THE POWER ON THE KNEEJOINT DURING SQUAT EXERCISES AS COMPARED TO CYCLING EXERCISES

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INTRODUCTION

The training exercise squat with barbell load is the most important exercise for cyclist. The squat does vary in the following parameters: load, time of execution (and consequently speed), quat angles:

athlete	load (kp)	knee angle (°)	time (s)	time to min (s)
H1	170	71	3.66	1.85
H1	180	70	4.25	2.14
H2	200	80	2.39	1.07
H2	220	82	2.27	0.97
H3	170.	89	2.42	1.31
H3	210	87	3.68	1.94

We use the inner knee angle as knee angle.
The squat does differ on essential degree concerning its way of execution, a qualitative parameter which is seldomy controlled and which never has be verified. We found that just this variation in the execution of this exercise depends on the joint momentum and the power capacity of the athlete in the hip and knee joint. With an increase in the intensity of exercise load until the physical limit we have to ask for a strategy for this increase. Thus we investigated into the effectivity of different ways of executing a squat: either increasing the barbell load or keeping this load but executing a deeper squat.

METHODOLOGY

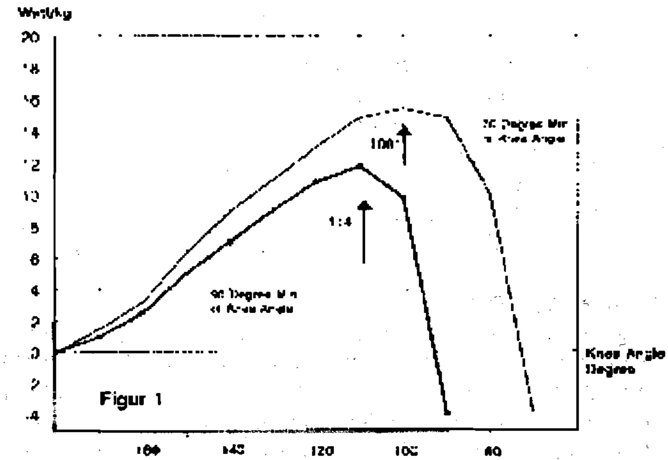
We used video analysis, modelling of the squat and of the cycling movement. We tested 12 elite sprinters in cycling with the following test procedure:
- video recording of the squat in training sessions with one lateral camera,
- determination of the hip angle, knee angle, the foot angle by video image analysis,
- calculation of the momentum in hip joint and knee joint, calculation of the mechanical joint power,
- calculation of optimal knee and hipjoint momentum during cycling and calculation of joint power,
- comparison of the results for training exercises and cycling movement,
- characterization of essential factors which determine performance capacity in the athletes as defined by clustering.

We only consider the cycling phase from the top dead centre (0° crank angle) to the bottom dead center (180" crank angle). The succeeding phase with an upward movement of the leg has only a secondary importance in this respect.

We used a simple segmental limb model with joint axies as a model since the ranges of knee angle to be investigated into allow a simple geometry of knee joint. Those joint moment we considered to be optimal when the forces towards the pedal were exclusivly acting tangentially on the chain wheel. This is justified by the facts that elite athletes accomplish an effectivity of more than 80% and that in experienced cyclists the power during the main drag phase before 90° crank angle is acting almost only tangentially.

RESULTS

To increase the effect of á squat either the load is increased or the squat is performed faster or the squat is performed to a lower trunk position. We show the **differences** between **70°** and **90°** squat. Figure 1 shows the joint power with the squat downwards in relation to the load when an athlete trains with a (1.5 times) higher load **for the** same time of one complete movement cycle. Figure 2 **showsó** the **power/load** when the squat is performed (1.5 times) faster but with the same load. In both cases the maximum power is reached for the **70°** squat at appr. **100°** knee angle and on the other hand for the **90°squat** at appr. **114°** knee angle.



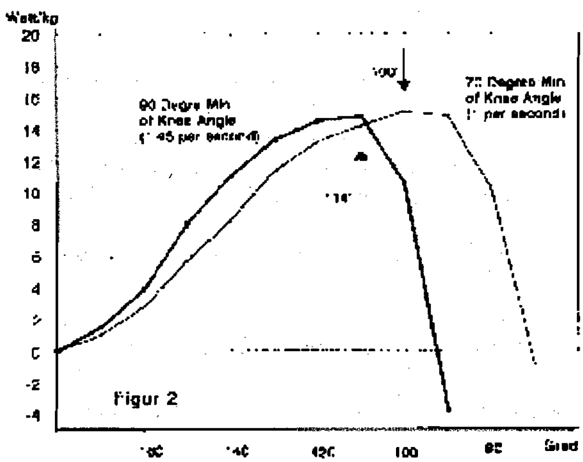
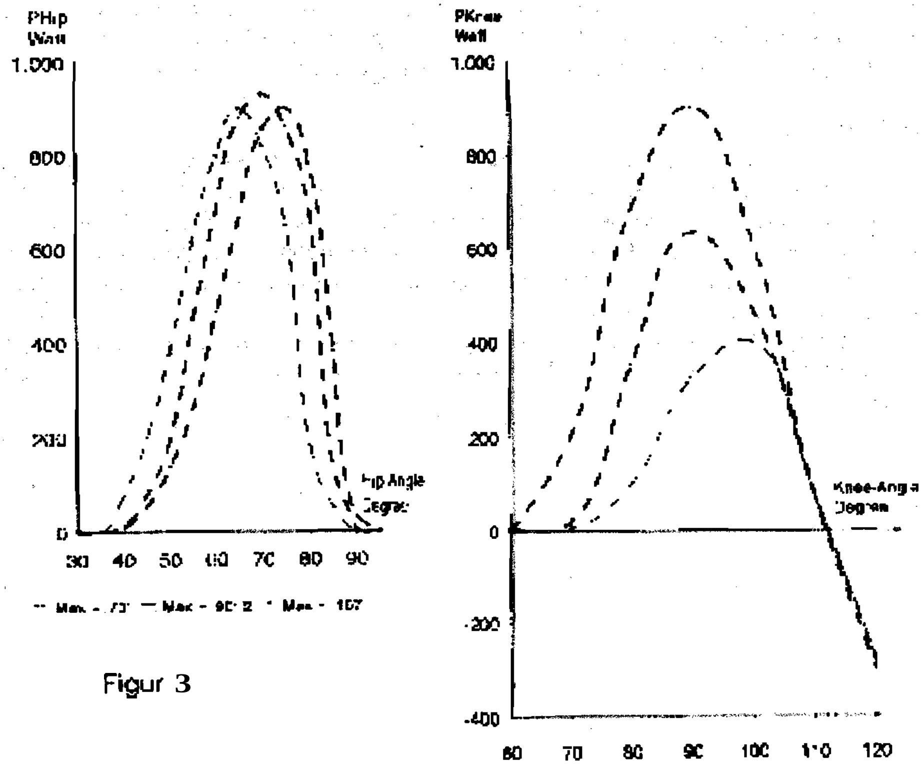
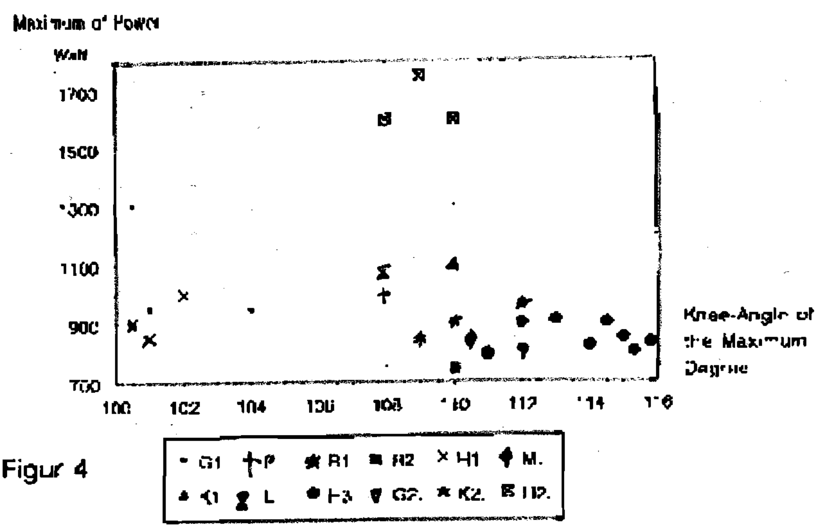


Figure3 shows the optimum course of the joint power during cycling exercise for the hip joint (left figure) and the knee joint (right figure). The optimum momentum was simulated for a pedal force maximum at **73°, 90°** and **107°** crank angle. In all three cases there is no joint power required at a-knee angle of about **115°.** The maximum output is requested for a knee angle of about **90-100°.**



Figur 3



Figur 4

Figure 4 shows the power maxima in relation to the **knee** angle where the maximum is accepted, which were found in real downward squat exercises. We found three clusters with a significant correlation to the performance capacity of sprint cyclists. One group of two sprinters trained with a **100° knee** angle and a maximum of about 1 kW. One athlete trained with 109° knee angle and a maximuí of 1 kW. Both groups were representing international top athletes. The group with less succsesfull athletes trained with a joint power below 1 kW and knee angleós of 112° and higher.

DISCUSSION

Based on the mechanical laws of cycling we concluded concerning an evaluation of an aim directed training using squat exercises that the lower squat (lowest knee angle 70°.) is more effective, because it is more specific for cycling, than a 90° squat. The effects of even lower sqats do not cover the real power output in cycling. They do only make sense via a transformed effect when the squat is performed with at least 1.5 times greater loads or with higher speed.

The clustering of the performance capacity of the athletes in relation to their way of performing the squat also showes that at least two techniques enable cyclists to reach first class.