THE EFFECT OF PEDAL BIOMECHANICS ON THE VENTILATORY THRESHOLD, VO_2 -MAX AND MOTION ECONOMY OF CYCLISTS

by

KARIEN SKEEN

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DEDICATION

This dissertation is dedicated to my parents!

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SYNOPSIS

TITLE	The effect of pedal biomechanics on the ventilatory threshold, VO_2-max and motion economy of cyclists
CANDIDATE	Karien Skeen
PROMOTOR	Prof. P.E. Krüger
CO-PROMOTOR	Mr. P.P.J. Oosthuizen
DEGREE	MA (HMS)

Cycling is one of the most popular methods people use to stay fit. More and more people are starting to take part in competitive cycling in order to explore their strength. As sport is one of the main features in modern day society, the research market is actively busy to improve sport in all possible ways. As it is known, the traditional cycle pedal crank has been unchanged for centuries. While research is daily being done on different bicycle frames, clothing, techniques and training programs, not many people have tried to improve the biomechanics of the cycle pedal crank.

The purpose of this study was to determine whether the different cycle pedal crank biomechanics would influence various physiological parameters, including the ventilatory threshold, VO_2 -max and economical motion of cyclists.

A total of 20 students, men and woman, all aged 20 to 24 years participated in this study. They were all recreational cyclists with no major known injuries. Each subject was tested both on the traditional pedal crank as well as the new designed pedal crank. This means that each subject formed part of the experimental group as well as the control group and the results of each person were measured against himself. Each subject performed 4 tests, namely an economical movement test on the new designed as well as the traditional pedal crank set, and a VO_2- max test on the new designed as well as the traditional pedal crank set.

The tests were done over a 4- week period with one week recovering time in between each test. The subjects started off on the new designed pedal crank with a sub-maximal

economical movement test cycling for 6 minutes continuously against a set resistance while the Schiller CS-100 gas analyzer measured the physiological parameters. After one week a VO_2 -max test was done on the new designed pedal crank. In the third week the subjects performed another sub-maximal economical movement test with the gas analyzer, but this time on the traditional cycle pedal crank. A week thereafter the last VO_2 -max test was done on the traditional pedal crank mechanism.

There was a significant difference for VO_2 scores on test 1 and 3 ($p < 0,02$) during the economical movement test. The VO_2 scores were significantly higher when using the traditional pedal crank than the new designed pedals. A statistical significant correlation ($p < 0,05$) was found between heart rate and VO_2-max results in test 1. This means that the higher the heart rate of the person, the higher the VO_2. A strong positive correlation ($p < 0.05$) was found between the heart rate and VO_2 for test 2 (traditional pedal crank). It is clear that lower scores of heart rate correlate with lower scores of VO_2 and higher scores of heart rate correlate with higher scores of VO_2. The heart rate: VO_2 correlation of test 3, using the traditional pedal crank set, was stronger than that of test 1 with the new designed pedal crank set.
No significant statistical differences were found between the heart rate scores in test 1 and 3 ($p > 0.5$) or the RQ scores in test 1 and 3 ($p > 0.5$). The kind of pedal crank used does not seem to have an effect on the heart rate or RQ scores during sub- maximal cycling at a constant speed and resistance. Significant strong positive correlation ($p < 0.05$) was found between the heart rate and RQ scores in test 1 as well as in test 3. This means that there is a strong tendency that the higher the heart rate score, the higher the RQ score. The correlation between heart rate and RQ scores was higher in test 1 when making use of the new designed pedal crank set than with the traditional pedal crank set in test 3.

The results of the statistical analysis indicate that there is a statistically significant difference between the heart rate at the ventilatory threshold during a VO_2-max test on the two crank sets ($p = 0.02$). These results indicate that the heart rate at the ventilatory threshold is significantly higher when making use of the new designed pedal crank set. A significant difference was found between the lactate scores at maximum speed in test 2 and 4 ($p = 0.01$). Lactate scores were significantly higher at maximum speed when making use of the new designed pedal crank. There is a strong statistical positive

correlation (p=0.02) between heart rate and lactate levels at minimum speed. This means that the higher the heart rate at the beginning of the test, the higher the lactate levels will be.

There is a significant statistical difference between the heart rate scores at the minimum speed ($p = 0.01$) and maximum speed ($p = 0.0005$) on test 2 and 4. The heart rate scores were significantly higher at both minimum and maximum speed when making use of the new designed pedal crank than with the traditional pedal crank set . No significant differences were found on VO_2 scores at minimum ($p > 0.5$) or maximum ($p=0.57$) speed in tests 2 and 4. A strong positive correlation ($p > 0.5$) was found between heart rate and VO_2 at maximum speed during a VO_2-max test. The results indicate that the lower scores in heart rate correlates with the lower VO_2-scores and the higher heart rate scores correlate with higher VO_2 scores.
No significant differences were found on RQ scores at minimum ($p > 0.5$) or maximum ($p > 0.5$) speed in tests 2 and 4.

In conclusion, the results indicate that the new designed pedal crank does affect some of the physiological parameters of cycling, but that it has no effect on the VO_2-max values. This study proves that the new designed pedal crank does improve the cyclist's ventilatory threshold and that the economical motion is also better during cycling.

KEY WORDS: Cycling, ventilatory threshold, VO_2- max, economical movement, exercise heart rate, cycle pedal crank, lactate, biomechanics of cycling, respiratory quotient.

SAMEVATTING

TITEL	Die invloed van pedaal biomeganika op die ventilatoriese draaipunt VO_2 -maks en ekonomie van beweging by fietsryers
KANDIDAAT	Karien Skeen
PROMOTOR	Prof. P.E. Krüger
MEDE-PROMOTOR	Mnr. P.P.J. Oosthuizen
GRAAD	MA (MBK)

Fietsry is een van die mees algemene oefeninge wat mense doen om fisiek fiks te bly. Meer en meer mense begin ook aan kompeterende fietsry deelneem om sodoende hulle kragte te meet. Sport kom baie na vore in die moderne samelewing en die navorsingsmark probeer sport op elke moontlike terrein verbeter. Die tradisionele fiets trapmeganisme was onveranderd die afgelope paar dekades. Met navorsing wat gerig is op verskillende fietsraamwerke, klere, tegnieke en oefenprogramme is daar nog min navorsing gedoen in 'n poging om die biomeganika van die fietstrap te verbeter.

Die doel van die eksperimentele epidemiologiese studie was om te bepaal of die biomeganika van die fietstrap 'n invloed het op verskeie fisiologiese parameters, naamlik die ventilatoriese draaipunt, VO_2 maks en ekonomie van beweging by fietsryers.

In die studie is daar van 20 studente tussen die ouderdom van 20 en 24 jaar gebruik gemaak as proefpersone. Al die proefpersone was sosiale fietsryers met geen huidige beserings nie. Elke proefpersoon is op beide die tradisionele en nuut ontwerpte fietstrap getoets, betekende dat elke persoon deel van die eksperimentele asook kontrole groep uitgemaak het. Die resultate van elke proefpersoon is dus met homself vergelyk. Elke proefpersoon het 4 toetse uitgevoer, naamlik ekonomie van beweging op die tradisionele en nuut ontwerpte fietstrappe en 'n VO_2 -maks toets op die tradisionele en nuut ontwerpte fietstrappe.

Die toetse is uitgevoer oor 'n tydperk van 4 weke met 1 week hersteltyd tussen elke toets. Die eksperiment het begin met 'n toets vir ekonomie van beweging op die nuut ontwerpte fiets trappe deur vir 6 minute teen 'n konstante weerstand te trap. Die fisiologiese parameters is tydens die toets deur die Schiller CS-100 gasanaliseerder gemeet. Na 'n week is 'n VO_2 -maks toets uitgevoer op die nuut ontwerpte fietstrappe. In die derde week het die proefpersone die tweede toets vir ekonomie van beweging gedoen, maar hierdie keer op die tradisionele fietstrappe. 'n Week later is die laaste VO_2 -maks toets uitgevoer op die tradisionele fietstrapmeganisme.

Die toets vir ekonomie van beweging het die volgende resultate getoon:
Die verskil in VO_2 waardes was beduidend tussen die tradisionele en ontwerpte trapstelsel ($p < 0,02$). Die VO_2 waardes was beduidend hoër met die gebruik van die tradisionele fietstrapstelsel. Daar was 'n statistiese beduidende korrelasie ($p < 0,05$) tussen harttempo en VO_2 -maks resultate in toets 1 op die nuut ontwerpte trapstelsel wat daarop dui dat die VO_2 -maks verhoog tydens 'n toename in harttempo. 'n Sterk positiewe korrelasie is gevind tussen harttempo en VO_2 -maks waardes op die tradisionele fietstrapstelsel. Die harttempo:VO_2 korrelasie was sterker op die tradisionele trapstelsel as op die nuut ontwerpte trapstelsel. Daar was geen beduidende verskille in die harttempo waardes ($p > 0.5$) of die RQ waardes ($p > 0.5$) op die tradisionele en nuut ontwerpte trapstelsels nie. 'n Beduidende sterk positiewe korrelasie is gevind tussen harttempo en RQ waardes. Albei trapstelsels het getoon dat RQ waardes verhoog soos wat die harttempo toeneem. Hierdie tendens het sterker na vore gekom met die gebruik van die nuut ontwerpte trapstelsel as met die tradisionele trapstelsel.

Die resultate verkry tydens die VO_2 -maks toetse toon die volgende:
Die statistiese analise toon aan dat daar 'n beduidende verskil is in harttempo by die ventilatoriese draaipunt ($p = 0,0241$). Die resultate toon dat die harttempo hoër is by die ventilatoriese draaipunt wanneer daar gebruik gemaak word van die nuut ontwerpte trapstelsel. 'n Sterk positiewe korrelasie ($p = 0,02$) is gevind tussen harttempo en laktaatvlakke by minimum spoed. Dit beteken dat die laktaat vlakke hoër is by 'n hoër harttempo aan die begin van die toets. Daar is ook gevind dat die laktaatwaardes beduidend hoër is by maksimum spoed op die nuut ontwerpte trapstelsel ($p = 0,0076$).

'n Beduidende verskil in harttempowaardes is gevind by minimum spoed ($p = 0,0123$) en maksimum spoed ($p = 0,0005$) op die twee trapstelsels. By beide die minimum en maksimum spoed was die harttempo waardes hoër wanneer daar gebruik gemaak is van die nuut ontwerpte trapstelsels. Geen beduidende verskille is gevind vir VO_2 waardes by minimum ($p > 0,5$) en maksimum ($p > 0,5$) spoed nie. 'n Beduidende positiewe korrelasie ($p = 0,006$) is gevind tussen harttempo en VO_2 by maksimum spoed. Die resultate toon aan dat laer harttempowaardes gepaard gaan met laer VO_2 waardes. Geen beduidende verskille is verkry vir RQ waardes by minimum ($p = 0,3600$) of maksimum ($p = 0,3044$) spoed nie.

Samevattend kan verklaar word dat die nuut ontwerpte trapstelsel wel 'n invloed het op verskeie fisiologiese parameters by fietsryers, maar nie op die VO_2-maks nie. Die studie bewys dat die nuut ontwerpte trapstelsel wel 'n fietsryer se ventilatoriese draaipunt en ekonomie van beweging verbeter.

SLEUTELWOORDE: Fietsry, ventilatoriese draaipunt, VO_2 -maks, bewegings ekonomie, oefenharttempo, fietstrapstelsel, laktaat, biomeganika van fietsry, respiratoriese koëffisiënt.

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