ON THE OBJECTIVITY OF KINEMATIC DATA OBTAINED FROM KINEMATIC ANALYSIS OF THE MOVEMENT

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INTRODUCTION

The introduction of new processes and the utilization of increasingly perfect devices leads to the development of systems providing enormous quantities of data. This trend makes itself manifest even in the research of motion via the kinematographical examination method. Yeadon (1994). Wisner (1992) show the basic characteristics for determining points coordinates of accuracy, precision and resolution system. Dainty (1987) and McLaughlin (1977) define various sources of error in the process of data recording and evaluating. The effect of cameras, film materials and recording frequency on the accuracy system has been examined by French (1981). Angulo (1992) and Kennedy (1989) are concerned with the accuracy between film and video techniques. Bate (1993) examined the accuracy of the peak motion measurement system from the viewpoint of object placement on the plane recorded. Given practical demands, it is of the utmost importance to obtain a fast transfer of results. Since in some situations (e.g. races) it is impossible to fasten the signs right on the sportsman's body, the systems for automatic motion record evaluation can't be used well. In this case it proves convenient to treat the videoanalyser record using more subjects. Mekota (1985) designates the dependence of the data evaluated by a single person carrying out the evaluations, as data objectivity. Miller (1973) is concerned with some of the individual factors associated with the objectivity problem. He emphasizes the necessity of locating crucial points on the human body. Shapiro (1987) used to ensure that the video analysis system gave an acceptable representation of digitized points two experienced with film and one novice. The present study tries to solve the following questions:

a) What is the difference between the values (angle sizes) obtained by data evaluation made by more persons ?

b) What part does the evaluator's experience and training play in this difference ?

c) What is the relation between the analysis results obtained by the group of evaluators and the values obtained by repeated evaluation made by a single person only?

METHOD

The evaluation of the record was carried out using the system for the kinematic analysis of ski-jumping developed in our workplace. Within the last two years we have been able to evaluate by this system about 600 take-offs of a ski-jumper. The motion record was made during the Intersporttournee held in Innsbruck in 1992 and 1993 resp. The resolution of the motion analysis system is 0.17% of the field of view. Out of the coordinates of the defined points on the racer's body angle sizes characterizing the take-off course of the jumping skier were determined (see Fig. 1). The treatment of the data obtained went through the following phases:

1. Evaluation of 3 positions of the racer made by a group of 10 persons (physical culture college students) mastering fundamental knowledge of the system's application, whose work was not restricted by any external intervention whatsoever.

2. Evaluation of one position made by 30 persons chosen out of the precending group. Each of these persons took part in an evaluation training (10 practical lessons

over 3 weeks), where the final location of the points chosen on the human body was performed.

3. Comparison of the values obtained by evaluation of one position in a group of 100 jumping skiers. The record obtained was treated by two evaluators. The first of them was concerned with the longterm work using the system, the second was chosen out of the group referred to as sub 2. The same person repeated all of the activity after a week had elapsed, when he had not been engaged with the system.

The statistical data elaboration was carried out using the standard programme STATGRAPHICS. Basic statistical characteristics, coefficient of variance and pair t-test determinations took place in the process. The objectivity coefficient was set as the correlation coefficient between the values measured by two separate evaluators (see sub. 2).

Figure 1 Fundamental schematic of evaluation points and of measured angular values

RESULTS AND DISCUSSION

Sub 1) In table 1 there are examples of the fundamental statistical characteristics obtained by 30 persons for the evaluation of the position on the take-off edge. The range of the variable span in six angles evaluated is remarkably high amounting to 6.10ø-24.63ø (for position 4 m in front of the edge 12.53ø-30.84ø, 2 m behind 7.59ø-32.740). In view of these results, it may well be stated that the mere knowledge of the anatomical body structure is not sufficient to obtain the objectivity required.

Table 1 The angle values obtained after evaluation by 30 people

Angle	Mean	SD	Min	Max	Range	Coeff. of variance
αC	60.21	2.56	54.88	61.92	10.04	4.26
αK	133.25	2.78	129.06	138.70	9.64	2.08
αT	30.08	1.72	26.75	32.85	6.10	5.73
αA	163.78	7.36	151.22	175.85	24.63	4.49
αE	138.36	8.01	131.71	153.18	21.47	5.79
αR	84.12	2.59	80.40	90.87	10.47	3.08

Sub 2) The results obtained by evaluation of one position by 10 persons were compared to those obtained by 25-fold evaluation of the same position by one experienced evaluator (tab. 2). The higher variable span in angle αT - αE obtained by repeated measurement done by one person, was caused by extreme values. The value of the coefficient of variance in the angles in question proves to be lower than in the corresponding ones obtained by the group of 10 evaluators; The differences between angle sizes obtained by the group of 10 persons are comparable with those arising from the repeated evaluation performed by one evaluator.

Table 2 The comparison between 10 persons (after practice) and 1 experienced evaluator

Angle	values after evaluation by 10 persons		25-fold evaluation by experienced evaluator	
	Range	Var.Coeff.	Range	Var.Coeff.
αC	3.50	1.54	4.06	2.10
αK	3.52	1.14	4.21	1.24
αT	2.50	4.75	2.83	3.60
αA	3.83	0.76	4.05	0.57
αE	5.75	1.44	6.17	1.13
αR	2.56	1.00	2.27	0.63

Table 3 The fundamental statistical characteristics for the objectivity determination

Angle		EE	NT	NT7	Eex	NT	Eex	NT7	
αC	57.09	3.57	57.28	3.75	57.90	3.62	.954	-1.486	.921	-5.372
αK	104.41	6.36	107.20	6.95	107.94	6.65	.936	-0.580	.944	-2.422
αT	18.73	.4.84	19.17	4.66	19.67	4.77	.936	-3.381	.941	-6.030
αA	184.90	10.04	185.11	9.08	185.62	9.64	.975	-0.489	.975	-3.247
αE	148.12	15.40	148.99	15.36	149.90	14.95	.976	-2.452	.977	-5.408
αR	93.27	2.71	93.44	3.06	90.50	2.88	.921	-1.767	.918	-2.036

Sub 3) The fundamental statistical characteristics for the obtained data objectivity determination are to be found in tab. 3. The objectivity coefficient value is over the range 0.921 - 0.976. The values of the pair t-test are not (except for the angles αT, αE) statistically significant over 5% of the significance level. For evaluation made after 7 days, the changes of the objectivity coefficient values are not significant (except for angle αC), the pair t-test values are, however, statistically significant for all of the angles over 5 percent of the significance level. The seven-day absence of one of the evaluators led to a decrease in the accordance of data obtained by two evaluators. The degree of that man's training had most likely not reached the desired standard.

CONCLUSIONS

Out of the stated results it may well be deduced that the videorecorder evaluation by more persons can take place on the following conditions:

- knowledge of the system and a good training of the evaluator,
- unambiguous determination of significant points on the human body,
- study of the laws of motion examined,
- repeated training in the case of a long-term interruption of the work on the system.

REFERENCES

Angulo, R.M., Dapena, J. **(1992).** Comparison of film and video techniques for estimating three-dimensional coordinates within a large field. International Journal of Sport Biomechanics. **8, 145-151.**

Bate, P. Hoffmann, E. **(1993).** Accuracy of the peak motion measurement system. In: Proceedings of the 14th Congress ISB '93, Paris, **112-113.**

Dainty, D.A., Norman, R.W. **(1987).** Standardizing biomechanical testing in sport. Champaign, Human Kinetics Publishers.

French, E.K. **(1981)** Validity and reliability of kinematic data from two dimensional cinematography. Unpublished doctoral disertation. Indiana University.

Kennedy, P.W., Wright, D.L., Smith, G.A. **(1989).** Comparison of film and video techniques for three-dimensional DLT repredictions. International Journal of Sport Biomechanics, **5, 457-460.**

McLaughlin, T.M., Dillman, Ch.J., Lardner, T.J. **(1977).** Biomechanical analysis with cubic spline functions. Research Quarterly, **48,570-582.**

Mekota, K. **(1975).** Mereni a testy v antropomotorice. Skriptum. Olomouc. Univerzita Palackeho.

Miller, D.I., Nelson, R.C. **(1973).** Biomechanics of Sport. Philadelphia, Lea & Febiger.

Shapiro, R., Blow, Ch., Rash, G. **(1987).** Vidw digitizing analysis system. International Journal of Sport Biomechanics, **3, 80-86.**

Wisner, D.M. **(1992).** Determination of the precision, accuracy and resolution of a video-based motion analysis system. M.S. Purdue University.

Yeadon, M.R., Challis, J.H. **(1994).** The future of performance-related sports biomechanics research. Journal of Sports Sciences, **12, 3-32.**