A COMPARISON OF PEDALING MECHANICS IN EXPERIENCED POSE AND TRADITIONAL CYCLISTS

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The purpose of this study was to describe the mechanical differences between two experienced male Pose cyclists and traditional cyclists. Pose cycling requires a specific set-up that attempts to place the centre of mass over the pedal to increase the non-muscular force/power component during the downstroke. Results revealed that for the Pose cyclists the centre of mass was closer to vertically above the pedal when in the horizontal forward position. Non-muscular contributions to pedal power tended to be greater in the Pose cyclists compared to the traditional cyclists. In addition, we found joint differences in the power contribution to pedal power in the traditional cyclists who relied more heavily on contributions from the muscles spanning the knee joint, whereas Pose cyclists had greater ankle and hip power contributions.

KEYWORDS: GRAVITY, CENTRE-OF-MASS, TECHNIQUE

INTRODUCTION: When performing sporting movements, it is important to employ movement techniques that are beneficial with respect to the goal of the task. Depending on the movement to be performed a good technique can be characterized by maximizing parameters such as metabolic efficiency or the mechanical effectiveness of the applied forces.

In cycling, the role of pedaling technique has been debated. While cyclists can consciously apply muscular forces more effectively to the pedals (Mornieux et al., 2008), increases in mechanical effectiveness are not associated with increases in metabolic efficiency (Korff et al., 2007).

Training with uncoupled cranks teaches cyclists to apply muscular forces more effectively (Williams et al., 2009). However, uncoupled cranks are not allowed in competition, hence, the need for a technique that uses coupled pedals.

Another pedaling technique that has been promoted in the popular literature is the so called Pose technique (Romanov, 2008). The Pose cycling technique aims to increase the gravitational contribution to the pedal force by placing more body weight over the pedal by way of a specific bicycle set-up. In addition, cyclists are encouraged to consciously use their body weight to enhance pedal power during the downstroke. Hence, Pose cycling aims to increase the non-muscular contribution to pedal power during the downstroke (Romanov, 2008).

Non-muscular forces can be quantified through inverse dynamics (Kautz & Hull, 1993), and it has been suggested that minimizing non-muscular forces plays an important role when selecting a preferred pedalling cadence. Thus, an aim of the present study was to describe the non-muscular power contributions for Pose cyclists and traditional cyclists during the downstroke of the crank cycle. A further aim was to describe differences in their pedalling technique by comparing the effective forces and the joint power contributions to total power.

METHODS: Two male Pose cyclists (age: 43 and 55 years, stature: 1.83 and 1.73 m, leg length 0.96 and 0.91 m, mass: 75.0 and 78 kg) and two traditional male cyclists (age: 35 and 35 years, stature: 1.85 and 1.83 m, leg length 0.98 and 0.95 m, mass: 74.5 and 82.0 kg) participated in the current study. All of the participants were experienced cyclists (>20 years) and considered to be exemplars of their respective techniques. Ethics approval for all procedures was obtained from Brunel University and all participants provided written informed consent. Steady state cycling at 200 W was performed at three cadences (70, 90, and 110 rpm) on an electromagnetically braked cycle ergometer (Velotron, Racermate,

USA), which was calibrated before the start of the study using a dynamic calibrator (Model 17801, Vacumed, CA).

Pedal-reaction forces were measured at 960 Hz using a custom-made force pedal with two triaxial piezoelectric force sensors (Kistler, model 9251AQ01). Pedal angle and crank angle were measured at 120 Hz using an eleven-camera motion-analysis system (Motion Analysis, Santa Rosa, CA). Force and kinematic data were low-pass filtered (second-order Butterworth) using cutoff frequencies of 20 and 10 Hz, respectively. Pedal angle and crank angle were calculated from the kinematic data. The force data (forces normal and tangential to the pedal) were down sampled to match the kinematic data. Using the kinematic and force data, the force components perpendicular and radial to the crank were calculated. Hip transfer power was defined as the dot product of hip reaction forces and hip linear velocity). The joint powers for the hip, knee and ankle joints were derived using standard inverse dynamics techniques (Hull and Jorge, 1985).

All joint angular positions were obtained from the motion analysis data. Linear and angular velocities and accelerations of the limb segments were determined by finite differentiation of position data with respect to time. Using these geometrically determined kinematics together with pedal forces, we determined the joint moments at the ankle, knee and hip joints. These moments were multiplied by the corresponding joint angular velocities to obtain joint powers. Hip transfer power was calculated as the dot product of hip reaction force and hip linear velocity (Broker & Gregor, 1994). The hip transfer power was included in this calculation to account for muscular power that resulted in linear motion of the hip (i.e. not angular motion of the joints of the lower limb). For all participants the derived power profiles were representative of fifty complete revolutions within the exercise bout. Pedal power was defined as the dot product of pedal force and pedal linear velocity. For each participant mean pedal power was calculated as the average pedal power over the corresponding pedal power profile. Hip, knee and ankle joint powers were averaged over the corresponding joint power profiles. Muscular pedal power was calculated by adding the muscular joint powers (ankle, knee, hip and hip transfer) at each point. Non-muscular pedal power was calculated by subtracting the sum of muscular joint powers and hip transfer power from total pedal power at each time increment. Joint powers as well as muscular and non-muscular pedal powers were normalized by mean pedal power to allow for meaningful comparisons. Each participant's bike set up was recorded (Table 1).

Table 1. Participants' cycle ergometer set ups

| Bicycle setup: Participants	crank length (cm)	seat height crank-saddle (normalized)	seat angle (º)	handle bars position to saddle A-P (cm)	S-I (cm) (normalised)
Pose 1	17.5	0.39	77.5	0.34	0.01
Pose 2	17.5	0.40	80.0	0.31	0.02
Trad 1	17.5	0.45	73.0	0.39	0.07
Trad 2	17.5	0.45	74.0	0.37	0.04

A-P = anterior-posterior S-I = superior-inferior

RESULTS: The cycle ergometer set up differed between the Pose cyclists and the traditional cyclists. When normalised by body height, saddle length as well as vertical and horizontal handle bar position with respect to the middle of the saddle were smaller for the Pose cyclists compared with the traditional cyclists (table 1). In addition, the Pose cyclists used a steeper seat angle.

Table 2. Pose cyclists (*N=2*) and traditional cyclist's (*N=2*) parameters for one pedal cycle ($\bar{x}$ of fifty cycles)

	Averaged non muscular contribution during the downstroke (normalised)	Maximum non muscular contribution (normalised)	Ankle Power contribution (%)	Knee Power contribution (%)	Hip Power contribution (%)
Pose 70 rpm	1.12	2.09	7.91	48.13	37.55
Pose 90 rpm	1.07	2.16	6.35	60.32	27.83
Pose 110 rpm	1.24	2.49	8.62	62.04	23.30
Trad 70 rpm	0.78	1.51	10.16	48.21	31.73
Trad 90 rpm	0.84	1.91	7.53	63.71	19.99
Trad 110 rpm	1.06	2.35	2.61	98.59	-6.55

In agreement with our hypothesis, the non-muscular contribution for Pose cyclists was larger than that for traditional cyclists. In addition, the joint power contribution to total power differed between the groups (Table 2). The knee power contribution to total pedal power was greater for the traditional cyclists, whereas the ankle and hip contributions were smaller. This effect was more apparent at the higher cadences. This difference in coordination patterns is illustrated in Figure 1.
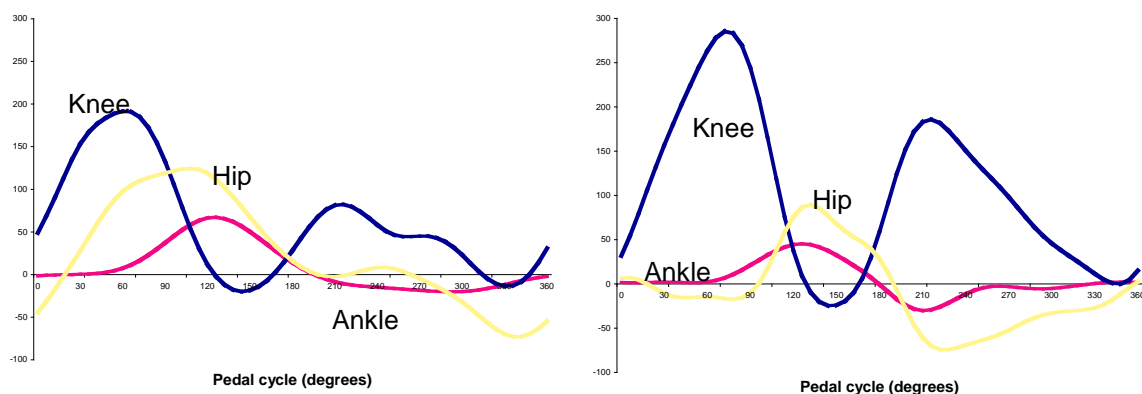
Figure 1. Pose (left *N=2*) and traditional (right *N=2*) ankle, knee and hip joint powers at 110 rpm

DISCUSSION AND CONCLUSIONS: Our findings demonstrate that the Pose cyclists produce a greater non-muscular contribution to pedal power during the downstroke when compared to traditional cyclists. This difference is accompanied by differences in the relative joint power contributions to total power. Hence, Pose cyclists may have an advantage in triathlon and distance cycling while traditional cyclists may be more effective in sprint cycling. Note that a greater non-muscular contribution during the downstroke (i.e., a greater gravitational assist) will result in a greater negative (mechanically ineffective) non-muscular contribution during the upstroke, it remains to be seen if the observed difference in technique (as described by mechanical parameters) can translate into improvements in performance and/or efficiency. This should be the subject of future research.

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