BIKEFITTING CURRENT STATE OF THE ART AND FUTURE DIRECTIONS

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Science and Cycling 2021

INTRODUCTION

- objective
  - give outline/overview of current bikefitting state-of-art and future direction
- target populations for bikefitting
  - recreational/competitive cyclists
- bikefitting areas of interest
  - contact point adjustment
  - static fitting/bike sizing
  - dynamic analysis
  - pedaling analysis (3D pedaling analysis with bilateral measurement every 3 degrees of the pedal stroke)
  - bike adjustment
- future concepts
  - on the bike measurements (dynamic fitting/power meters with 'true' bilateral 2D pedaling analysis)
  - easier ways to do bike sizing for consumers
  - further developments

TARGET GROUPS FOR BIKEFITTING

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- recreational
  - wants injury free cycling experience
  - looking for comfort, but also performance
  - looking for advice to purchase new bike or to adjust position on an existing bike to improve comfort/performance
  - the question which size do I need is one of the most pertinent questions for people looking for a new bike, a large database and tested algorithm is the best solution here
  - wants to get good advice and concrete steps/guidance to follow up.
- competitive
  - wants injury free cycling experience
  - looking for performance, but also comfort
  - looking for advice to adjust position on an existing bike to improve comfort/performance or to purchase new bike
  - looking for advice to improve pedaling technique/performance
  - wants to get good advice and concrete steps/guidance to follow up

CYCLING RELATED INJURIES

recreational riders

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- many studies showing that bike fit related injuries are prevalent in both competitive riders as well as recreational riders.
- most prominent areas in recreational cyclists are:
  - neck 23%
  - lower back 22%
  - knees 16%
  - hand (13%)
  - genital area (12%)
  - shoulder (11%)
  - data from Priego Quesada JI, Kerr ZY, Bertucci WM, Carpes FP (2019) A retrospective international study on factors associated with injury, discomfort and pain perception among cyclists. PLoS ONE 14 (1): e0211197. https://doi.org/10.1371/journal. pone.0211197

CYCLING RELATED INJURIES

competitive/professional riders

- In a study among 65 professional athletes, the percentage of cyclists with traumatic injuries increased from 39.5% in the cyclists surveyed between 1983 and 1995 to 53.9% in the cyclists surveyed between 2003 and 2009.
- In this same study, severe traumatic lesions decreased from 49.9% in the historical group to 10.5% in the contemporary group ($p<0.01$). Patellofemoral pain decreased from 28.8% (historical) to 6.1% (contemporary) ($p<0.01$). Muscle injuries substantially increased from 13.4% to 44.9% ($p<0.01$).
- The authors concluded that in modern cycling, the riders seem to be at a higher risk for traumatic injuries overall but a lower risk for severe lesions. Moreover, the number of tendon-related issues seemed to have decreased, whereas the incidence of muscle injuries increased.
- Barrios C, Bernardo ND, Vera P, Laı´z C, Hadala M. Changes in Sports Injuries Incidence over Time in World-class Road Cyclists. Int J Sports Med. 2015; 36: 241–248. https://doi.org/10.1055/s-0034- 1389983 PMID: 25376727

STATIC FITTING VERSUS DYNAMIC FITTING

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- a static fit can be very helpful to determine a starting point for a dynamic fit, or to find the correct size bike and more-or-less correct saddle height;
- however due to various factors such as: hip rocking, ankling technique, flexibility, leg length differences (functional or anatomical)
- a dynamic fit is the preferred method to come to an optimal position, but 3D systems (like bikefitting.com, Retül, STT, …) still have a higher accuracy than markerless and 2D systems (with errors up to 10%);
- references:

  - G. Serrancolí et al.: Marker-Less Monitoring Protocol to Analyze Biomechanical Joint Metrics. Digital Object Identifier 10.1109/ACCESS.2020.3006423
  - R.R. Bini, P. Hume: A Comparison of Static and Dynamic Measures of Lower Limb Joint Angles in Cycling: Application to Bicycle Fitting. June 2016Human Movement 17(1):36-42. DOI:10.1515/humo-2016-0005

STATIC FITTING/BIKE SIZING

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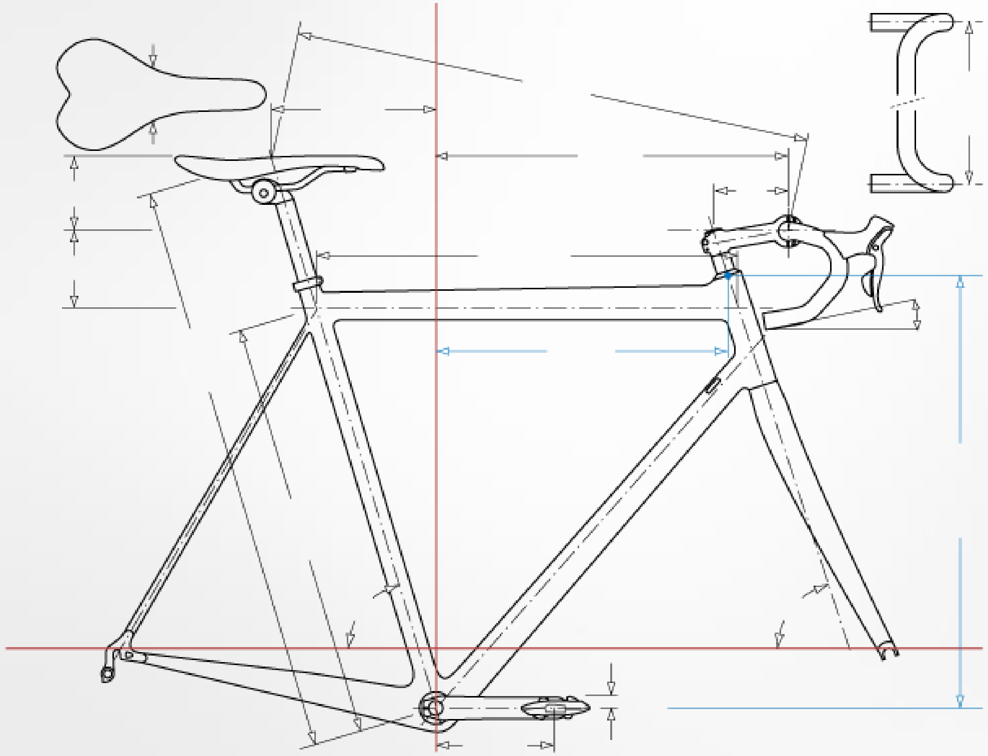
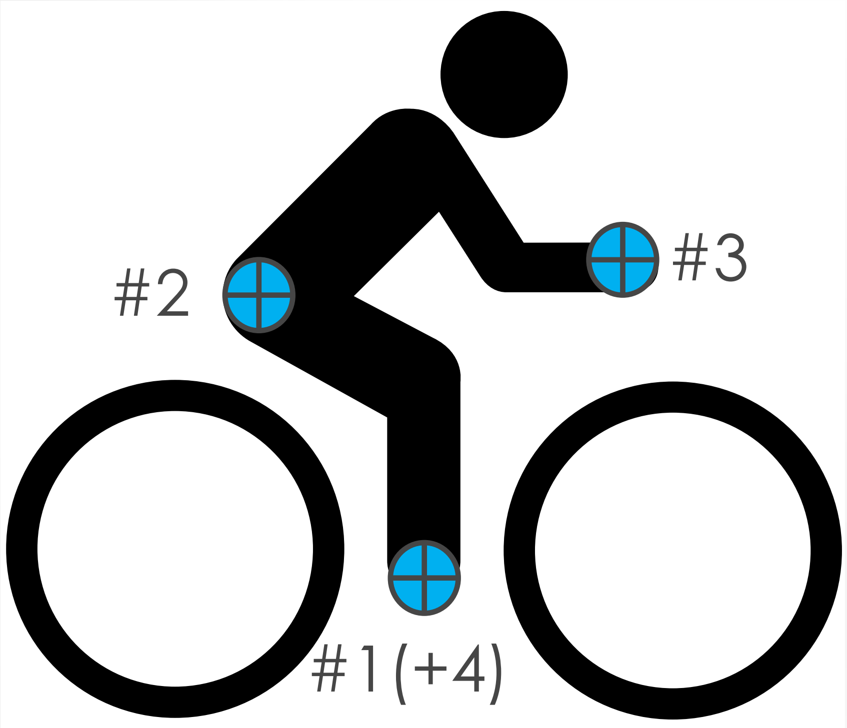
- step #3: static fitting
  - fit based on body measurements
  - helps 90% of cyclists to be better fitted



DYNAMIC FITTING

- step #4: dynamic fitting
  - fine tune of the position for 10% of cyclists
  - bring scientific evidences of short and long terms benefits



STATIC VERSUS DYNAMIC BIKE FITTING

SHIMANO

- saddle height/ knee angle is the only parameter in cycling with an optimal range backed up by scientific data
- saddle height should be 106-109% of inseam according to ancient research by Nordeen-Snyder (1977). Based on efficiency data (O2 uptake)
- knee extension angle should be 25-30 degrees at bottom dead center (measured statically with goniometer) or 30-40 degrees when measured dynamically with a 2D or (preferably) 3D camera according to various sources like Bini (2011)

› Med Sci Sports. Summer 1977;9(2):113-7.

The effect of bicycle seat height variation upon oxygen consumption and lower limb kinematics

K S Nordeen-Snyder

PMID: 895427

Abstract

VO2 was obtained for 10 women bicycling on rollers at 3 saddle heights (SH), 95, 100 and 105% trochanteric height. Kinematic patterns described by the hip, knee, ankle and foot were discerned from one pedal cycle at each of the 3 SH. Subjects cycled on a Fuji Dynamic 10 10-speed bicycle, at 60 rpm, (a work load of 799 kpm/min was applied by a tensioning belt from a bicycle ergometer) until they reached steady state. Expired air was then collected and cine films were taken during gas collection. The 100% SH was most efficient, mean values for 95, 100 and 105% SH were 1.69, 1.61 and 1.74 lit/min, respectively. Kinematic patterns showed no variation in the range of motion (ROM) at the hip, values at the dead centers (DC) did change. The ROM at the knee varied from 69 to 82.9 degrees, 95 to 105% SH, values at the DC varied also. Plantar flexion (PF) at bottom dead center increased by 10% from 95 to 105% SH. Foot angle showed no significant variation with increasing SH. The major adaptations to increases in SH are found at the knee and in ankle PF.

Effects of Bicycle Saddle Height on Knee Injury Risk and Cycling Performance

Rodrigo Bini,[1,2] *Patria A. Hume*[1] and *James L. Croft*[1]

1 Sport Performance Research Institute New Zealand, School of Sport and Recreation, Auckland University of Technology, Auckland, New Zealand
2 CAPES Foundation, Ministry of Education of Brazil, Brasilia, Brazil

Contents

Abstract

Incorrect bicycle configuration may predispose athletes to injury and reduce their cycling performance. There is disagreement within scientific and coaching communities regarding optimal configuration of bicycles for athletes. This review summarizes literature on methods for determining bicycle saddle height and the effects of bicycle saddle height on measures of cycling performance and lower limb injury risk. Peer-reviewed journals, books, theses and conference proceedings published since 1960 were searched using MEDLINE, Scopus, ISI Web of Knowledge, EBSCO and Google Scholar databases, resulting in 62 references being reviewed. Keywords searched included 'body positioning', 'saddle', 'posture, 'cycling' and 'injury'. The review revealed that methods for determining optimal saddle height are varied and not well established, and have been based on relationships between saddle

STATIC VERSUS DYNAMIC FITTING

comparison study

SHIMANO

- in a study by Ferrer-Roca, it was observed that riders who choose a saddle height outside the optimal range according to inseam measurements, were more likely to have a knee extension angle inside the recommended range
- factors like ankling technique and hip rocking play an important part in this
- therefore, this is particularly relevant in Elite cyclists

Vilas-Boas, Machado, Kim, Veloso (eds.)
Biomechanics in Sports 29

Portuguese Journal of Sport Sciences
11 (Suppl. 2), 2011

STATIC VERSUS DYNAMIC EVALUATION IN BIKE FITTING: INFLUENCE OF SADDLE HEIGHT ON LOWER LIMB KINEMATICS

Ventura Ferrer-Roca[1], Andreu Roig[1], Pedro Galilea[1] and Juan García-López[2]

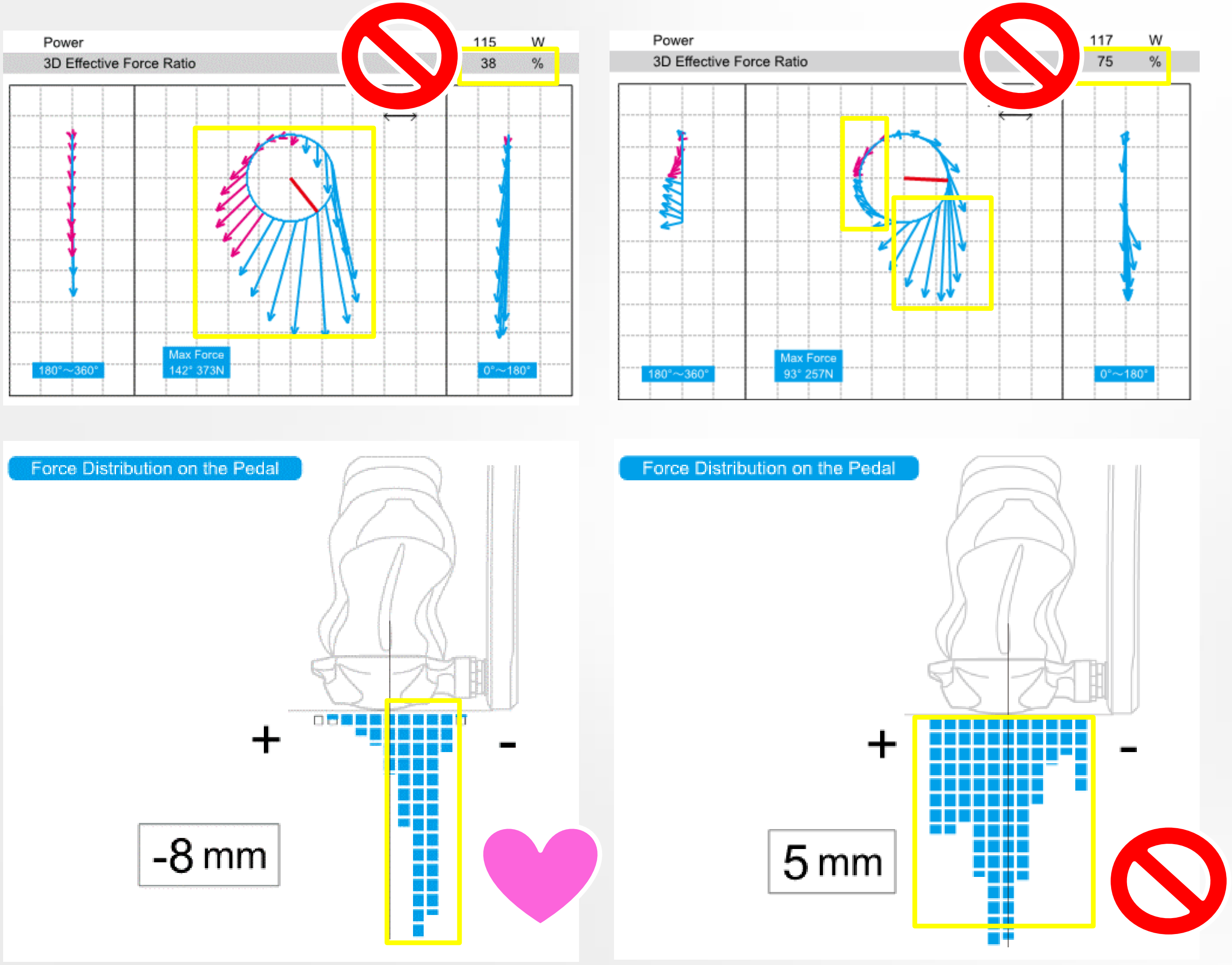
GIRSANE Research Group, High Performance Sport Center (CAR), Sant Cugat del Vallès, Spain[1]
Faculty of Physical Activity and Sports Sciences, University of Leon, León, Spain[2]

The purpose of this study was to verify if high-level cyclists achieve an appropriate kinematic pattern using their habitual bike fit. Twenty-three elite cyclists participated in the study. Many riders, 56.5%, used a habitual bike fit in which the saddle height was outside of the recommended range from 106% to 109% of the inseam. Surprisingly, however, we found an inappropriate knee flexion angle in only 26% of all the cyclists. Nevertheless, our results support the view that adjusting saddle height from 106% to 109% of the inseam would not prevent knee injuries in well-trained cyclists. Results support the contention that saddle height, inseam length and knee angle are highly related (R^2=0.963 and p<0.001). We propose a novel equation that relates these factors in order to recommend an optimal saddle height.

KEY WORDS: Road cycling, biomechanics, anthropometrics, cycling position, overuse injuries.

PEDALING ANALYSIS

- step #5: pedaling analysis
  - L/R balance
  - mechanical efficiency
  - foot stability
- improving mechanical efficiency doesn’t immediately imply an improvement in gross efficiency. Longer term adaptation required!



PEDALING ANALYSIS

SHIMANO

Effect of Pedaling Technique on Mechanical Effectiveness and Efficiency in Cyclists

THOMAS KORFF[1], LEE M. ROMER[1], IAN MAYHEW[1], and JAMES C. MARTIN[2]

[1]Brunel University, Centre for Sports Medicine and Human Performance, Brunel University, Uxbridge, UNITED KINGDOM; and [2]The University of Utah, College of Health, Salt Lake City, UT

ABSTRACT

KORFF, T., L. M. ROMER, I. MAYHEW, and J. C. MARTIN. Effect of Pedaling Technique on Mechanical Effectiveness and Efficiency in Cyclists. *Med. Sci. Sports Exerc.*, Vol. 39, No. 6, pp. 991–995, 2007. **Purpose:** To optimize endurance cycling performance, it is important to maximize efficiency. Power-measuring cranks and force-sensing pedals can be used to determine the mechanical effectiveness of cycling. From both a coaching and basic science perspective, it is of interest if a mechanically effective pedaling technique leads to greater efficiency. Thus, the purpose of this study was to determine the effect of different pedaling techniques on mechanical effectiveness and gross efficiency during steady-state cycling. **Methods:** Eight male cyclists exercised on a cycle ergometer at 90 rpm and 200 W using four different pedaling techniques: preferred pedaling; pedaling in circles; emphasizing the pull during the upstroke; and emphasizing the push during the downstroke. Each exercise bout lasted 6 min and was interspersed with 6 min of passive rest. We obtained mechanical effectiveness and gross efficiency using pedal-reaction forces and respiratory measures, respectively. **Results:** When the participants were instructed to pull on the pedal during the upstroke, mechanical effectiveness was greater (index of force effectiveness = 62.4 ± 9.8%) and gross efficiency was lower (gross efficiency = 19.0 ± 0.7%) compared with the other pedaling conditions (index of force effectiveness = 48.2 ± 5.1% and gross efficiency = 20.2 ± 0.6%; means and standard deviations collapsed across preferred, circling, and pushing conditions). Mechanical effectiveness and gross efficiency during the circling and pushing conditions did not differ significantly from the preferred pedaling condition. **Conclusions:** Mechanical effectiveness is not indicative of gross efficiency across pedaling techniques. These results thereby provide coaches and athletes with useful information for interpreting measures of mechanical effectiveness. **Key Words:** COACHING, BIOMECHANICS, CYCLING, ECONOMY

- Instructing trained cyclists to pull up during pedal stroke increases mechanical efficiency but not gross efficiency
- Long term adaptation required? What would happen if we measure them after 2 weeks of pedaling technique training?

ON THE BIKE MEASUREMENTS

Future of bikefitting: pedaling analysis and power meter

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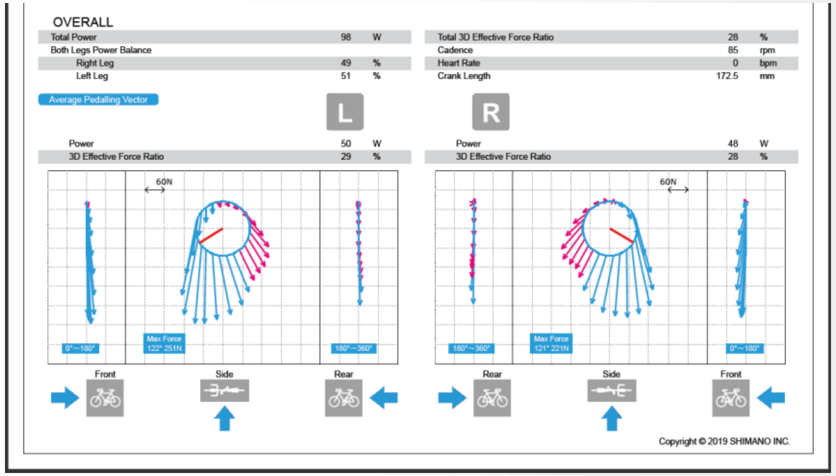

OVERALL

Total Power	98	W	Total 3D Effective Force Ratio	28	%
Both Legs Power Balance			Cadence	85	rpm
Right Leg	49	%	Heart Rate	0	bpm
Left Leg	51	%	Crank Length	172.5	mm

Power	50	W	Power	48	W
3D Effective Force Ratio	29	%	3D Effective Force Ratio	28	%

ON THE BIKE MEASUREMENTS

Future of bikefitting: dynamic measurements outside

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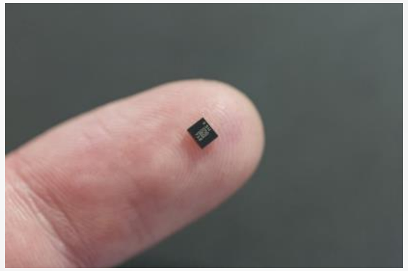
- Dynamic bike fit
  - Current: bikefit studio with 3D Motion Analyzer
  - Future: indoor bikefit with outdoor IMU*-based system?

*Inertia Measurement Unit



LASER JIG FOR TIME TRIAL BIKE ADJUSTMENT VERIFICATION

BFC and UCI collaboration

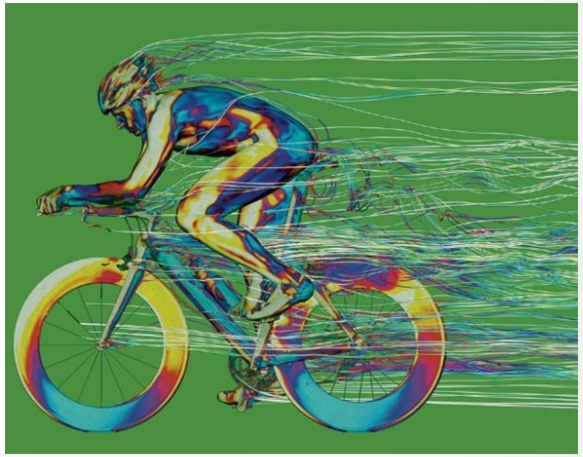
bikefitting.com

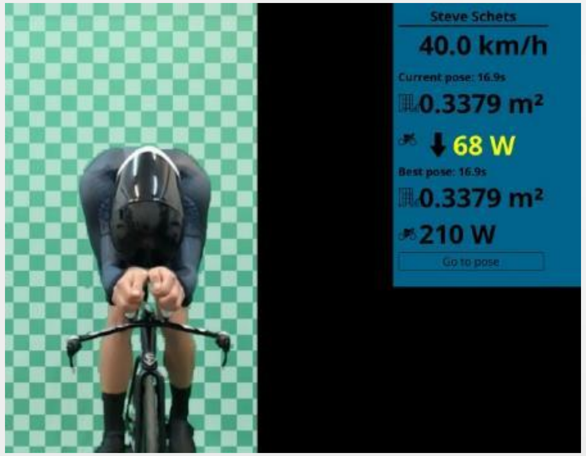
- horizontal and vertical encoders for length (X) and height (Y) measurements similar to existing bike adjuster
- laser for bike points spotting
- measurement error of laser tool <1mm
- tactile display with immediate results calculation
- check of correct saddle setup
- check of correct extension setup
- measurement process must be completed in less than 60 seconds

BIKEFITTING FUTURE DIRECTIONS

What about the aero topic

- Not always simple and affordable





SUMMARY

- bikefitting is important for riders of all levels
- a complete service package is important to offer and this can be obtained from different manufacturers nowadays
- static fitting and dynamic fitting both have their own target group
- pedaling analysis can be a powerful tool to detect differences in L/R balance and foot stability
- future developments are expected in the area of more on-the-bike measurements and estimation of aerodynamic performance

QUESTIONS?