The Comprehensive Diagnostic Analysis and Training Program Development of Hong Kong Elite Sprint and Long Jump Athletes

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CONTENT

I. ABSTRACT

The aims of this project were to improve the performance of the elite Hong Kong cerebral palsied athletes in track and field events of 100m sprint and 4x100m relay and to help them to win medals and break the record of these events in 1996 Atlanta Paralympic Games.

To realise these aims, kinematics and dynamics approaches including video filming, motion analysis and Cybex strength test were employed to analyse the techniques of elite Hong Kong cerebral palsied athletes in 100m sprint and 4x100m relay and profile the event related physical fitness of the athletes, so as to provide scientific data and advice to the coaches.

The execution of this research project was divided in two phases. The first phase was confined in the period from April 1995 to November 1995. During this phase emphasis was placed on developing the speed and strength ability, and improving the 100m sprint performance and the strength training were focused. Two comprehensive kinematics tests for sprint running and start technique were conducted in the training sessions. All the data collected were compared with the corresponding able bodied athletes and analysed based on the knowledge of sports science, so as to reveal the individual technique deficit and physical fitness requirement. According to the analysing results, coach worked out the winter training program for the athletes.

The second phase was confined from December 1995 to September 1996, and the emphasis was mainly placed on preparing for the 1996 Atlanta Paralympic Games. Two kinematics tests were completed. The first test was conducted on 5 January 1996 to examine the improvement of speed ability after the execution of the one-year training program and to profile the physical fitness condition of the athletes. In order to help the physically disabled athletes to prepare for the coming Atlanta Paralympic Games, the second test was scheduled on 7 June 1996 in Wan Chai during athletic competition. In this test, four high speed video cameras were combined used to film the 100m sprinting performance of the target athletes over the 100m range. The outcomes of this test provided information to the coach for the detailed training plan towards the Atlanta Paralympic Games. This approach reflected the need of improving the anaerobic endurance power of the subject athletes.

In the 1996 Atlanta Paralympic Games, the Hong Kong physically disabled athletes won the gold medal of 4 x 100m relay and braked the world record of this event with the result of 50.46 seconds. Such achievements have direct impact on the community in terms of the values of the disabled people and promote public awareness of the importance of sports for the disabled.

II. BACKGROUND

In recent years, the sports techniques for the physically disabled athletes have improved substantially. Hong Kong disabled sports are leading Asia in events such as Cerebral Palsied Sprint (100M, 200M, and 400M ranked first), long jump and 4x100M relay (close to world level). Such achievements have direct impact on the community in terms of the values of the disabled. Also, the good performance in sports by disabled athletes can increase the self esteem for both the disabled and able bodied people.

The Hong Kong physically disabled athletes will take part in the 1996 Atlanta Paralympic Games. The current best results of the local cerebral palsied athletes are 12"05 (100m), 57"64 (400m), and 52"5 (4x100m). The goals in the Atlanta Games are to break the world record of 100m (11"79), 400m (56"8) and 4x100m relay (51"5). In order to further improve the sports efficiency in these and other events, a comprehensive study of the sports techniques of the disabled athletes are necessary. It has been shown many times that studying athletic activities using the tools of sports biomechanics, sports physiology and other related areas provides information for training and technique modification which lead to improve performance. However, limited scientific research has been done on the analysis of the disabled athletes, Additional benefits may be gained from studying the performance of the disabled athletes by contribution to help in the medical treatment of the physically disabled.

III. METHODOLOGY

The main approach used in this study includes comparison and analysis. The sports techniques and physical characteristics of the elite disabled sprinters were compared with the able bodied athletes from China and Hong Kong at the relevant level. The data of these able bodied athletes were obtained from the published paper or from our previous researches. The comparison and analysis were based on the knowledge of sports science to indicate the individual deficit both in technique and with specific aspects of physical fitness.

The methods of kinematic and dynamic analysis were used in this study. In the kinematic analysis four video cameras were combined used to record the technical characters of the physically disabled athletes over the total 100m range. The video tapes were then digitised and analysed on Peak Motion Analysis System. In dynamic analysis, the strength test system of Cybex 6000 was employed to profile the strength conditions of disabled sprinters. According to these information, suggestions towards strength training were offered to coaches. Details of the methodology employed in this research were given in the following sections.

III. RESULTS AND DISCUSSION

Part 1

ANALYSIS ON TECHNIQUE DEFICIENCY OF DISABLED SPRINTER CHAN SING CHUNG AND THE WAYS OF IMPROVEMENTS

INTRODUCTION

Chan Sing Chung, Hong Kong disabled sprinter, achieved three gold medals of 100m, 200m and 400m sprints in 1994 FESPIC and his best result of 100m sprint is 12.05s. In order to help him to improve his technique for the coming Atlanta Paralympic Games, we used high speed video camera to film his performance during his training sessions on 6 June 1995. The results that we obtained will discuss with the coach of Chan to find out the ways of improvement.

PURPOSE

To find out the technique deficiency of disabled sprinter Chan Sing Chung and the ways of improvements.

METHODS

A video camera with frequency 50Hz and shutter speed 1/250s was situated at the left pointing perpendicular to the motion plane with a distance 20m apart. Three trial runs were filmed at this training session. Each analysis, 3 strides at the range of 27 to 33m away from the starting point were used. The video materials were then processed by PEAK PERFORMANCE SYSTEM. The data was compared with Ku Wai Ming, the Hong Kong 100m elite sprinter.

RESULTS AND DISCUSSION

Table 1. The time parameter of Chan Sing Chung and Ku Wai Ming

Name	Trial	Range (m)	Supporting time ST (s)			Flight time FT (s)			Total time (s)			ST:FT		
			R-1	L-2	R-3	R-1	L-2	R-3	R-1	L-2	R-3	R-1	L-2	R-3
Chan	1st	27-33	0.12	0.10	0.10	0.12	0.14	0.14	0.24	0.24	0.24	1:1	1:1.4	1:1.4
	2nd		0.10	0.12	0.12	0.12	0.12	0.12	0.22	0.24	0.24	1:1.2	1:1	1:1
	3rd		0.12	0.10	0.12	0.12	0.14	0.12	0.24	0.24	0.24	1:1	1:1.4	1:1
		Mean:	0.113	0.107	0.113	0.12	0.133	0.127	0.233	0.24	0.24	1:1.07	1:1.27	1:1.13
Ku		30-40	0.095			0.12			0.215			1:1.25		

R-1: 1st stride (right leg takeoff)
L-2: 2nd stride (left leg takeoff)
R-3: 3rd stride (right leg takeoff)

Table 2. The parameters of stride frequency, stride length and average speed of CM.

Name	Trial	Range (m)	Stride frequency SF (1/s)			Stride length SL (m)			Average speed AS (m/s)		
			R-1	L-2	R-3	R-1	L-2	R-3	R-1	L-2	R-3
Chan	1st	27-33	4.55	4.17	4.17	1.81	1.98	1.97	8.23	8.25	8.21
	2nd		4.35	4.00	4.55	1.86	1.96	1.76	8.09	7.84	8.00
	3rd		4.17	4.17	4.17	1.93	1.94	1.94	8.04	8.08	8.08
		Mean:	4.36	4.11	4.30	1.87	1.96	1.89	8.12	8.06	8.10
Ku		30-40	4.65			2.14			9.95		

With reference to table 1,

1. Chan's supporting time, was comparatively long. This phenomenon exits in both legs. This may due to the strength of his legs and the problem of neuromuscular co-ordination.
2. Chan's flight time was fairly good. There is no great difference when compared with the data of Ku Wai Ming. There was no obvious technique difference between Chan's legs.
3. Chan's total time was comparatively long because of his long supporting time. This will affect his stride frequency and speed.
4. Chan should reduce the supporting time so that the ratio of ST and FT falls between 1:1.2 and 1:1.4 which are reasonable.

With reference to table 2,

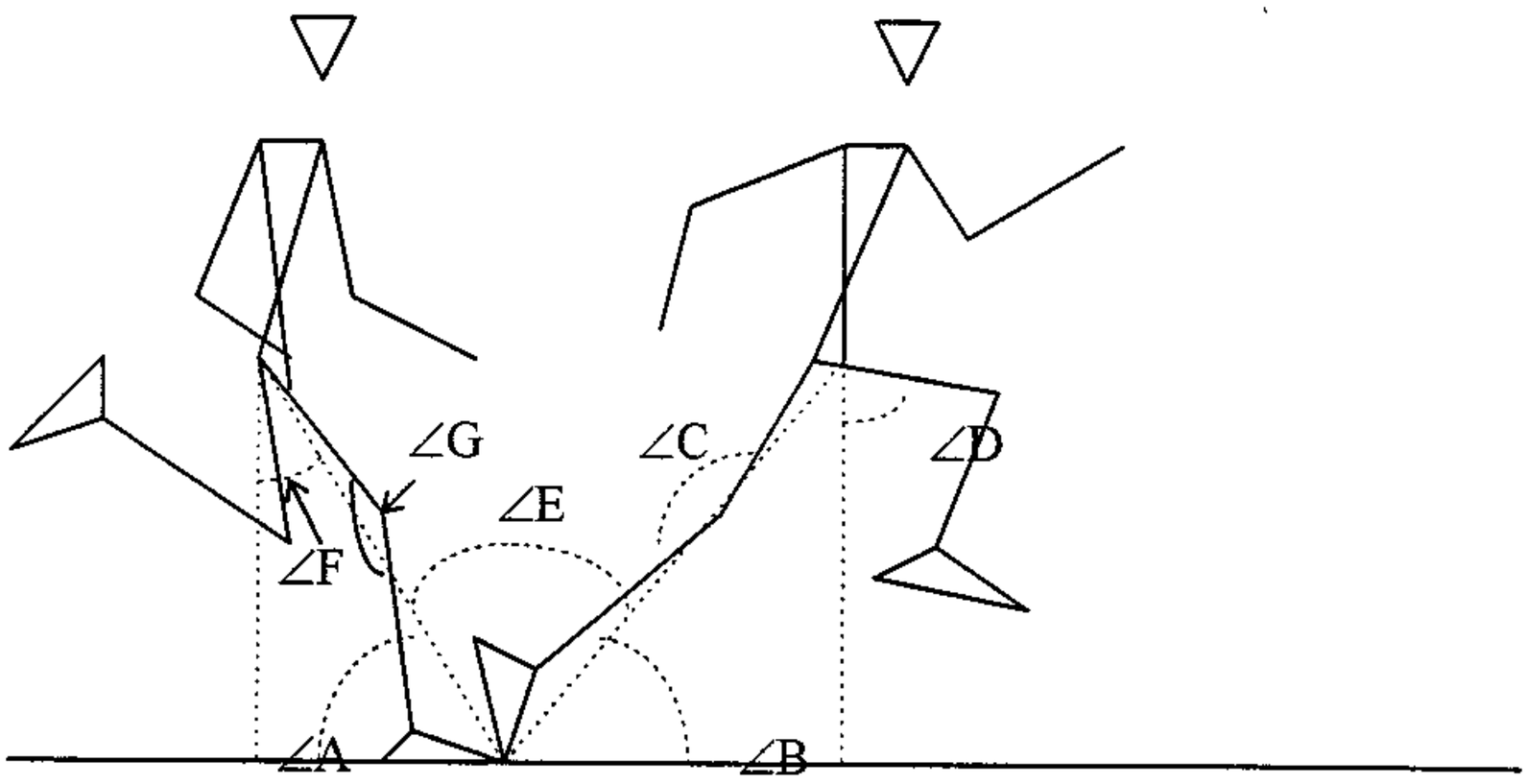
1. Chan's stride frequency, stride length and average speed were less than Ku. If he want to achieve the result of 12.00s, his average speed must exceed 8.5m/s in 30-40m distance. Also, the parameters of SF and SL should be improved.
2. The stride frequency at second stride (L-2) is greater than at first stride (R-1) and third stride (R-3).
3. The stride length at the second stride (L-2) was more stable and longer than the first and the third one.

Table 3. The angular parameters

Name	Trial	Range (m)	∠A (°)			∠B (°)			∠E (°)			Vsua (°/s)		
			R-1	L-2	R-3	R-1	L-2	R-3	R-1	L-2	R-3	R-1	L-2	R-3
Chan	1st	27-33	68.8	64.3	63.7	56.7	60.1	62.8	57.5	55.6	53.5	472.5	556.0	535.0
	2nd		67.6	60.9	62.2	59.7	54.4	58.3	52.7	64.7	59.5	527.0	539.1	495.8
	3rd		66.2	65.6	64.0	53.8	58.5	54.9	60.0	55.9	61.1	500.0	559.0	509.2
		Mean:	66.5	63.6	63.3	56.7	57.7	58.7	56.7	58.7	58.0	499.8	551.4	513.3
Ku		30-40	55.2			61.0			63.7			672.0		
			∠C (°)			∠D (°)			Vpa (°/s)			∠G (°)		
			R-1	L-2	R-3	R-1	L-2	R-3	R-1	L-2	R-3	R-1	L-2	R-3
Chan	1st	27-33	150.2	156.6	150.5	72.6	73.3	72.3	444.3	442.0	429.8	130.4	134.6	135.4
	2nd		150.6	154.9	150.4	69.6	71.6	70.1	390.2	424.8	378.0	134.0	137.3	139.6
	3rd		147.0	152.6	146.9	69.6	75.9	68.6	408.5	445.1	396.4	135.6	138.2	136.7
		Mean:	149.3	154.7	149.3	70.6	73.6	70.3	414.3	437.3	401.4	133.3	136.7	137.2
Ku		30-40	158.0			78.0			530			149.1	154.0	

∠A: Touchdown angle
∠B: Takeoff angle
∠E: Supporting angle
Vsua: Average angular velocity of supporting angle
∠C: Knee angle at takeoff
∠D: Lifting knee angle of swinging leg at takeoff
Vpa: Angular velocity of pawing
∠G: Knee angle at touchdown

Fig. 1 Stick figure showing the joint angles



With reference to table 3,

1. The touchdown angle (∠A) was comparatively large and the knee angle at touchdown (∠G) was less than Ku. Although this technique can reduce the resistance at touchdown, it is the main reason to cause his stride length less than Ku.
2. The take-off angle (∠B) and knee extension angle (∠C) are reasonable.
3. Supporting angle (∠E) and the supporting angular velocity were small. This made the stride frequency and speed becoming small. This may due to the low muscle strength of leg.
4. The knee lift angle (∠D) was not large enough. This can affect his stride length.
5. The pawing angular velocity was small. This will increase his supporting time and reduce his speed. This may due to the problem of neuromuscular-muscular problem and also the hip & thigh muscles were not strong enough.

CONCLUSION AND SUGGESTION

Chan is a potential disabled sprinter. After our analysis, we discovered that there is no obvious difference of his sprinting technique between right and left legs. It is important that he should try to reduce his supporting time and increase his stride length.

Detail explanations were given below:

1. From the data, we observed that there was no obvious difference in technique between two legs. This is abnormal in disabled sprinter. This may due to the technique of the normal leg (left) was affected by the disabled leg. Since it is difficult for him to control the disabled leg smoothly, we suggest that technique training should concentrate on the normal leg.

2. He should pay attention to this during his technique training. The pawing technique at touchdown was not good enough. A special strength training program for the muscles of hip and ankle extensions should be employed.
3. Moreover, he should increase his knee extension angle during touchdown. Hence, the pawing technique will be improved and the stride length will be increased.
4. The ability of rapid extension of legs should be strengthen by strength training program.

This is our first biomechanical analysis for disabled sprinter. Since there is a lack of data in disabled sprinters, we used Hong Kong 100m sprinter Ku Wai Ming's data for our reference. We hope that the coach often gives us idea and discusses with us in order to help Chan to achieve a better result.

Part 2

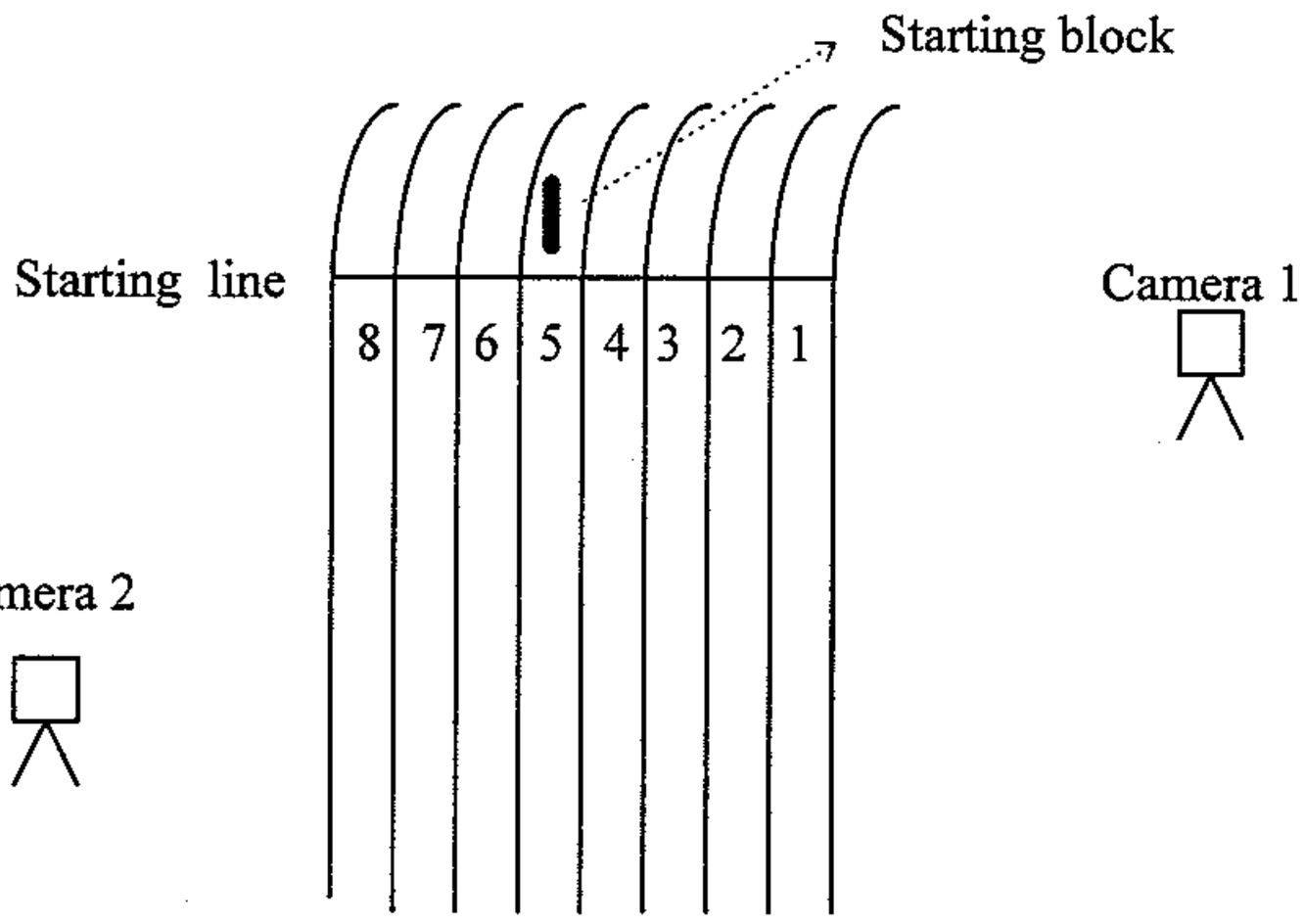
ANALYSIS ON SPRINT START TECHNIQUE OF 100M SPRINTER CHAN SING CHUNG

PURPOSE

The purpose of this study was to find out the sprint start characteristics of disabled sprinter Chan Sing Chung and his drawback, so as to set-up a technique profile.

METHODS

Figure 1: Position of the video cameras.



Two video cameras with frequency 50Hz and shutter speed 1/500s were laid up at the left and the front right with respect to the sprinter (Figure 1). Then video materials were analysed with PEAK PERFORMANCE SYSTEM.

The data were compared with the world top level sprinters.

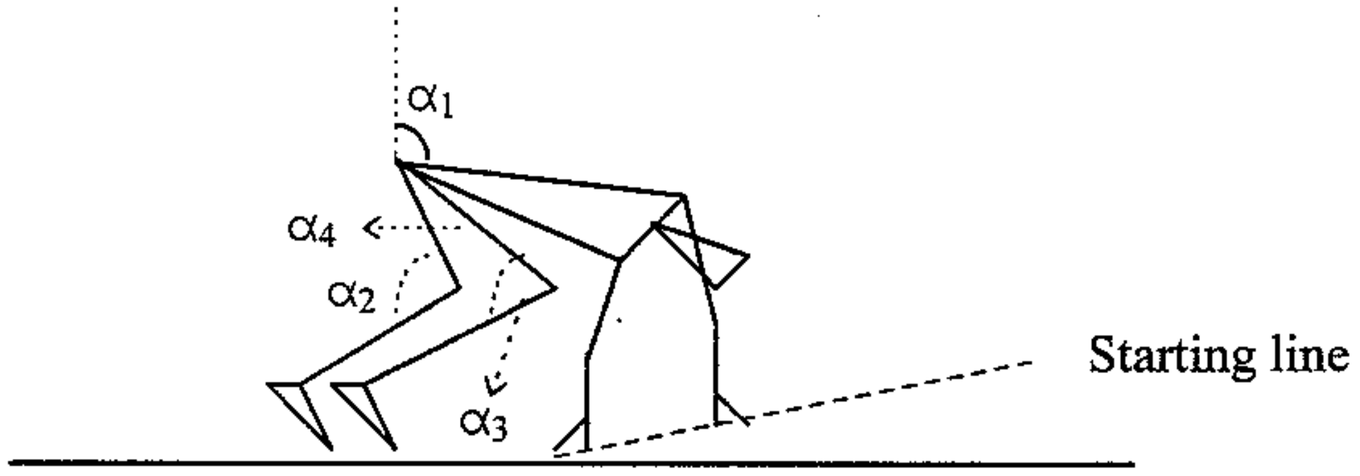
RESULTS AND DISCUSSION

Table 1: Kinematic parameters at sprint start and takeoff.

Trial	α_1 (°)	α_2 (°)	α_3 (°)	α_4 (°)	H_{cm} (cm)
1	108.8	85.7	118.1	33.5	0.655
2	111.5	99.2	124.9	27.1	0.651
3	111.5	97.6	117.2	30.6	0.648
Mean	110.6	94.2	120.7	30.4	0.651
[π] Lit	104 (98-112)	100 (92-105)	129 (115-138)	34 (27-40)	0.6-0.66

α_1 - Angle of forward inclination of trunk.
α_2 - Fore knee angle (left).
α_3 - Back knee angle (right).
α_4 - Lateral angle between thighs.
H_{cm} Height of mass centre at takeoff.
[π] Literature value.

Figure 2: Stick figure showing the joint angles of set posture.



From Table 1, when Chan was in his set position (Figure 2), his mean forward inclination angle of trunk (α_1) was 110.6° and fell within the rational range which is between 98° and 112°. The literature value was 104°. Front and back knee angles and the lateral angle between thighs (α_4) fell within the range. But the data were at the lower boundary. Chan should increase his knee angles (α_2 & α_3) for 6° to 8°. There are two different ways to attain this. First, raising the hip up, but the forward inclination angle (α_1)of body may exceed the rational range. Second, moving the mass centre slightly to the front so that the distance between the body mass centre and start line could be shortened when the sprinter was in set position. However, the body load on two arms will be great. When the sprinter started, he/she could obtain relatively large horizontal component of takeoff force so that a high horizontal velocity and acceleration power could be produced. At the same time, the body mass centre could be increased gradually so that better starting technique could be achieved.

Table 2: Takeoff duration.

Trial	T (s)	Mean (s)	Result of 100m sprint (s)	Horizontal velocity of mass centre at start (m/s)	Mean (s)
1	0.26			2.78	
2	0.24	0.247	12.05	2.96	2.90
3	0.24			2.97	
World	0.257		10.83	3.31	
class	0.359	0.323	10.95	3.53	3.40
female	0.369		11.12	3.75	
sprinters	0.307		11.08	2.99	

From Table 2, the average takeoff duration of Chan was 0.247s. But the literature value was 0.323s. The average horizontal velocity of Chan's start was 2.9m/s. The literature value was 3.4m/s. From these data, we know that the horizontal velocity of Chan's start was relatively low. I believe that this is related to the posture of sprint start and takeoff motion. The takeoff technique was not good enough, so that his power could not fully release. As the result, the horizontal velocity will be lower.

Table 3: Time distribution at different phases.

Trial	T_1 (s)	T_2 (s)	T_3 (s)	T_4 (s)	T_5 (s)	T_A (s)	T_6 (s)	T_7 (s)	T_8 (s)	T_B (s)	T_9 (s)	T_{10} (s)	T_{11} (s)	T_c (s)	T (s)	T' (s)
1	0.26	0.08	0.06	0.14	0.08	0.28	0.04	0.10	0.06	0.20	0.06	0.10	0.14	0.30	1.12	1.20
2	0.24	0.10	0.06	0.10	0.08	0.24	0.02	0.12	0.10	0.24	0.02	0.10	0.10	0.22	1.04	1.16
3	0.24	0.08	0.06	0.10	0.08	0.24	0.02	0.12	0.10	0.24	0.02	0.10	0.10	0.22	1.02	1.16
Mean	0.247	0.093	0.060	0.113	0.08	0.253	0.027	0.113	0.087	0.227	0.033	0.100	0.113	0.246	1.06	1.173
World class sprinter	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0.91-0.97

T_1- Duration of takeoff.
T_2- First flight time.
T_3- Right leg touchdown time.(first stride)
T_4- Right leg pawing time. (first stride)
T_5- Second flight time.
T_6- Left leg touchdown time. (second stride)
T_7- Left leg pawing time. (second stride)
T_8- Third flight time.
T_9- Right leg touchdown time. (third stride)
T_{10}- Right leg pawing time. (third stride)
T_{11}- Fourth flight time.
T_A- First stride time.
T_B- Second stride time.
T_c- Third stride time.
T- Total stride time for 3 strides (exclude reaction time).
T'- Five metre time.

From table 3, Chan took 1.17s to lapse five metres and literature value was 0.91-0.97s. The different was from 0.20 to 0.26s.

Table 4: Stride lengths

Trial	First stride (m)	Second stride (m)	Third stride (m)	Fourth stride (m)	Sum of four strides (m)
1	0.961	0.954	1.109	1.34	4.364
2	0.959	0.878	1.079	1.286	4.202
3	0.882	0.898	0.985	1.211	3.976
Mean	0.934	0.910	1.058	1.279	4.180

Table 4 shows the stride lengths of Chan.

CONCLUSION

The joint angles of Chan at set position were reasonable. However, if he could move his body mass centre slightly forwards, his horizontal velocity at start could be increased. Therefore, his sprint start technique could be improved.

At leaving the starting block, his front leg should be extended fully, hence, the horizontal velocity could be increased.

Part 3

KINEMATICS AND DYNAMICS PROFILE OF 100M SPRINTER CHAN SING CHUNG

PURPOSE

The purpose of this study was to analyse the techniques of sprint and long jump events of cerebral palsied athletes using the kinesiological, biomechanical and physiological approaches and to provide the scientific data and advice to the coach in such way to assist the coach to enhance the performance of these events of Hong Kong.

METHODS

Four 3CCD video cameras (50Hz) with shutter speed 1/500s were located at 16m 26m, 36m, and 46m away from the 100m start line. Panning technique was employed so that the movement of the sprinter was captured from 10m point to 90m point. 40 calibration marks were put at the side of the track. Each marks was 2m apart starting from 10m point to the end of track. Four complete strides were selected at 10m intervals from the video materials for analysis by the PEAK Performance System.

In order to profile the muscular dynamic characteristics, the Cybex 6000 machine was used to measure the strength of the knee, ankle, and hip muscles.

RESULTS AND DISCUSSION

Kinematic analysis

Table 1: The kinematic data of Chan Sing Chung and Top Chinese female sprinters.

Distance	Name	Time (s)	No. of stride	*Average stride length	Average velocity	Max. velocity
10-20m	Chan	1.30	5.6	1.79	4.31	8.48
	Zhang	1.29	5.7	1.76	4.41	
	Tian	1.33	6.3	1.58	4.75	
20-30m	Chan	1.20	5.1	1.96	4.25	8.78
	Zhang	1.03	5.1	1.95	4.98	
	Tian	1.07	5.3	1.88	4.97	
30-40m	Chan	1.20	5.0	1.99	4.18	8.94
	Zhang	1.01	4.9	2.03	4.86	
	Tian	1.04	5.1	1.95	4.92	
40-50m	Chan	1.16	4.8	2.07	4.16	9.30
	Zhang	1.00	4.8	2.07	4.83	
	Tian	1.02	5.1	1.99	4.93	
50-60m	Chan	1.16	4.8	2.07	4.16	8.90
	Zhang	1.00	4.8	2.07	4.84	
	Tian	1.04	5.2	1.98	4.85	
60-70m	Chan	1.16	4.8	2.07	4.16	9.31
	Zhang	1.01	4.9	2.05	4.82	
	Tian	1.07	5.1	1.97	4.74	
70-80m	Chan	1.18	4.8	2.07	4.07	9.16
	Zhang	1.03	4.9	2.03	4.79	
	Tian	1.09	5.1	1.98	4.65	
80-90m	Chan	1.22	4.8	2.07	3.95	9.00
	Zhang	1.03	4.9	2.05	4.72	
	Tian	1.09	5.4	2.01	4.57	

Chan : Chan Sing Chung
Zhang : Zhang Cai Hua
Tian : Tian Yu Mei
* The stride length was calculated with respect to the mass centre.

From Table 1 :

1. The technique of Chan between 40-70m was stable. The stride length was maintained at about 2.07m starting from the distance of 40m. The highest velocity achieved was 9.31 m/s. This reflects the training level was high. However, if Chan wanted to attain the result within 12 seconds in 100 sprint. The highest velocity should be 9.6m/s or above. This can be achieved by increase the amount of training in rapid motion so that the velocity of immediate run can be improved.

2. The differences of stride lengths of Chan and top chinese female sprinters was great. This may due to the neuro-muscular disording of his leg. Therefore, the

increase in the neuro-muscular control ability was the major factor to improve the result.

Result of 100m sprint

Zhang Cai Hua :11.35s
Tian Yu Mei :11.77s
Chan Sing Chung : 12.05s

Table 2: The time parameters of Chan Sing Chung and Ku Wai Ming

Name	Distance	Flight time		Supporting time		Time for one stride		Supporting time/ Flight time	
		Left	Right	Left	Right	Left	Right	Left	Right
Chan Sing Chung	10-20m	0.13	0.13	0.10	0.10	0.23	0.23	1:1.3	1:1.3
	20-30m	0.15	0.13	0.10	0.09	0.25	0.22	1:1.5	1:1.44
	30-40m	0.14	0.14	0.10	0.10	0.24	0.24	1:1.4	1:1.4
	40-50m	0.14	0.14	0.10	0.10	0.24	0.24	1:1.4	1:1.4
	50-60m	0.14	0.15	0.10	0.09	0.24	0.24	1:1.4	1:1.67
	60-70m	0.13	0.15	0.10	0.09	0.23	0.24	1:1.3	1:1.67
	70-80m	0.14	0.14	0.11	0.10	0.25	0.24	1:1.27	1:1.4
	80-90m	0.15	0.14	0.11	0.10	0.26	0.24	1:1.36	1:1.4
	Mean	0.14	0.14	0.103	0.0963	0.243	0.236	1:1.37	1:1.45
Ku Wai Ming	30-40m	0.12		0.095		0.215		1:1.25	

Right: Right takeoff leg.
Left: Left takeoff leg.
Supporting time: Time period between a leg touching the ground and take off.
Flight time: Period between a leg take-off from the ground and touch down of another leg.
Stride time: Supporting time + flight time.

From Table 2:

The takeoff time of left leg was a little longer. The supporting time of right leg was relatively long at the moment of the left leg takeoff.

The contact time includes the sum of landing, supporting and takeoff times.

Table 3: The joint angles and angular velocities.

Name	Distance	∠A °		∠B °		∠C °		∠D °		∠E °		∠F °		Vsup (deg/s)		Vpa (deg/s)	
		L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
Chan (second test)	10-20	68.1	67.2	62.0	63.0	153.0	154.9	61.9	72.8	51.3	49.9	132.8	142.4	513	499	426	432
	20-30	72.0	73.3	57.6	51.8	158.6	151.3	65.9	65.9	50.4	55.1	146.9	133.0	457	551	500	507
	30-40	65.6	59.7	64.8	67.8	154.5	154.6	64.5	66.3	53.1	52.6	140.0	145.5	546	526	464	396
	40-50	63.6	66.4	58.6	60.8	159.5	156.2	58.7	58.9	57.7	55.1	140.1	136.8	577	551	453	433
	50-60	69.8	64.4	60.5	65.1	156.2	155.3	57.6	60.2	49.8	56.7	142.7	138.3	553	567	491	479
	60-70	70.6	67.1	62.7	60.0	159.1	161.5	54.1	54.2	46.6	53.0	150.9	138.2	515	530	464	444
	70-80	63.9	63.3	61.1	63.5	159.5	154.8	60.0	61.0	53.9	57.1	133.9	143.1	539	518	438	386
	80-90	66.4	64.8	58.6	55.7	159.3	157.2	59.9	54.1	55.1	62.9	140.8	135.9	551	524	474	405
	Mean	67.5	65.8	60.7	61.0	157.5	155.7	60.3	61.7	52.2	55.3	141.0	139.2	529	533	464	435
Chan (first test)	27-33	64.9	63.6	57.7	57.7	154.7	149.3	70.5	73.6	57.4	58.7	135.3	136.7	507	551	437	408
Ku Wai Ming	30-40	55.2		61		158.0		78.0		63.7		154.0	149.1	672.0		530	

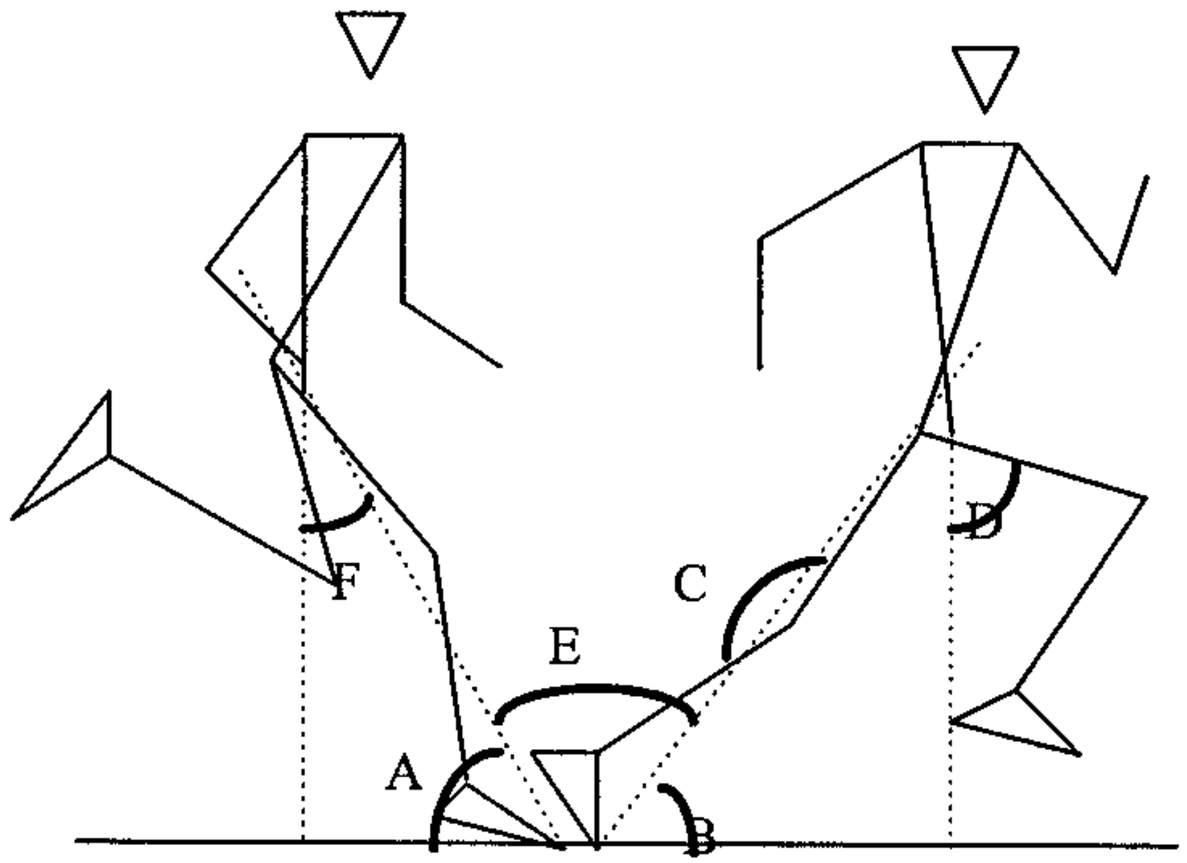
Definition of some terms (Figure 1):

Touch down angle (∠A): At the instant of touch down, the angle between the horizontal line and the line joining the hip joint and toe.
Takeoff angle (∠B): At the instant of takeoff, the angle between the horizontal line and the line joining the hip joint and toe.
Supporting angle (∠E): 180 ° - (∠A + ∠B)
Knee extension angle (∠C): At the instant of take off, the angle between thigh and shank of supporting leg.

Knee lift angle (∠D): At the instant of take off, the angle between the vertical line and the line joining the hip joint and knee joint of swinging leg.

Pawing angle (∠F): At the instant of the front paw touch down, the angle between the vertical line and the line joining the hip joint and toe.

Figure 1: Definition of Angles.



From Table 3:

The angular velocity of pawing (Vpa) was increased when compared with the last result.

The touchdown angle (∠A) and takeoff angle (∠B) was larger than last result. This will reduce the supporting angle (∠E). However, the angular velocity of supporting angle (Vsup) did not increase. This indicates the power of ankle flexion and extension were not enough. The Cybex result has already proven this. In addition, by observation from the video tape, Chan touchdown with his sole. This led to a large touchdown angle and also major reason that the small angular velocity of supporting angle.

At the instant of the extension of knee, the upward angle of swinging leg (∠D) was reduced. This will affect the stride length.

The kinematic parameters of left and right leg had obvious differences except angular velocity of pawing (Vpa).

Cybex Result

Knee Extension/Flexion

1. In terms of strength, Chan got good level of slow speed strength for both legs, although there was about 10% discrepancy between left and right knees at 60 deg/sec.
2. The weak point for Chan may be the speed power capacity and capability of his right leg. Therefore speed and power training for his right knee muscle is suggested. Moreover, general muscle training for his knee flexors on both knee should be increased in order to make his H:Q Peak torque ratio increase to over 65%.
3. Moreover, he has to train his left knee extensor in full range of motion.

Ankle

Very weak dorsiflexor, has to do more training for both legs, in order to raise the dorsiflexors/plantorflexors peak torque ratio higher than 30%.

Hip

For the hip flexor, the bilateral discrepancy was getting less as measured at very high speed of movement - 300deg/sec.

But according to the graphs, his left side hip movement was not doing good. He has to re-do this test, before any conclusion can be made.

CONCLUSION

1. The technique of immediate run of Chan was stable.
2. The major factor affect the result was the stride frequency. Therefore, the increase in stride frequency was the major topic in his training program. i.e. strengthen the co-ordination of the neuromuscular control.
3. The fast muscle group for the flexion and extension of ankle and knee were weak. This led to the angular velocity of the swinging of supporting leg too slow. This should be paid attention to the training of the contraction of fast muscle.
4. During touchdown, rapid pawing technique should be emphasised.
5. We paid attention to the development of the disabled leg at the same time the ability of normal leg should be improved.

Part 4

KINEMATIC PROFILE OF 100M SPRINTING TECHNIQUE AND WAYS FOR IMPROVEMENT - PREPARING CHAN SING CHUNG FOR 1996 ATLANTA PARALYMPIC GAMES

INTRODUCTION

Chan Sing Chung, Hong Kong disabled sprinter, will take part in the coming Atlanta Paralympic games in September this year. In order to help him to prepare for this competition, the fourth test was organised on 7 June 1996 in Wan Chai during the athletic competition in which Chan competed. The results that we obtained were discuss with the coach of Chan to find out the ways of improvement.

PURPOSE

The purpose of this study was to find out the technique deficiency of disabled sprinter Chan Sing Chung and the ways of improvements.

METHODS

Three video cameras with frequency 50Hz and shutter speed 1/500s were situated at the right side of Chan Sing Chung pointing perpendicular to his motion plane with a distance about 20m apart. The range of 20m to 80m away from the starting point were used. The video materials were then processed by PEAK PERFORMANCE SYSTEM. The data was compared with his previous results.

RESULTS AND DISCUSSION

Table 1: The kinematics parameters of Chan Sing Chung in two different trials.

Distance	Test	Time spent	No. of strides	Average strid length	Average stride freq.	Average velocity	Maximum velocity
20-30	Second	1.20	5.1	1.96	4.25	8.35	8.18
	Third	1.17	5.1	1.97	4.33	8.54	9.13
30-40	Second	1.20	5.0	1.99	4.18	8.37	8.94
	Third	1.14	4.8	2.06	4.25	8.75	9.31
40-50	Second	1.16	4.8	1.99	4.16	8.58	9.30
	Third	1.14	4.8	2.07	4.24	8.77	9.40
50-60	Second	1.16	4.8	2.07	4.16	8.58	8.90
	Third	1.19	4.9	2.05	4.10	8.40	9.16
60-70	Second	1.16	4.8	2.07	4.16	8.59	9.31
	Third	1.18	4.9	2.04	4.15	8.48	9.13
70-80	Second	1.18	4.8	2.07	4.07	8.47	9.16
	Third	1.19	4.9	2.05	4.09	8.41	8.97

From Table 1:

1. The first 50m was performed quite well since most of the data were obviously improved. The maximum velocity was 9.40m/s.
2. The next 50m was performed not so well when compared to the second test. The data reflects his anaerobic endurance was not enough. Therefore, he should be increased his anaerobic ability in his training.
3. The key factor that affected Chan's result was the low stride frequency. In his training, the neuromuscular control exercise should be included like down slope running, windward running, high knee & high speed station running, small stride running and "running the mark" which is designed to increase the stride frequency.

Table 2: Time parameters.

	Distance	Flight time		Support time		Time for one complete stride		Support : flight	
		L	R	L	R	L	R	L	R
Second Test	20-30	0.15	0.13	0.10	0.09	0.25	0.22	1:1.5	1:1.44
	30-40	0.14	0.14	0.10	0.10	0.24	0.24	1:1.4	1:1.4
	40-50	0.14	0.14	0.10	0.10	0.24	0.24	1:1.4	1:1.4
	50-60	0.14	0.15	0.10	0.09	0.24	0.24	1:1.4	1:1.67
	60-70	0.13	0.15	0.10	0.09	0.23	0.24	1:1.3	1:1.67
	70-80	0.14	0.14	0.11	0.10	0.25	0.24	1:1.27	1:1.4
	Mean	0.14	0.142	0.10	0.095	0.24	0.236	1:1.38	1:1.5
Third Test	20-30	0.12	0.14	0.10	0.10	0.22	0.24	1:1.2	1:1.4
	30-40	0.13	0.15	0.10	0.09	0.23	0.24	1:1.4	1:1.5
	40-50	0.14	0.14	0.10	0.09	0.24	0.23	1:1.5	1:1.4
	50-60	0.14	0.14	0.10	0.10	0.24	0.24	1:1.4	1:1.4
	60-70	0.14	0.14	0.10	0.10	0.24	0.24	1:1.4	1:1.4
	70-80	0.13	0.14	0.11	0.10	0.24	0.24	1:1.3	1:1.3
	Mean	0.13	0.142	0.102	0.097	0.235	0.238	1:1.137	1:1.4

R:	The stride that the right leg started to takeoff.
L:	The stride that the left leg started to takeoff.
Supporting time:	Time period between a leg touching the ground and take off.
Flight time:	Period between a leg take-off from the ground and touch down of another leg.
Stride time:	Supporting time + flight time.

From Table 2:

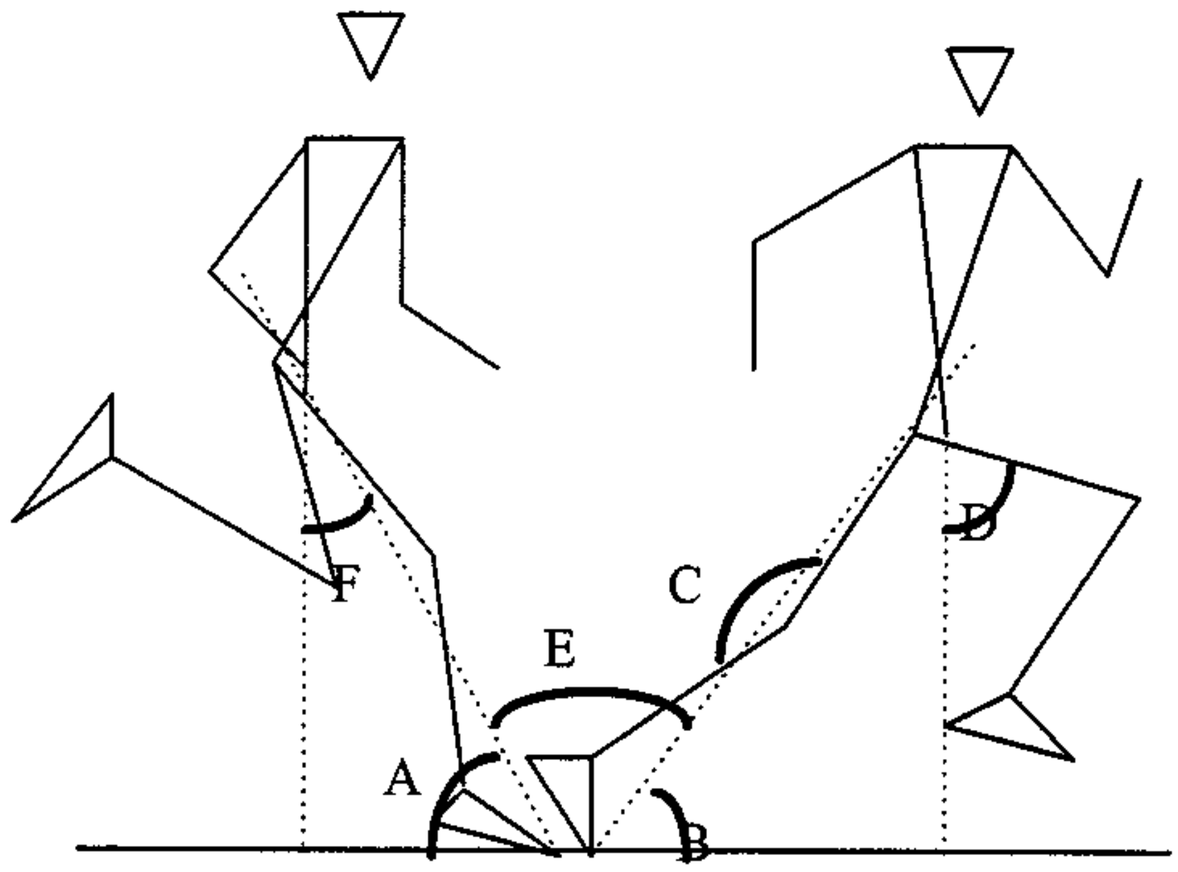
1. The flight time of Chan when his left leg started to takeoff was shorter than the flight time of Chan when his right leg started to takeoff.
2. The supporting time of right leg was long.
3. No obvious differences in time parameters between left and right leg.

Table 3: Angle parameters.

Name	Date	Distance	∠A °		∠B °		∠C °		∠D °	
			L	R	L	R	L	R	L	R
Chan	6/1/95	27-33	64.9	63.6	57.7	57.7	154.7	149.3	70.5	73.6
Sing	25/12/95	10-90	67.5	65.8	60.7	61.0	157.5	155.7	60.3	61.7
Chung	7/6/96	20-80	67.4	68.3	57.3	56.2	159.2	160.2	54.8	52.5
Ku Wai Ming		30-40	55.2		61		158.0		78.0	
Name	Date	Distance	∠E °		∠F °		Vsua (deg/s)		Vpa(deg/s)	
			L	R	L	R	L	R	L	R
Chan	6/1/95	27-33	57.4	58.7	135.3	136.7	507	551	437	408
Sing	25/12/95	10-90	52.2	55.3	141.0	139.2	529	533	464	435
Chung	7/6/96	20-80	56.1	55.4	140.0	139.4	583	554	485	477
Ku Wai Ming		30-40	63.7		154.0	149.1	672		530	

Touch down angle (∠A):	At the instant of touch down, the angle between the horizontal line and the line joining the hip joint and toe.
Takeoff angle (∠B):	At the instant of takeoff, the angle between the horizontal line and the line joining the hip joint and toe.
Knee extension angle (∠C):	At the instant of take off, the angle between thigh and shank of supporting leg.
Knee lift angle (∠D):	At the instant of take off, the angle between the vertical line and the line joining the hip joint and knee joint of swinging leg.
Supporting angle (∠E):	180 ° - (∠A + ∠B)
Pawing angle (∠F):	At the instant of the front paw touch down, the angle between the vertical line and the line joining the hip joint and toe.
(Vsua):	Average angular velocity of supporting angle.
(Vpa):	Angular velocity of pawing.

Figure 1: Definition of Angles.



From Table 3:

1. The angular velocity of pawing was obviously increased especially in right leg (disabled) so that the value was almost the same of the left leg.
2. The angular velocity of supporting phase ($\angle$E) in both legs were improved.
3. At the instant of the extent of supporting leg, the upward angle of swinging leg ($\angle$D) was decreased. This will reduce the stride length.
4. At the extent of supporting leg, the knee angle ($\angle$C) was greater than before. This reflects the extent was enough. However, the stride frequency of Chan was low. The "bend driving" style technique should be employed.
5. The angular parameters were quite the same between left and right legs.

CONCLUSION AND SUGGESTION

1. The key factor to improve Chan's result was to increase the stride frequency. If he wanted to achieve the result around 12 seconds, the stride frequency should be above 4.3 strides/second in 20m to 80m range.
2. The speed endurance of Chan should be increased. The technique and power of Chan at the last 50m were poor. A scientific training plan should be arranged two months before the Olympic games. The speed endurance should be focused on during the last training session before Olympic Games.
3. The angular velocities of pawing and swinging were greatly increased. Try to continue to increase these ability in future training.
4. Before Olympic games, Chan should monitor his body function so that the physical fitness should be in the best condition to take part in the Olympic games.
5. The starting technique of Chan was relative poor. Therefore this should be paid more attention to.

V. SUMMARY OF THE RESEARCH PROJECT

The premeditated results of this study has been achieved and the research paper "*The technical analysis of the Asian top disabled sprinter - Chan Sing Chung*" was published in June 1996 at the Symposium of International Biomechanics in Sports. The response to this presentation was very positive. ISBS Chairman commended, that this research was the first one in the ISBS symposium history, and the results were significant. This study is agreed to be a good start as an essential part of sports science development in Hong Kong in providing support to disabled sports. Some of the achievement of this research, both in the development of methodology and acquisition of knowledge, can be described as follows:

- More than two cameras were combined used in this project to film the sprinting performance of Hong Kong physically disabled sprinters over the 100m range. So that more complete diagnosis could be realised.
- The profile of sprinting technique of Hong Kong cerebral palsied athletes were obtained.
- The profile of muscle dynamic characteristics of Hong Kong cerebral palsied athletes were obtained.
- Technique support to Hong Kong disabled athletes was given. No doubt, this support contributed to the improvement of training programs and achievement in sports performance.

It is international widely recognised that the sports biomechanics has become more and more important to enhance the athletic performance, when they really want to break the records or become the top level athlete or win medals in the high level international competition. This fact was further proved by this research project. It is hoped that the Hong Kong cerebral palsied athletes will maintain their international leading position. To achieve the aim, continues support to the disabled sports from all aspects of our community is necessary. Some suggestions were given as follows:

- More attention should be paid to help the elite disabled athletes, who have won great honour for Hong Kong, in their living, studying and training problems, and their career opportunity as well.
- More sports science support should be provided to the elite disabled athletes of Hong Kong to help them improving physical fitness and sports performance.
- More attention should be placed on the training which directly prepare the athletes for important competition. The training site out of Hong Kong, for example in China, would benefit the athletes of their good preparasion for competition.

ABSTRACT

THE COMPREHENSIVE DIAGNOSTIC ANALYSIS AND TRAINING PROGRAM DEVELOPMENT OF HONG KONG ELITE SPRINT AND LONG JUMP ATHLETES

Submitted By

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To

The Hong Kong Sports Development Board

January 1997

I. ABSTRACT

The aims of this project were to improve the performance of the elite Hong Kong cerebral palsied athletes in track and field events of 100m sprint and 4x100m relay and to help them to win medals and break the record of these events in 1996 Atlanta Paralympic Games.

To realise these aims, kinematics and dynamics approaches including video filming, motion analysis and Cybex strength test were employed to analyse the techniques of elite Hong Kong cerebral palsied athletes in 100m sprint and 4x100m relay and profile the event related physical fitness of the athletes, so as to provide scientific data and advice to the coaches.

The execution of this research project was divided in two phases. The first phase was confined in the period from April 1995 to November 1995. During this phase emphasis was placed on developing the speed and strength ability, and improving the 100m sprint performance and the strength training were focused. Two comprehensive kinematics tests for sprint running and start technique were conducted in the training sessions. All the data collected were compared with the corresponding able bodied athletes and analysed based on the knowledge of sports science, so as to reveal the individual technique deficit and physical fitness requirement. According to the analysing results, coach worked out the winter training program for the athletes.

The second phase was confined from December 1995 to September 1996, and the emphasis was mainly placed on preparing for the 1996 Atlanta Paralympic Games. Two kinematics tests were completed. The first test was conducted on 5 January 1996 to examine the improvement of speed ability after the execution of the one-year training program and to profile the physical fitness condition of the athletes. In order to help the physically disabled athletes to prepare for the coming Atlanta Paralympic Games, the second test was scheduled on 7 June 1996 in Wan Chai during athletic competition. In this test, four high speed video cameras were combined used to film the 100m sprinting performance of the target athletes over the 100m range. The outcomes of this test provided information to the coach for the detailed training plan towards the Atlanta Paralympic Games. This approach reflected the need of improving the anaerobic endurance power of the subject athletes.

In the 1996 Atlanta Paralympic Games, the Hong Kong physically disabled athletes won the gold medal of 4 x 100m relay and braked the world record of this event with the result of 50.46 seconds. Such achievements have direct impact on the community in terms of the values of the disabled people and promote public awareness of the importance of sports for the disabled.

Specific Recommendation Regarding The Application Of The Research Findings For Coaches, Administrators And Athletes

From The Final Report

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The running technique of Hong Kong elite disabled athletes were analysed using both motion analysis and muscle dynamic testing methods. Our attention was mostly placed on the technique improvement of Chan Sing Chung, who played determinant rule in the 4×100m relay in 1996 Atlanta Paralympic Games. In this competition, Chan Sing Chung and his team-mates won the gold medal and broke the Olympic record. Although this brilliant success, we still would like to give some recommendations to coaches and athletes for further improvement.

Leg Techniques during Sprinting:

1. From the data, we observed that there was no obvious difference in technique between two legs. This is abnormal in disabled sprinter. This may due to the technique of the normal leg (left) was affected by the disabled leg. Since it is difficult for him to control the disabled leg smoothly, we suggest that technique training should concentrate on the normal leg.
2. He should pay attention to this during his technique training. The pawing technique at touchdown was not good enough. A special strength training program for the muscles of hip and ankle extensions should be employed.
3. Moreover, he should increase his knee extension angle during touchdown. Hence, the pawing technique will be improved and the stride length will be increased.
4. The ability of rapid extension of legs should be strengthen by strength training program.

The Start Techniques:

1. The joint angles of Chan at set position were reasonable. However, if he could move his body mass centre slightly forwards, his horizontal velocity at start could be increased. Therefore, his sprint start technique could be improved.

2. At leaving the starting block, his front leg should be extended fully, hence, the horizontal velocity could be increased.

The Muscle Dynamic Characteristics of the Legs:

1. The technique of immediate run of Chan was stable.
2. The major factor affect the result was the stride frequency. Therefore, the increase in stride frequency was the major topic in his training program. i.e. strengthen the co-ordination of the neuromuscular control.
3. The fast muscle group for the flexion and extension of ankle and knee were weak. This led to the angular velocity of the swinging of supporting leg too slow. This should be paid attention to the training of the contraction of fast muscle.
4. During touchdown, rapid pawing technique should be emphasised.
5. We paid attention to the development of the disabled leg at the same time the ability of normal leg should be improved.

The Strategy for 100m Race:

1. The key factor to improve Chan's result was to increase the stride frequency. If he wanted to achieve the result around 12 seconds, the stride frequency should be above 4.3 strides/second in 20m to 80m range.
2. The speed endurance of Chan should be increased. The technique and power of Chan at the last 50m were poor. A scientific training plan should be arranged two months before the Olympic games. The speed endurance should be focused on during the last training session before Olympic Games.
3. The angular velocities of pawing and swinging were greatly increased. Try to continue to increase these ability in future training.
4. Before Olympic games, Chan should monitor his body function so that the physical fitness should be in the best condition to take part in the Olympic games.
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It is international widely recognised that the sports biomechanics has become more and more important to enhance the athletic performance, when they really want to break the records or become the top level athlete or win medals in the high level international competition. This fact was further proved by this research project. It is hoped that the Hong Kong cerebral palsied athletes will maintain their international leading position. To achieve the aim, continues support to the disabled sports from all aspects of our community is necessary. Some suggestions were given as follows:

1. More attention should be paid to help the elite disabled athletes, who have won great honour for Hong Kong, in their training and their career opportunity.
2. More sports science support should be provided to the elite disabled athletes of Hong Kong to help them improving physical fitness and sports performance.
3. More attention should be placed on the training sessions which directly prepare the athletes for important competition. The training site out of Hong Kong, for example in China, would very well benefit the athletes of their good preparation for competition.

- End.