BIOMECHANICAL ANALYSIS OF THE PADDLING TECHNIQUE AND THE VELOCITY OF 1000M FULL PADDLING EVENT: A CASE STUDY.

Yinghua Song, Xiaowei Dong and Yan Wang[1]
Henan Research Institute of Sport science, Zhengzhou, Henan, China
[1]Henan Employee Medical college, Zhengzhou, Henan, China

Biomechanical analysis from data obtained by video camera was used to investigate the paddling technique and the velocity of 1000m full paddling event. The results showed the characteristics and the advantages of Meng's paddling technique. The data also revealed deficiencies and provided a set of kinematics parameters for evaluation, diagnosis and training of paddling techniques.

KEY WORDS: paddling technique, pulling oar force

INTRODUCTION: Meng Guanliang is an experienced Chinese canoeist, who consistently won the gold medal in many important games. In 1997 and 1998, he won the 1000m single paddling competition at the 8th National Games of China. He was also successful at the 13th Asian Games in this event. His best achievement was 4'06", which matched that of the 23rd Olympic Games champion, reaching world class standards. However, there were significant differences in technique when compared with the world champion. In order to determine the extent of his technical capabilities and deficiencies, the paddling technique and the velocity of full paddling were analyzed. By applying the principles of biomechanical analysis, the canoeist can make best use of his technical advantages. Therefore, the purpose of this study is to provide a set of kinematics parameters for evaluation, diagnosis and training of paddling techniques.

METHOD: M-5 Video camera (Vidicon, Japan) and remote measure force instrument was used to obtain a spot test of Meng's (M) 1000 meter.method of paddling. The sampling points were located at 500m and 1000m.
The photos were analyzed by a 85ST-3019 (China) photo analysis instrument . Computer calculations were done on all kinematics parameters.

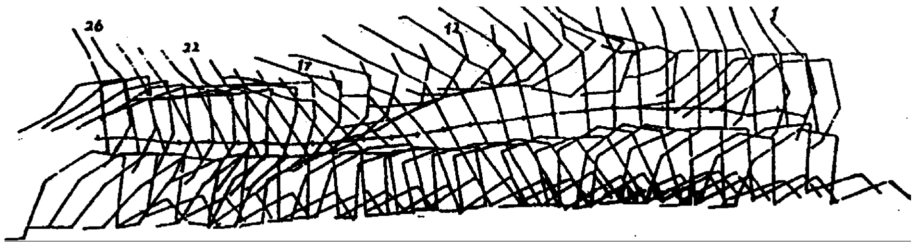


Figure 1 - Continuous roller chart of a motion cycle.

RESULTS AND DISCUSSION: The analysis instrument produced a continuous roller graph of a paddling motion cycle and oar movement (Figure 1 and Figure 2). The force instrument calculated a continuous force curve of paddling (Figure 3 and Figure 4). The other kinematics data are shown in Table 1, Table 2, Table 3 and Table 4. The cycle of paddling motion was divided into five stages. These are swinging the oar in air, inserting oar in air, digging water stage, pulling oar in water, and lifting oar out of water.
Single paddle technical analysis. The technical characteristics of a stroke are presented here. The canoeist's stroke speed was considered to be fast at 4.0m/s (4.06m/s). Stroke displacement was 4.16m. The pulling oar range was 2.65m (2.72m). A stroke took 1.04s (1.07s) to complete. The dispersion of maximum and minimum speed in a motion cycle was as little as 2.56m/s (2.65m/s). Boat barocenter wave was only 0.21m. This was less than the 23rd Olympic Games champion, recorded at 0.25m.

Note: The data in brackets were those of the 23rd Olympic Games champion.

Oar swing in air. This was defined as the stage when oar was brought out of water (Figure 2). The angle between the oar and the horizon varied from 30 degrees to 123 degrees (Table 1). Time elapsed was 0.4s which represented 38.4% of a motion cycle (Table 2). This time was longer than the 32% required by modern paddling technique. The prolonged oar swing time caused a reduction in the boat speed of 1.35m/s.

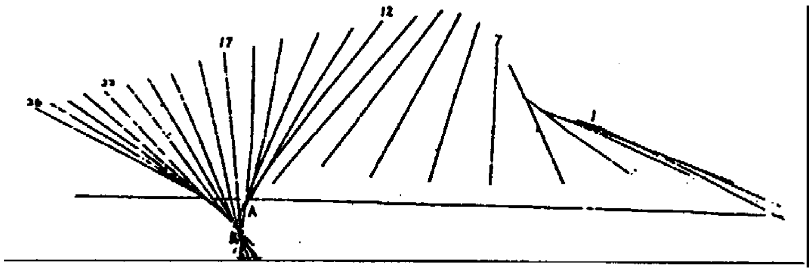


Figure 2 - Continuous moving roller chart of oar

The following were the causes leading to prolonged oar swing time. The oar swing speed was slow. The average angular velocity was only 258 DEG/s. An excess in the amount of body turn lengthened the arc line of oar swing. It had been 0.24s before the oar was lifted from the water.

Table 1 Speed Analysis of Stroke & Instantaneous Angle of Oar

	Swing oar	insert oar	dig water	pull oar	lift oar	emerge water
Speed (m/)	4.31	2.96	3.60	5.21	4.92	4.32
Angle of oar (DEG)	30	123	128	90	45	30

Table 2 Time of Stages & Average Angular Velocity A Stroke

	swing oar	insert oar	dig water	pull oar	lift oar out of water
Time(s)	0.40	0.08	0.16	0.24	0.16
Relative Time (%)	38.4	7.7	15.4	23.1	15.4
Angular speed (DEG/s)	258	62.5	237.5	187.5	93.8

Inserting oar in air. At this stage, the oar moved quickly forwards and down into water from the top point (chart 2). It was short, taking only 0.08s, which was 7.7% of a motion cycle. This time compared favorably to that of the world first class athlete (about 8%). The water entry angle of oar was 128 degrees, which was in the proper range (125°-130°). The turn angular velocity of oar was less at 62.5 DEG/s. This effectively increased the range of the oar.

Digging water stage. In this stage, the oar was pulled from water entry point to the vertical station. From this stage, the paddling generated propelling power. The effective propelling power formula was $F=N\cdot \sin\alpha$ (N is the interaction force of water and oar, α is the angle of oar and horizontal line). The nearer this was to 90 DEG of the water entry angle, the bigger was the value of $\sin\alpha$. It was obvious that the most effective angle of application was between 120 DEG and 60 DEG. So, at the beginning of paddling, athlete should exert strength, reaching maximum strength in this way. It was considered inadvisable to exert

strength in the end stage of paddling.
This stage took the canoeist 0.16s, which was 15% of a motion cycle. The water entry angle of oar varied considerably from 128 DEG to 90 DEG. Angular velocity was 237.5 DEG/s. The relative time of digging water stage was close to that of the world champion. The amount of angular velocity that the Chinese canoeist achieved was greater than that of the world champion (232 DEG/s). All of above factors indicated that the Chinese canoeist was swift and powerful in the digging water stage (at water entry point A. chart 2). In this stage, the speed of canoe increased rapidly from 3.6m/s to 5.21m/s (fastest speed), which was nearly as same as that of the world champion (5.23m/s).
Pulling water stage. After oar passed the vertical station, supporting point moved down to B (chart 2). Then, the process continued to enter pulling oar stage. The interaction force between oar and water reached the maximum value. The angle between the oar and horizon varied from 90 DEG to 45 DEG. The angular velocity was obviously reduced to 187.5 DEG/s. This was demonstrated as the Chinese canoeist maintained maximum speed with a strong pulling technique. This stage took 0.24s, which was 24% of a motion cycle. The speed of the canoe was reduced from 5.21m/s to 4.92m/s. The reduction in speed was not considerable. The high speed of the canoe was sustained by maximum pulling force. However, compared with the world champion, the relative time of pulling oar was less, and the time to keep up canoe high speed was minimal. The reasons for these discrepancies are outlined here. The angular velocity of pulling oar was considerably higher. The turn of oar was larger and the angle of application was not used to its best advantage.
Lifting oar out of water. When oar was pulled too near to athlete body, the angle of oar was out of the proper range, and therefore the pulling oar cannot adequately propel canoe. This process then moved into the stage of lifting oar out of water (chart 2). This stage took 0.16s, which was 15.4% of a motion cycle. The immersion angle was greater at 30 DEG. The standard immersion angle was 27 DEG. The reason leading to a bigger immersion angle was that the angular velocity of pulling oar was less at 93.8 DEG/s. The greater angle was followed by a greater resistance.

Table 3 Time and Speed Subsection of Meng

Subsection of the whole way	250m	500m	750m	1000m
Subsection Time(s)	60.16	122.37	185.35	248.12
Time per stage (s)	60.16	62.21	62.98	62.77
Speed per stage (m/s)	4.16	4.02	3.98	3.97

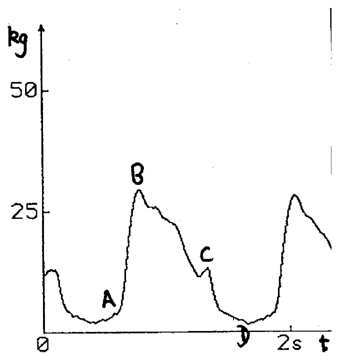
Velocity characteristics of the total performance
Rhythm of speed. In the first 250m event, the canoe speed was fastest at 4.16 m/s. In the 4th 250m event, the speed was slowest at 3.97 m/s. In the final 750m event, canoe speed was steady. The wave range of canoe speed was about 0.05m/s. In the early 750m, the average speed of canoe was 4.05m/s. The difference of canoe speed between early 750m and last 250m was 0.08m/s. Overall, the average speed was 4.03m/s.
These data indicated that the Chinese canoeist had steady speed ability and good speed endurance in final stages. However, his speed in the beginning was a bit slow.
Difference from the 23rd Olympic games champion. From the chart 4, it was clear that the difference in first 250m was 0.86s. This was 47.8% of the whole difference. The difference in the second 250m was only 0.24s. The difference in last 250m was reasonable at 0.29s.

Table 4 Difference From the 23rd Olympic Games Champion

	Achievement (s)	250m	500m	750m	1000m
Olympic Games champion	246.32	59.30	61.97	62.36	62.69
Meng Guanliang	248.12	60.16	62.21	62.77	

62.98				
Difference	-1.8	-0.86	-0.24	-0.41
-0.29				
%	4.78%	13.3%	2 2.8%	16.1%

Characteristics of paddling strength. Figure 3 was the propelling curve that was tested on the oar. The curve was divided into three segments. From point A to point B, the segment zoomed and increased rapidly to maximum. The segment matched the digging water stage. From point B to point C, the segment that declined slowly was the propelling stage of paddling. The segment from point C to D was the lifting oar out of water. In this stage, the curve declined rapidly.



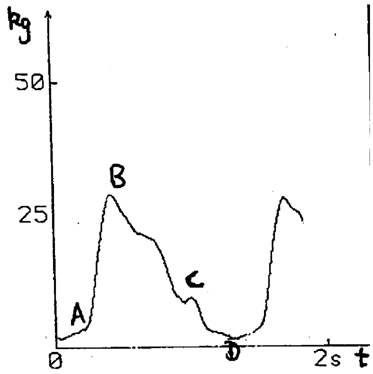


Figure - 3 The propelling curve **Figure – 4 The pulling oar force curve**

From Figure 3, the following conclusions were made on the technique of the Chinese canoeist. The force of digging water was considerable at 28kg. The digging water time was only 0.16s. It showed that as soon as oar entered water, maximum strength was exerted. Then, as quickly as possible, a steady supporting point was found in order to take the advantage for successive pulling oar. In this stage, the speed of canoe was raised rapidly from 3.6m/s to 5.21m/s. Unfortunately, the peak value of digging water force was less than the world class athlete's (about 30kg).
In pulling oar stage, the pulling oar force declined slowly. This took advantage of the angle of application, maintaining pulling oar strength so that canoe gained powerful propulsion.
In lifting oar stage, the force on oar declined rapidly. This was demonstrated by considerable speed in lifting oar stage. The fast speed ensured that the process moved to next paddling cycle as quickly as possible. This was a good technique.
Figure 4 illustrates the pulling oar force curve at the end of event. In shape, it was similar to that at the point of 500m. It showed that the canoeist had good endurance ability that ensured his technique.

CONCLUSION: In general, the Chinese canoeist demonstrated a world class paddling technique with an average speed of 4.03m/s. The reduction of speed was minimal at 2.56m/s. The wave of canoe was also small at 0.21m. His digging water time was short and water entry angle was reasonable. The differences in technique were the following. Swing oar time was rather prolonged at 0.40s. The oar swing was not effective. The pulling oar time was relatively short. The immersion angle was too great. The speed of whole course was fast. The speed in final 750m was steady, but the speed at beginning was relatively slow. Endurance in final stages was good.

REFERANCES:

Andy, Tono. (1991). *Collected edition of canoe*. Wuhan Institute of Physical Education Press (1994). Training material of countrywide gig and canoe coaches, training and technique of canoe. Wuhan, China: Wuhan Instituted of Physical Education Press.
Yin Sulin. (1990). Paper collection of canoeing . Wuhan Institute of Physical Education Press.