AN ANALYSIS OF THE FORWARD STROKE AS USED IN A WILD WATER KAYAK ON FLAT WATERS

Miroslav Janura, Jiří Kratochvíl, Michal Lehnert, František Vaverka

Faculty of Physical Culture, Palacký University, Olomouc, Czech Republic

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The forward stroke is one of the basic motion activities that are typically used for canoeing in white water. Kinematic analysis (4 women, 5 men; junior representatives and talented competitors) of records from three cameras was used. The movement of the kayak was carried out with maximal velocity. General parameters of the stroke on the left and right side of the kayak were determined utilizing the APAS system. Lower velocity losses in the catch and pull phase of the paddle, a shorter time of the pull phase, higher frequency of the strokes are typical for kayakers with better levels of efficiency. The movement of the right and left wrist of these competitors in the frontal plane is more symmetrical. The deviation of the trunk is less in the sagittal plane as well as the sideways movement of the kayak.

Keywords: Kinematic analysis, forward stroke, kayak, wild water.

INTRODUCTION

Technique in the movement activities is sometimes defined as "mechanical skill in art". In the art of kayaking it is necessary to balance the body and the boat simultaneously with producing of the greatest boat speed. Experience and research studies (Lauder & Kemecsey, 1999) have shown that the quality of the forward stroke (in connection with other efficiency factors) is the limit for the maintenance of the maximal velocity of motion. This stroke is the prerequisite for a good level for steering the kayak. The forward stroke is usually divided into four phases: catching the water with the paddle, a pull phase, a recovery (transfer) phase and air-work of the paddle. The first three phases are active and cause the forward motion of the kayak. The most effective is the pull phase with the paddle in a vertical position and with a maximal pull area. Therefore a longer paddle is better, because the paddle is in the optimal position a longer time. In the course of paddling with a shorter paddle, the strokes are shorter. There exist losses in the moment when both blades are out of the water. The tilt of the "upper" hand at the site of the stroke is further disadvantageous. It is not economical because the direction of force of the "push" by the upper extremity is not parallel with the resultant direction of the movement. It produces a lean of the trunk of the paddlers as well as the kayak. The turning of the kayak from the straight direction is considerable if the path of the blade is not close to the kayak. The holding of the paddle in a vertical position, perpendicular to the direction of the movement for a longer part of the stroke is a key sign of the effect. However it is necessary to adjust the length of the paddle to the somatic and physiological properties of the paddler (Bunc et al., 2002; Kračmar et al., 1998).

The aim of the study was to determine valid parameters and use them for the quantification of the differences among the kayak paddlers with various efficiencies in the forward stroke.

METHOD

The training canal, part of the gentle watercourse area was used for recording of the movement of a group of women (n = 4, average age 15.6 ± 3.4) and men (n = = 5, average age 19.5 ± 7.5) who took part in the recording. All these individuals were experienced paddlers, either junior representatives or talented competitors. The number of training units differed from 4 to 8 per week. The banks of the canal were well acceptable for the location of the cameras. The space was delimited by means of two slalom goals (9 m long and 3 m wide; Fig. 1). The track in front of this space was sufficiently long enough to gain the maximal velocity. The space was calibrated by placing a 1 m cube on the canoe (was stabilized with stretched ropes) at the start and finish of the recording space.

The kayakers performed three sprints each with maximal velocity in the calibrated space. Each position was characterized by 10 points: the grip of the hand on the shaft of the paddle (left and right), the elbows (l, r), the shoulders (l, r), the chin, glabella, the ends of the kayak.

Fig. 1
The schema of the analyzed space and the location of the cameras

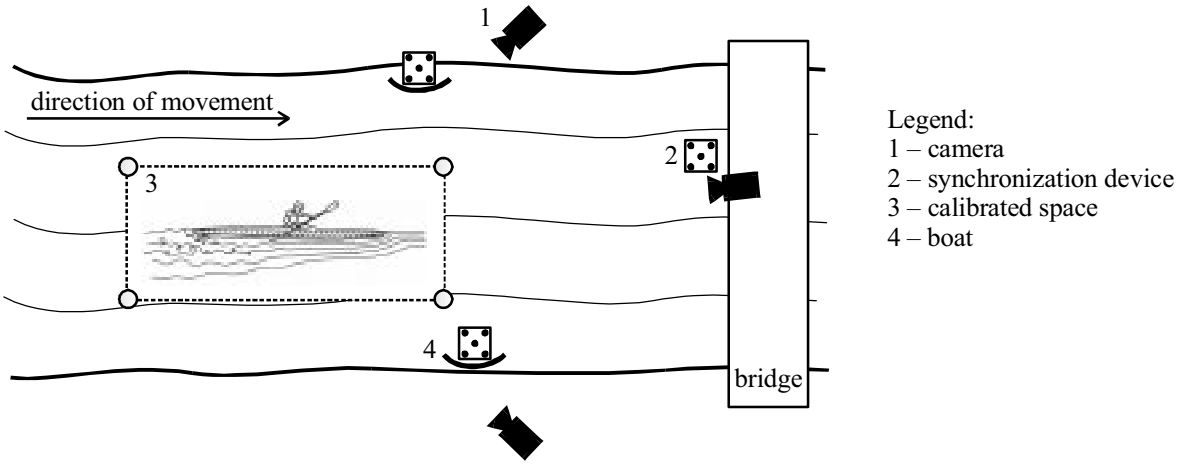


TABLE 1
The basic time parameters in the course of the forward stroke

Parameter	AA*	BB*	CC*	DD*	EE	FF	GG	HH	JJ
V	3.48	3.56	4.12	3.66	3.67	4.30	3.31	3.68	3.79
F	1.75	1.96	2.33	1.96	2.17	2.38	1.82	2.08	1.89
Ts	0.57	0.51	0.43	0.51	0.46	0.42	0.55	0.48	0.53
Tp	0.42	0.38	0.30	0.38	0.33	0.30	0.43	0.37	0.41
Tpp	74	75	70	75	72	71	78	77	77
Ta	0.15	0.13	0.13	0.13	0.13	0.12	0.12	0.11	0.12
Tap	26	25	30	25	28	29	22	23	23

Legend:
V – average velocity in the course of the forward stroke, F – frequency of the strokes, Ts – time of the stroke, Tp – time of the pull phase, Tpp – share of glide time in stroke time (%), Ta – time of the air-work, Tap – share of air-work time in the stroke time (%), * – female

TABLE 2
Basic angle parameters of the forward stroke

Parameter	AA*	BB*	CC*	DD*	EE	FF	GG	HH	JJ
Cr	41	28	35	36	35	39	21	38	30
PUr	20	18	19	22	9	8	20	5	13
Cl	36	28	38	34	39	35	26	35	23
PUl	15	17	12	12	4	5	17	6	18
ECr	135	149	122	135	132	138	133	150	154
EPUr	65	82	66	70	110	72	91	99	91
ECl	117	138	110	133	144	124	137	108	143
EPUl	46	85	62	62	91	71	66	91	94

Legend:
Cr (Cl) – the angle of the catch = the angle between the shaft of the paddle and the horizontal plane in the catch phase on the right (left) side of the kayak
PUr (PUl) – the angle of the pull-up = the angle between the shaft of the paddle and the horizontal plane in the pull-up phase on the right (left) side of the kayak
ECR (ECl) – the angle of the elbow in the catch phase on the right (left) side of the kayak
EPUr (EPUl) – the angle of the elbow in the pull-up phase on the right (left) side of the kayak
* – female

Records were digitalized by means of the APAS system at the frequency of 50 Hz. A sequence of 30 pictures which represented one double stroke (one stroke on the left and right side of kayak) was selected. The parameters were chosen on the basis of researchers and coaches (Plagenhoef, 1979; Kendal & Sanders, 1992; Baker et al., 1999) who had solved similar problems. The numerical data was completed with the graphic interpretation of selected points and body segments.

RESULTS AND DISCUSSION

The basic time parameters of the analysis are given in TABLE 1.

To compare the possibilities of these parameters with the best flatwater kayaking competitors a share (%) of the pull phase in the total time of the stroke (Tpp) was used. These values range from 70% to 78%. Plagenhoef (1979) presents the ideal value of 69%. Kendal and Sanders (1992) measured a range from 65–72%.

The basic angle parameters for the detail analysis of the technique are given in TABLE 2.

The angle of the catch on the right (21–41°) and left (23–39°) side of the boat differs slightly and are similar to the values presented by Plagenhoef (1979). The differences between the angle of the elbow in the catch (left side: 108–144°, right side: 122–154°) and pull-up (left side: 46–94°, right side: 65–110°) phase are bigger. The smaller angle of the elbow is typical for the slalom competitors. They are all always prepared to perform the driving strokes. The average value of the elbow measured from the speed kayak paddlers (Baker et al., 1999) was 146° in the catch and 114° in the pull-up of the paddle.

The inter-individual trajectory differences of the right and left wrist in a frontal plane are illustrated in Fig. 2.

GG – A nearly symmetrical path with maximum range in a horizontal direction. The shape of the paths suggests a big overlapping of the hands over the lengthwise axis of the kayak.

JJ – An expressive asymmetry in the vertical direction influences the deviation of the kayak from a straight direction. For short time activity the asymmetry need not mean errors in the performance of the movement. In this case the difference in size is however a negative phenomenon.

CC – The movement of the right and left hand is fast to a minimum extent in a horizontal direction. It means that exceeding over the lengthwise axis of the kayak does not exist.

Interesting information is afforded by the graphic demonstration of the hands movement with regard to the kayak (in the system paddlers–kayak) in the sagittal plane (Fig. 3).

FF – The greater extent of the right hand in the vertical direction is typical for the dominant extremity.

AA – Trajectories are similarly symmetrical from the point of view of the extent of the vertical and horizontal direction. The pull phase is also similar (the oblique part of the bottom). The different position of the hands in the catch phase on the opposite side of the kayak causes the interruption of the curve.

CC – The similarity of the curve with the trajectory of the best competitors is the greatest. The speed of the left hand in the direction towards the water surface is lower in the first part of the pulling.

CONCLUSIONS

A higher average velocity of the kayak and a lower loss of velocity in the transfer and pull-up phase were found in the group of the best paddlers.

A higher stroke frequency and a higher share of glide time in stroke time are typical for a better performance of the stroke.

The effective technique of the best paddlers can be described as a symmetrical span of the movement of both hands, minimum movement of the trunk in an antero-posterior direction, and a greater rotation of the shoulders.

Fig. 2
Comparison of motion between the left and right wrist in a frontal plane (point C is the position of the paddle at the moment of the catch)

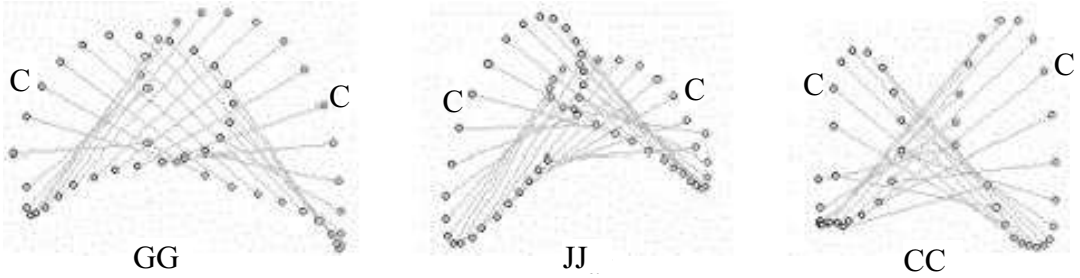
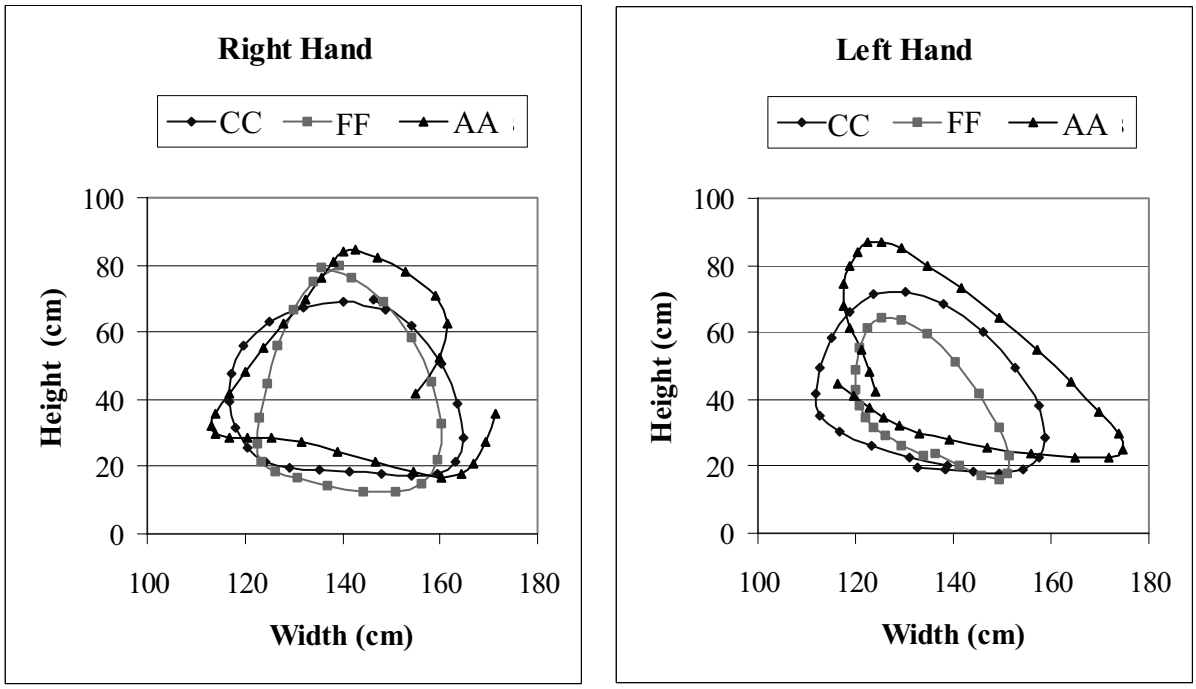


Fig. 3
Trajectory of the right and left hand with regard to the kayak in a sagittal plane



REFERENCES

Baker, J., Rath, D., Sanders, R., & Kelly, B. (1999). A three-dimensional analysis of male and female elite sprint kayak paddlers. In R. Sanders & B. Gibson (Eds.), *Scientific Proceedings of the XVII. International Symposium on Biomechanics in Sports* (pp. 53–56). Perth: Edith Cowan University.

Barton, G. (2002). *Epic wing paddles*. Retrieved 10. 3. 2004 from World Wide Web: http://www.epicpaddles.com/

Bolonsky, A. (2001). Efortless paddling. *Wavelength Paddling Magazine, April/May 2001*. Retrieved 16. 11. 2002 from World Wide Web: http://www.wavelength-magazine.com/2001/am01effort.htm

Bunc, V., Bílý, M., & Kratochvíl, J. (2002). Hodnocení rychlostních a vytrvalostních předpokladů vodních slalomářů v terénu. *Česká kinantropologie*, *3(2)*, 39–51.

Janura, M., Kubu, P., Kratochvíl, J., & Stromšík, P. (2000). Kinematic analysis of forward stroke at wild water kayak paddling. In F. Vaverka & M. Janura (Eds.), *Proceedings of the conference BIOMECHANICS OF MAN 2000* (pp. 251–254). Olomouc: Univerzita Palackého.

Kendal, S. J., & Sanders, R. H. (1992). Technique of elite flatwater kayak paddlers using the wing paddle. *International Journal of Sport Biomechanics, 8(3)*, 233–250.

Kračmar, B., Bílý, M., & Novotný, P. (1998). *Základy kanoistiky*. Praha: Karolinum.

Lauder, M., & Kemecsey, I. (1999). *Kayak technique - diagnosis and remedies*. Retrieved 6. 10. 2001 from World Wide Web: http://www.brunel.ac.uk/~spsrprb/frames/biox.htm

Lazauskas, L., & Tuck, E. O. (1996). *Low drag racing kayaks*. Adelaide: The University of Adelaide, Department of Applied Mathemathics. Retrieved 12. 9. 2001 from the World Wide Web: http://www.maths.adelaide.edu.au/Applied/llazausk/hydro/kayak/racing/racing.htm

Plagenhoef, S. (1979). Biomechanical analysis of Olympic flatwater kayaking and canoeing. *Res. Q. Exerc. Sport, 50(3)*, 443–459.

Rodano, R., Squadrone, R., Sacchi, M., & Marzegan, A. (2001). 3-D kinematic analysis of canoeing on simulator: differences between elite, intermediate and novice canoists. *Biomechanics symposia 2001*. San Francisco: University of San Francisco.

Sanders, R. H. (1998). *Lifting performance in aquatic sports*. Joondalup, Western Australia: Edith Cowan University. Retrieved 3. 10. 2004 from the World Wide Web: http://www.isbs98.uni-konstanz.de/fullpaper/FullRossSanders.pdf

Szanto, C. (1991). *Racing canoeing*. Beijing, China: China Printing Corporation.

Šebesta, P., & Podloucký, V. (2002). *Rychlostní kanoistika a systém tréninku Grega Bartona*. Praha: Český svaz kanoistů.

ANALÝZA ZÁBĚRU VPŘED NA KAJAKU PRO JÍZDU NA DIVOKÉ VODĚ V PŘÍRODNÍCH PODMÍNKÁCH

(Souhrn anglického textu)

Přímý záběr vpřed je jedna ze základních pohybových činností, jejichž zvládnutí je nezbytné pro dosažení kvalitní výkonnosti v kanoistice na divoké vodě. Analýzou záznamů přímého záběru (4 ženy, 5 mužů; juniorští reprezentanti a talentovaní závodníci) jsme ze tří kamer, pomocí systému APAS, určili základní kinematické parametry této pohybové činnosti na pravé a levé straně lodi. Pohyb lodi ve sledovaném úseku byl realizován maximální rychlostí. Pro provedení záběru u lepších kajakářů je typická: menší ztráta rychlosti ve fázi zasazení a přenosu pádla, zkrácení doby trvání fáze tažení, větší frekvence záběrů. U těchto závodníků jsme dále nalezli lepší symetrii pohybu pravé a levé horní končetiny, minimální pohyb trupu v předozadním směru a zmenšení výchylek lodi do stran.

Klíčová slova: přímý záběr vpřed, kinematická analýza, kajak pro jízdu na divoké vodě.

Doc. RNDr. Miroslav Janura, Dr.

Palacký University
Faculty of Physical Culture
tř. Míru 115
771 11 Olomouc
Czech Republic

Education and previous work experience

1992–1996 doctoral study program at Faculty of Physical Culture.

Foreign study visits – 1995 Lakehead University, Thunder Bay, Canada; 1996 Faculty of Sport, University of Ljubljana, Slovenia; 1998 Faculdade Motricidade Humana Lisabon, Portugal.

First-line publication

Janura, M. (2004). *Vybrané poznatky z analýzy techniky skoku na lyžích* [Monografie]. Olomouc: Univerzita Palackého.

Janura, M., Dvořáková, T., & Svoboda, Z. (2004). Využití analýzy videozáznamu pro potřeby hipoterapie. *Rehabilitácia*, *41(2)*, 115–119.

Janura, M., Míková, M., & Krobot, A. (2004). Ramenní pletenec z pohledu klasické biomechaniky. *Rehabilitace a fyzikální lékařství*, *1*, 33–39.

Janura, M., & Zahálka, F. (2004). *Kinematická analýza pohybu člověka* [Monografie]. Olomouc: Univerzita Palackého.