9.26
x15	33.51	46.11	40.47	-3.23	12.18	2.69	11.13	5.93
x16	-15.50	-6.15	19.83	0.73	-1.59	-0.12	-1.72	-0.50
x17	0.26	0.08	-21.08	0.87	3.47	1.83	1.89	3.58
x18	2.58	2.87	14.13	-0.25	0.17	-0.10	0.31	-0.12
x19	0.59	0.94	12.53	-1.01	0.75	-0.36	1.30	-0.44
x20	-0.41	-0.33	3.32	0.18	0.09	0.15	-0.07	0.25

CONCLUSION: This study firstly applied the ANNAMT to sports practice. This system has been demonstrated to be superior to both past and present analysis methods in many aspects. For example, there are advantages in standardization and planning of the technique analysis course. It is also considered to possess the "intelligence" of decision-making, which to some extent avoids the subjectivity and empiricism in training and research. It was able to separate the complex study from the more urgent application. This was compatible with in-depth study, and application of the results to training simply and directly. In addition, this technique gave t significant consideration to the systematical properties of human movement and other basic features that exist between the technique factors. Examples of these are the nonlinear relationships, hierarchy, variation, interaction and others. Therefore, this model was

a closer approximation of actual human movement.
The ANNAMT was able to be flexible in carrying out application of the research. It was able to meet the various needs of sport technique research. The present study could accomplish three types of technique analysis simultaneously. The first was reduction to the common technique principles of the specialized item/activity. The second analysis involved illustration of specific technique features of top-level athletes and finally, to accomplish the technique analyses and diagnosis of individuals. This research is systematic and continuous. After new samples were collected the model could be regenerated and the ANNAMT analysis ability could be enhanced. The success of the investigation of female shot put suggested that the artificial neural network has considerable potential for future sports research.

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