Quintic 4 Education

Case Study 6 – Cycle Ergometer

Proposed Subject Usage:

Coaches
Physiotherapy
Strength & Conditioning
Sports Science (1st/2nd and 3rd year)
Education Key Stage 4 +

Objective

- To identify difference in the cycling technique induced by seat height.
- To identify differences in the cycling technique induced by frequency (RPM)

Introduction

1) Method - Seat Height

The subject was asked to cycle at a constant rate of 70RPM, at 6 different seat heights (4,6,8,9,10 and 12) marked out on the cycle ergo meter. 30 seconds of 100Hz (Basler – High Speed Camera) video footage was taken per seat height. The video was calibrated using both a vertical and horizontal calibration measurement and automatically digitised. The data was then reduced to 3 complete leg cycles. (One complete cycle is defined as lowest vertical position of the toe, to lowest vertical position of the toe of the same foot on the next cyclic action).

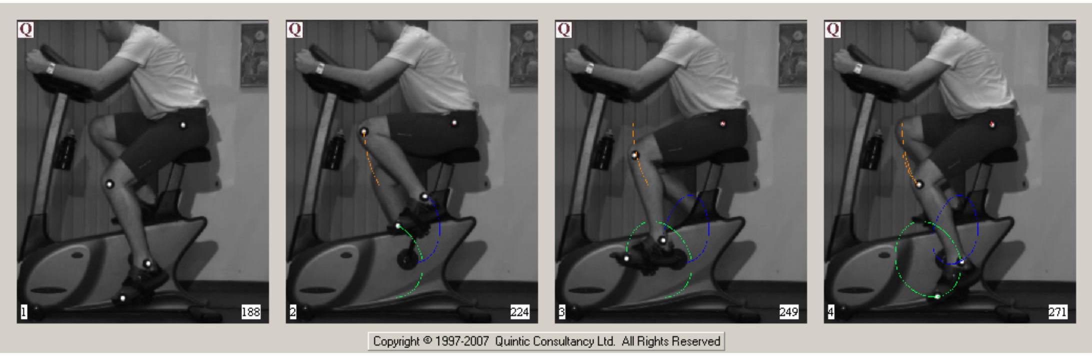


Figure 1: 100fps digitisation trace 1 complete cycle.

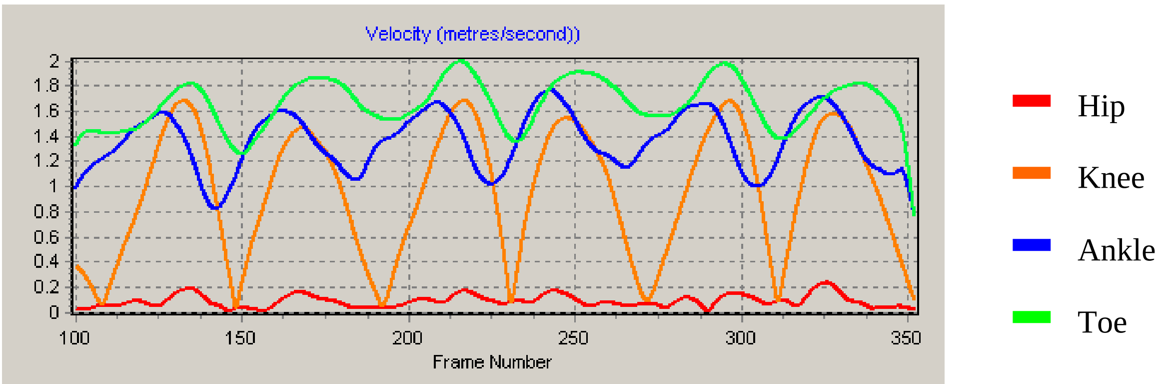


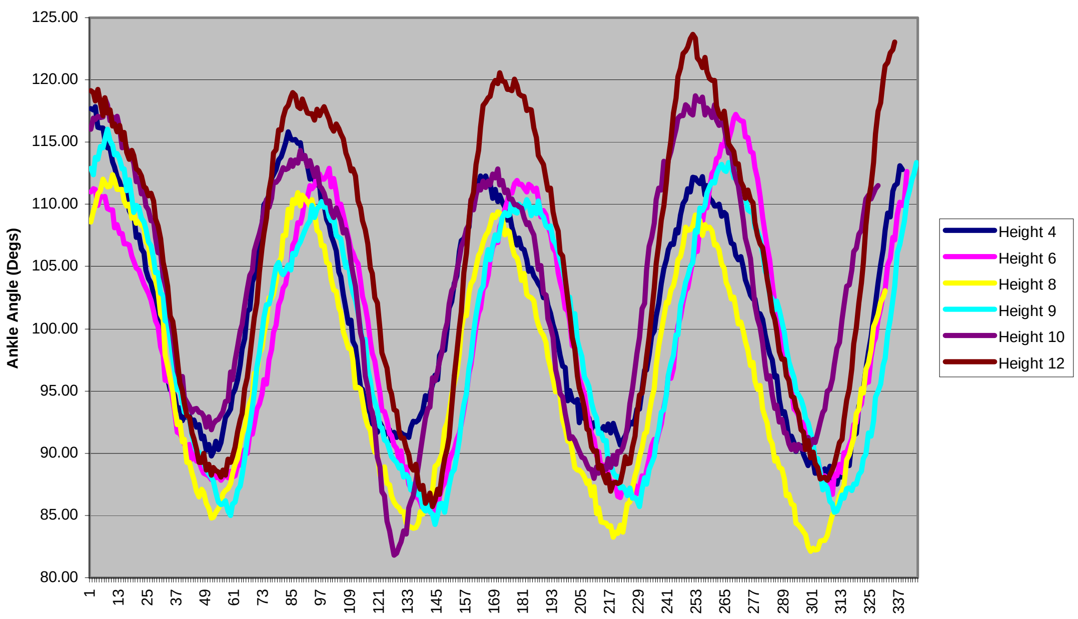
Figure 2: Velocity Graph at seat height 4 exported from Quintic Biomechanics v14

Quintic Biomechanics v14 Software functions that were used:

- Quintic Basler Capture
- Quintic Automatic Tracking
- Quintic Calibration
- Quintic Linear/Angular Analysis
- Export Analysis
- Export Data
- Image Capture

Results

Ankle Angle During the Cycling Action at Various Seat Heights



Knee Angle During the Cycling Action at Various Seat Heights

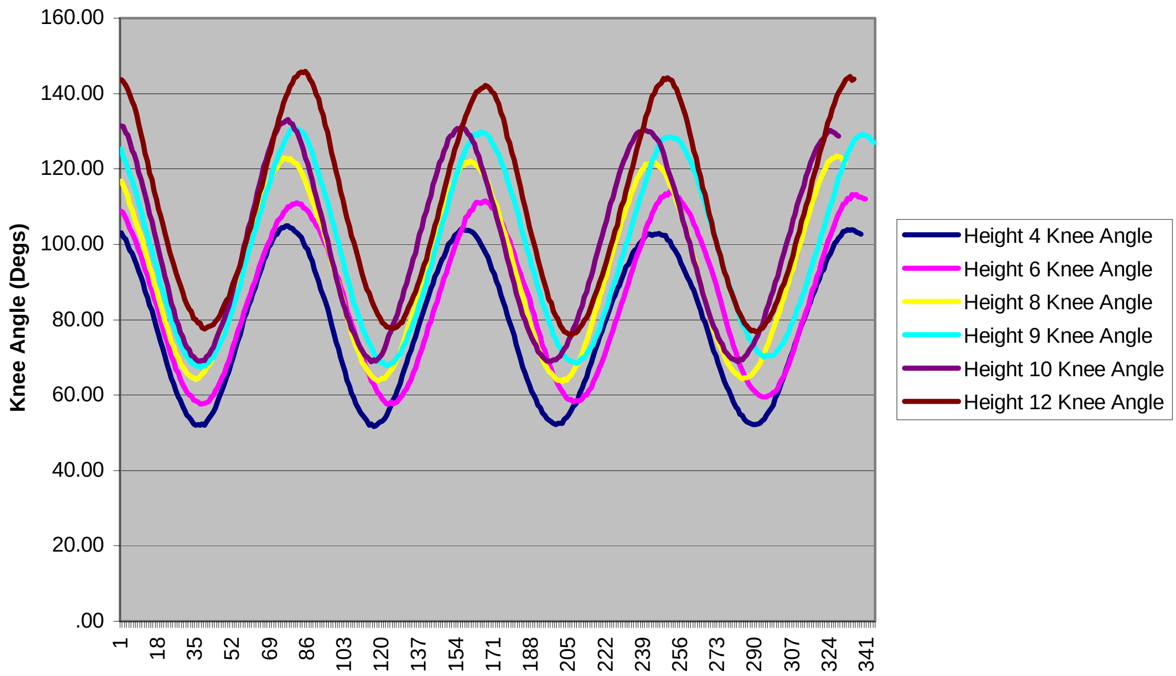


Table 1: shows the average values for Knee angles at TDC and BDC as well as the angular range of motion.

Seat Height	Knee Angle TDC	Maximum Knee Angle BDC	Range of Angular Knee Movement
4	51.98	104.99	53.01
6	57.69	111.10	53.40
8	64.13	122.93	58.79
9	67.34	130.96	63.63
10	69.02	133.18	64.16
12	79.06	145.77	66.71

Table 1

Table one illustrates that as seat height is increased maximum knee flexion increases at top dead centre (TDC) from 51.98º during the trial at height 4 to 79.06º during the trial at height 12. Maximum knee extension also increases near the BDC from 104.99º to 145º during trial 12.Analysis of the ankle angle during the cycling action shows that, as the seat height increases, so does the range of ankle motion Table 2 illustrates that angular range of motion of the ankle increased from 25.63º at the lowest seat height (4) up to 33.23º at the highest seat height (12). As saddle height increases, ankle plantarflexion increases near bottom dead centre (BDC) from 115.86º at seat height 4 to 118.96º at seat height 12 to prevent the knee from becoming fully extended.

Table 2: shows the average values for Ankle angles at TDC and BDC as well as the angular range of motion

Seat Height	Ankle Angle TDC	Ankle Angle BDC	Range of Angular Ankle Movement
4	90.23	115.86	25.63
6	87.87	112.45	24.58
8	85.54	110.94	25.39
9	85.01	110.21	25.20
10	81.81	114.36	32.55
12	85.73	118.96	33.23

Table2

Although power output was not calculated during this exercise, it it widely recognised that seat height is also linked to power production. If the seat is to high, force transfer through the quariceps and into the pedal crank is not effiecent. If the seat is to low the active muscles are restricted so cannot extend to the optimal force generating length. Alteration of saddle height by only 4% can affect power output by approximately 5%, or 84 seconds on a 28-minute, 15 kilometres time trial. (Lucia et al, 2001)

Future studies could include using varying types of bike frame of set-up, to examine how much different frame set ups, such as racer, triathlon, trial or mountain bike effect the kinematic movements of the cyclist. Future studies could also include the collection of power data to see which frame geometries allow the rider to produce maximum power. A research program like this would allow an athlete to identify which bike set up is efficient for which type of race, whether the race demands explosive power, or strength endurance.

2) Method Frequency (rpm)

The same subject was asked to cycle at his preferred seat height (9) and cycle at 5 different rpm (60,70,80,90,and 100) for 30 seconds. 30 seconds of 100Hz video capture commenced once the subject had signalled that he had reached the designates work rate. The video was then calibrated using both a vertical and horizontal calibration measurement and automatically digitised. The data was then reduced to 3 complete leg cycles for ease of analysis. (One complete cycle is defined as lowest vertical position of the toe, to lowest vertical position of the toe of the same foot on the next cyclic action).

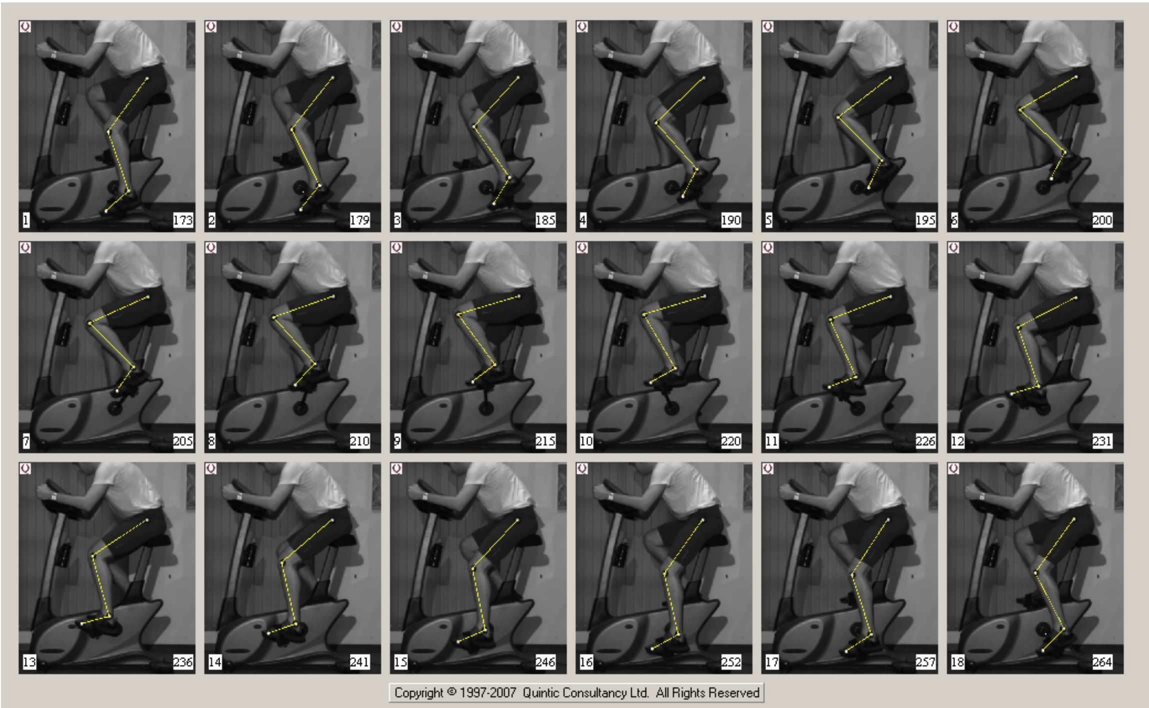


Figure 3: 4 Point (Hip, Knee, Ankle, Toe) Automatic digitisation at 100rpm exported from Quintic Biomechanics v14

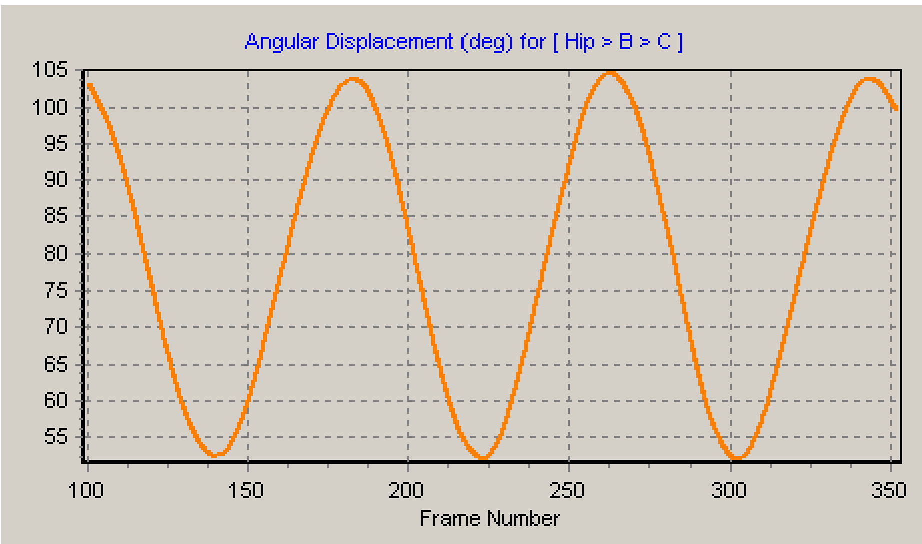
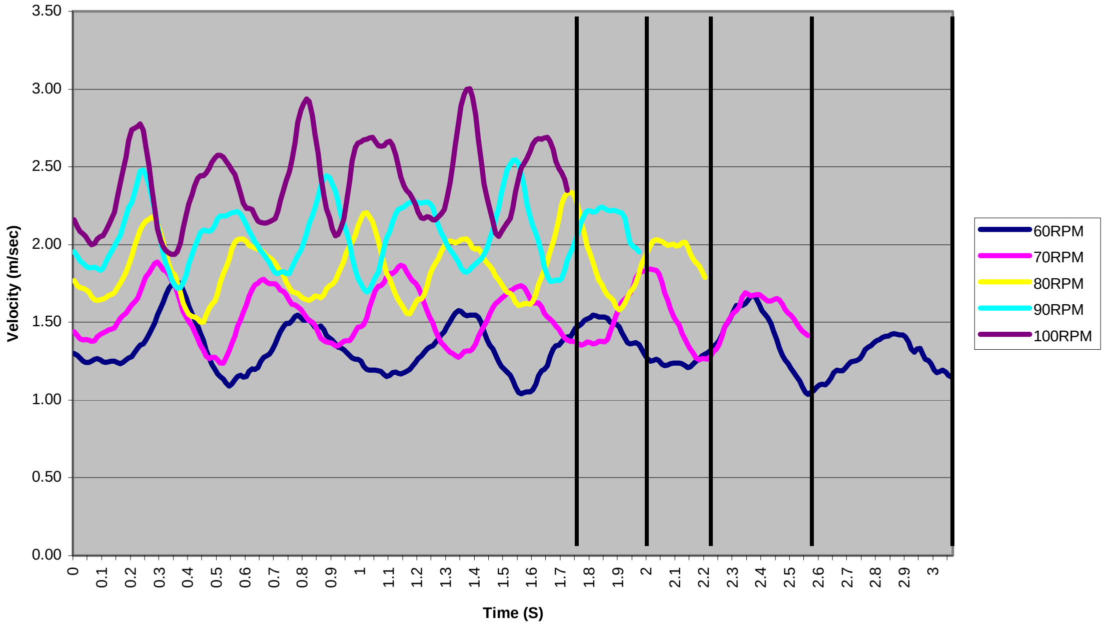
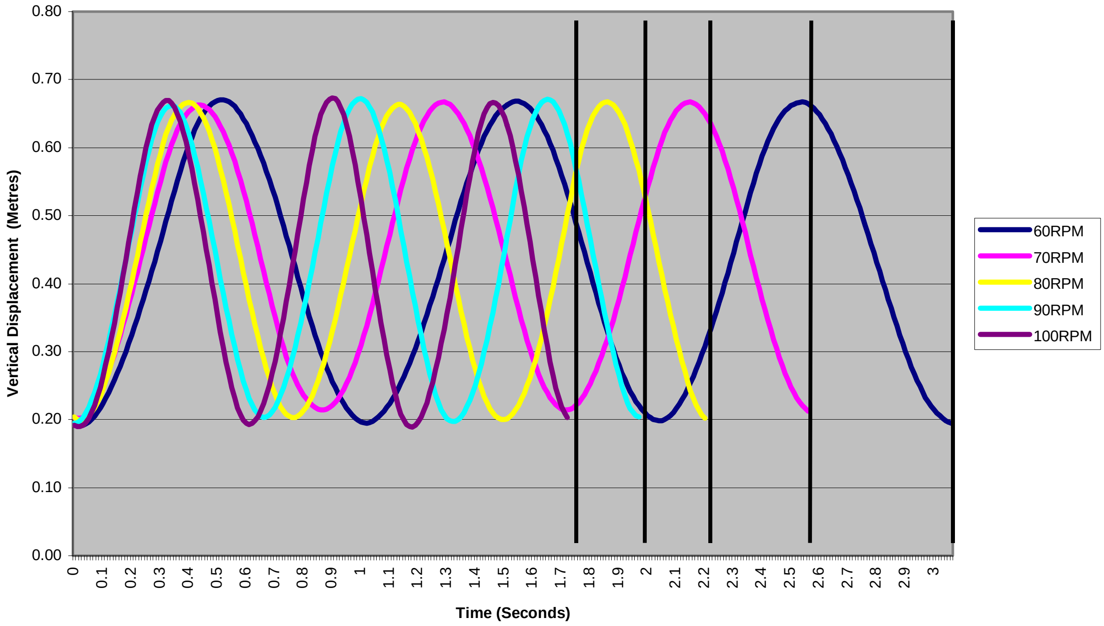


Figure 4:Angular Knee Displacement graph at 100rpm exported from Quintic Biomechanics v14.

Graph 1: Toe Velocity During 5 different work rates

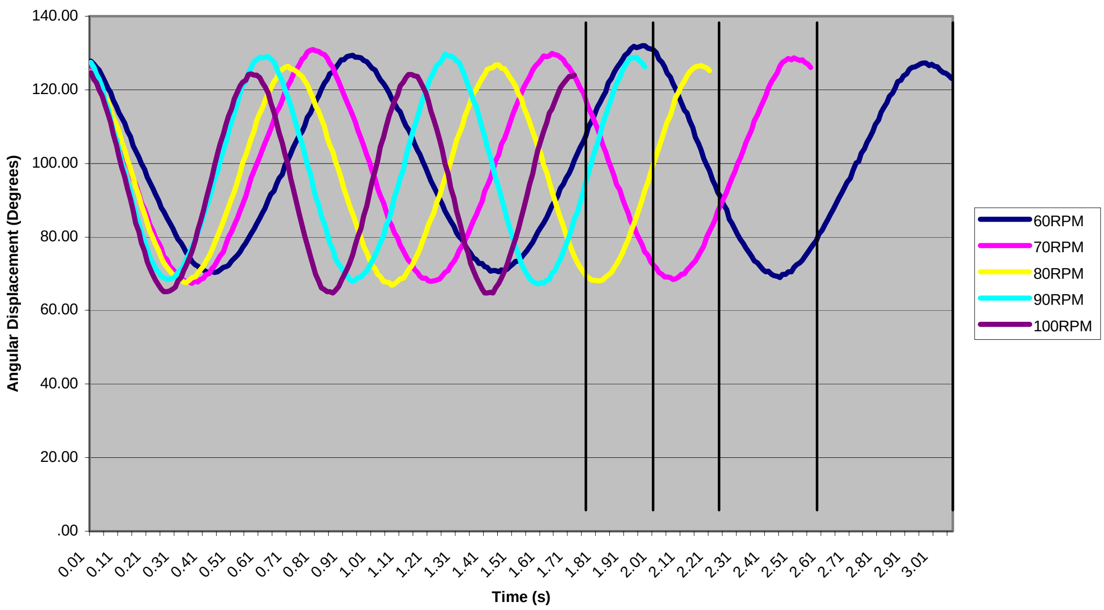


Graph 2: Vertical Toe Displacement During 5 Different Work Rates

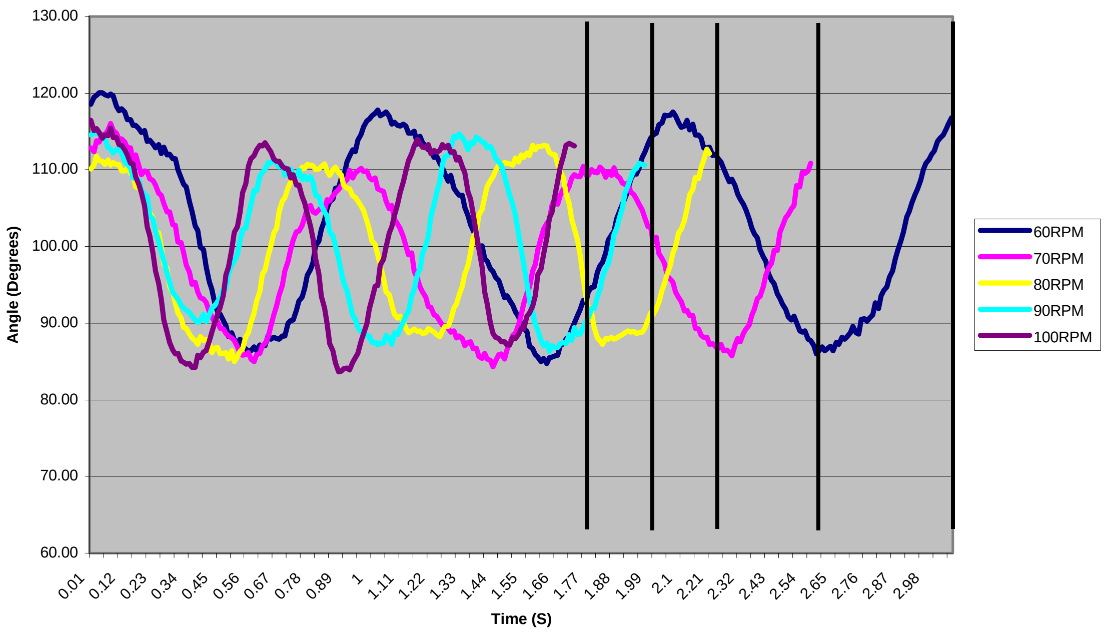


N.B The black lines on the graphs represent when each trial finished, as each trial was performed at a different rpm, the time to execute 3 complete revolutions was different.

Graph 3: Angular Knee Displacement at 5 different work rates



Graph 4: Angular Ankle Displacement at 5 different work rates



Analysis

Analysis of the cycling action at the various workloads has demonstrated that as the work rate increases there are few technical changes in the subject's technique. Graph 1 illustrates that as rpm increases, velocity of the toe also increases, this was expected as to increase the rpm the pedal has to complete more revolutions per minute which is achieved by the leg moving faster. Graph 2 shows that although the work rate increases the vertical displacement of the subjects toe stays constant, this again was expected as if vertical displacement increased, revolution time would also increase therefore causing rpm to decrease. During the 100RPM trial Graph 3 illustrates a noticeable decrease in knee extension near the BDC. Graph 4 also illustrates a significant decrease in ankle angle towards the BDC, as rpm increases.

	Toe Velocity m/sec		Vertical toe Displacement (m)		Knee Angle°		Ankle Angle°	
Trial	TDC	BDC	TDC	BDC	TDC	BDC	TDC	BDC
60rpm	1.10	1.15	0.67	0.20	70	128	84	117
70rpm	1.24	1.36	0.67	0.22	67	130	85	110
80rpm	1.5	1.65	0.66	0.20	67	128	88	110
90rpm	1.72	1.81	0.66	0.21	68	129	87	112
100rpm	1.94	2.14	0.67	0.21	64	124	84	113

To improve the accuracy of this study, the subjects optimal seat height could have been worked out as well as performing the trials on their current bike by using a turbo trainer set at a specific resisitance. This would have allowed the subject to adopt their natural ride position. To improve this study further power readings could also have been calculated during the different workloads and seat heights. This would allow the subject to design a training program depending on whether they required power for short sprint events or muscle endurance for longer events.

References

Lucia. A., Hoyos. J and Chicharro. J.L. 2001. Physiology of professional road cycling. Journal of Sports Medicine, 31,5,325-337.