# SHORT REPORT

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# Optoelectronic analysis of cyclists' position before and after a bike fit: A case study of a professional women's cycling team

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**Abstract**
Introduction. **Objective analysis of movement and position is useful for prevention of strains and injuries in professional sport. Correct bike fitting can be performed on the basis of a motion analysis system.** Aim of Study. **The aim of the study was to analyze changes in the position of female cyclists before and after bike fitting.** Material and Methods. **The study sample consisted of four female cyclists from a professional Polish cycling team TKK Pacific. The cyclists' position on the bike was analyzed with an optoelectronic system BTS SMART DX 7000, before and after bike fitting.** Results. **The statistical analysis did not reveal any differences in the cyclists' position before and after bike fitting. Individual results of particular participants were analyzed and suggestions related to changes in the position on the bike were given. All the studied cyclists still needed adjustment of their trunk and ankle joint positions. Three participants should have had a correction of the elbow joint angle. One cyclist needed a correction of the knee joint. The hip joint position was correct in all the cyclists.** Conclusions. **Cyclists should have their bikes fitted in a detailed and objective way. Objective movement analysis based on optoelectronic measurement as well as individual approach to each professional cyclist can improve the cyclist's position on the bike and minimize the risk of injuries.**

**KEYWORDS: movement analysis, bike fitting, optoelectronic system, cycling.**

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**What is already known on this topic?**
The most common bike fitting method is based on the knee angle when the pedal is in bottom dead center. The static method is chosen more often than the dynamic method; however, the results of these methods are substantially different. Objective bike fitting can be performed using a 3D kinematic system.

## Introduction

In professional cycling the rider's appropriate position on the bike is essential for preventing strains and injuries. On the other hand, equipment which is incorrectly fitted to the body can increase the risk of strains and injuries [1].

The determination of the cyclist's appropriate position should be based on detailed medical history and anthropometric measurements as well as objective bike fitting and periodic control of the position. Objective bike fitting can be performed using a motion analysis system, and such 2-D or 3-D systems have become very popular tools for evaluating cyclists [2, 3].

Fitting a bicycle depends on the type of cycling and is related to the connection points between the cyclist and the bicycle. These points are the right and the left foot, the pelvis, and the right and the left hand. Ideally placed connection points can improve a cyclist's comfortable position on the bike. A bike fit also involves three adjustments: saddle height, saddle-to-stem distance, and fore and aft saddle position.

**Aim of Study**
The aim of the study was to analyze changes in the position of female cyclists before and after bike fitting.

**Material and Methods**
The study sample consisted of four female cyclists from a professional Polish cycling team TKK Pacific. The participants' mean age was: 25 ± 6 years, and mean BMI was 20.2 ± 0.1 kg/m$^2$, i.e. within the normal range. The cyclists' position on the bike was evaluated twice: before and after bike fitting. Bike fitting was performed by an external bike fitter using the CycleOps PowerBeam Pro trainer, a goniometer, a plumb bob, and a centimeter elastic ruler. The analysis of the cyclists' position was performed with the use of the BTS SMART DX 7000 optoelectronic system consisting of eight TVC cameras emitting IR radiation. Angular evaluation was performed in two crank positions chosen from trials with low intensity pedaling:

- 1$^{st}$ position – crank at six o'clock – bottom dead center (BDC),
- 2$^{nd}$ position – crank at twelve o'clock – top dead center (TDC).

In the frontal plane, the distance between the knee joints was evaluated. In the sagital plane a cyclist' dominant side was analyzed in consideration of the angle between the trunk and the upper extremity as well as the angles in the elbow joint, hip joint, knee joint, and ankle joint. Individual results of particular participants were analyzed and suggestions related to changes in the position on bike were given.

For data processing the SMARTanalyzer, ver. 1.10.0225 was used. Preliminary statistic analysis was done using Microsoft Excel 2010 and Statistica v. 10. The following statistical tests were used: the Shapiro-Wilk test of normality, summary statistics, dependent samples t-test, and the Wilcoxon signed-rank test. The level of statistical significance was set at $\alpha = 0.05$.

**Results**
Summary statistics were applied for calculation of arithmetic means, medians and standard deviation for variables showed in Tables 1-2.

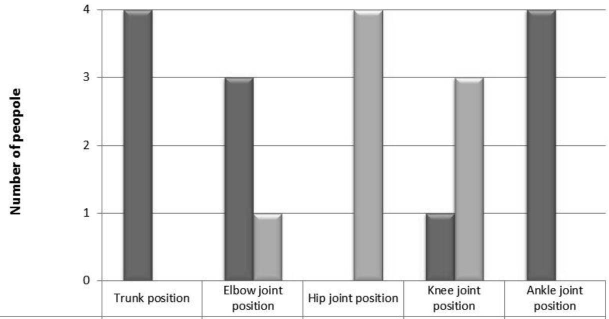
**Table 1.** Summary statistics for distance between knee joints before and after bike fitting. Values for distance shown in centimeters

| Parameter | Mean | SD | Median |
|---|---|---|---|
| Distance between knee joints before bike fitting | 17.0 | 4.0 | 15.0 |
| Distance between knee joints after bike fitting | 16.0 | 2.0 | 17.0 |

Distribution was evaluated with the Shapiro-Wilk Test of normality. Distribution that was not consistent with normal distribution was observed only in the cases of distance between the knee joints before bike fitting, the angle between the trunk and the upper extremity before bike fitting with crank in BDC, and the angle in the elbow joint after bike fitting with crank in TDC.
In the case of normal distribution a t-test was used, for other cases the Wilcoxon signed-rank test was applied.

**Table 2.** Summary statistics for particular parameters before and after bike fitting with crank position in BDC or TDC. Values for angular parameters shown in degrees

| | Parameter | BDC | | | TDC | | |
|---|---|---|---|---|---|---|---|
| | | Mean | SD | Median | Mean | SD | Median |
| before bike fitting | Angle between trunk and upper extremity | 74.7 | 5.3 | 76.9 | 76.0 | 4.2 | 75.2 |
| | Angle in elbow joint | 145.0 | 9.4 | 145.2 | 145.4 | 8.6 | 146.1 |
| | Angle in hip joint | 104.5 | 5.5 | 103.5 | 53.4 | 8.4 | 54.2 |
| | Angle in knee joint | 144.2 | 6.1 | 144.6 | 75.8 | 5.5 | 76.1 |
| | Angle in ankle joint | 143.7 | 0.6 | 143.6 | 123.7 | 12.3 | 123.5 |
| after bike fitting | Angle between trunk and upper extremity | 72.2 | 4.2 | 72.9 | 75.5 | 3.6 | 75.6 |
| | Angle in elbow joint | 143.5 | 10.2 | 141.0 | 143.7 | 12.5 | 138.6 |
| | Angle in hip joint | 100.9 | 4.6 | 99.5 | 55.1 | 4.0 | 56.4 |
| | Angle in knee joint | 143.1 | 5.2 | 144.1 | 74.2 | 4.0 | 74.4 |
| | Angle in ankle joint | 138.1 | 3.9 | 136.9 | 118.5 | 6.6 | 117.1 |




| | Trunk position | Elbow joint position | Hip joint position | Knee joint position | Ankle joint position |
|---|---|---|---|---|---|
| Require correction | 4 | 3 | 0 | 1 | 4 |
| Do not require correction | 0 | 1 | 4 | 3 | 0 |

**Position of particular body parts after bike fitting**

**Figure 1.** Analysis of the number of cyclists who need further body position correction of particular body parts after bike fitting

No differences were found between the variables before and after bike fitting. Figure 1 contains frequency tables for ordinal data, showing the number of cyclists who needed further position adjustment of particular body parts after bike fitting. All participating cyclists needed a correction of the trunk and ankle joint positions. Three cyclists required a correction of the elbow joint angle. One cyclist needed a correction of the knee joint. The hip joint position was correct in all the cyclists.

Individual results of particular participants were analyzed taking into consideration detailed antropometric measures. Suggestions related to changes in the position on bike were provided to the cyclists. It was recommended to each participant was to have a new, detailed and objective bike fit performed, because results of the earlier bike fits were not satisfactory.

## Discussion

It is important to understand the significance of a proper cyclist's position, joint movement changes, and adaptations to incremental fatigue during cycling [4]. Peveler et al. [5] indicated differences between static and dynamic bike fitting. They noticed that goniometer-adjusted saddle height is one of the most researched areas of bike fitting. While this measurement is taken when the cyclist maintains a static position with the pedal at BDC, the act of pedaling is dynamic, and angles do alter during movement. Researchers pointed to plantar flexion, which is increased when moving from stationary measures to active pedaling, and as a result, to an increase in the knee angle.

Although still greater than stationary measures, less plantar flexion occurred at higher intensities when compared to lower intensity cycling. Less plantar flexion at higher intensities is most likely a result of application of a greater downward torque occurring due to greater power requirements at higher intensities.

To evaluate cyclists' proper position in the present study we applied a dynamic approach. The bike fitting results were assessed during low intensity pedaling.

Zieliński et al. [1] suggested that injuries, which may lead to gonarthrosis, can be provoked by inadequate bike fitting in relation to the anthropometric characteristics of the body. They claimed that a wrong position of the knee joints can be caused by a wrong position of the bike saddle.

Much attention is paid to the positioning of the knee joints because knee joint injuries are the most common in cycling [6, 7]. This was confirmed in our study, because only one participant needed a correction of the knee joint position, whilst the other cyclists assumed the appropriate knee joint position. During bike fitting less attention was paid to body aerodynamics because each participant required a trunk correction, and three out of four needed changes of the elbow joint angular position. Aerodynamic optimization is necessary in cycling because an aerodynamically efficient body posture is the fundamental factor for achieving better outcomes. According to Chowdhury et al. [8] there are three commonly used positions in professional cycling, which depend on the type of race and road profile. In the upright posture the hands are placed on the upper part of the handlebars, and it is mainly used to cycle across a hilly terrain. A more upright position increases the cyclist's comfort, but at the same time creates greater wind resistance [9]. Dropped posture is characterized by the hands on the bottom of the handlebars. This position is usually adopted to minimize the projected frontal area at higher speeds. It reduces wind resistance by 30% in comparison to the position with hands placed on the top of the handlebars. The time trial posture is observed when the elbows are placed on the pads of the handlebars.

Researchers showed that the extremely low positioning of the handlebars leads to increased lumbar lordosis, that is why it is suggested they should be at same level or lower than the seat [10, 11]. A prolonged trunk flexed position during a sitting position provokes intervertebral stress and leads to increased thoracic and lumbar intradiscal pressure [12, 13]. This type of alternations may escalate in lower back pain [14], which is a very common injury in cyclists [15, 16, 17].

The correct cyclist's position in the present study should be the dropped position. The studied cyclists adopted a more upright body posture which was less aerodynamic. On the other hand, with a lower torso angle the reduction of peak power output could be observed [18, 19]. This decrease could be related to the fact that muscles are not working in their optimal range. Moreover, an excessively low position affects muscle recruitment and provokes greater muscular fatigue with increased pressure on the shoulder griddle, upper extremities, and the neck, as well as increased adductor activation to keep the lower extremities moving in the sagittal plane due to the extreme hip angles [20]. When a cyclist presents a more flat position, his or her physiological performance decreases significantly, independently of the training position. This is an additional reason why objective movement analysis should be performed to adjust cyclists' position and increase their performance.

## Conclusions

Detailed and objective bike fitting is necessary in professional cycling. An objective motion analysis based on optoelectronic measurements as well as individual approach to each professional cyclist can improve the cyclist's position on the bike and minimize the risk of prospective injuries.

**What this study adds?**

The study shows that dynamic bike fitting using an optoelectronic system is more detailed than static fitting. The cyclist's position parameters were assessed in bottom dead center an in top dead center, which made the analysis more comprehensive. Apart from the knee angle, the evaluated parameters included trunk position, elbow joints angles, hip joints, and ankle joints position.

## References


1. Zieliński P, Wrzosek Z, Demczyszak I. Choroba zwyrodnieniowa stawu kolanowego jako następstwo obrażeń u mężczyzn uprawiających kolarstwo. Kwart. Ortop. 2012; 2: 250-256.
2. Kopacz K, Fronczek-Wojciechowska M, Kosielski P, et al. Movement analysis in tandem track cyclist using video analysis. JKES. 2014; 68(24): 59-64.
3. Shan G. Biomechanical evaluation of bike power saver. Appl Ergon. 2008; 39(1): 37-45.
4. Mornieux G, Guenette JA, Sheel AW, et al. Influence of cadence, power output and hypoxia on the joint moment distribution during cycling. Eur J Appl Physiol. 2007; 102(1): 11-18.
5. Peveler W, Shew B, Johnson S, et al. A kinematic comparison of alterations to knee and ankle angles from resting measures to active pedaling during a graded exercise protocol. J Strength Cond Res. 2012; 26(11): 3004-3009.
6. Asplund C, St Pierre P. Knee pain and bicycling: fitting concepts for clinicians. Phys Sportsmed. 2004; 32(4): 23-30.
7. Champoux Y, Paré D, Drouet JM, et al. In-situ measurement of clipless cycling pedal floating angles. The Engineering of Sport. 2009; 7(1): 273-280.
8. Chowdhury H, Alam F, Mainwaring D. A full scale bicycle aerodynamics testing methodology. Procedia Eng. 2011; 13: 94-99.
9. Silberman MR, Webner D, Collina S, et al. Road bicycle fit. Clin J Sport Med. 2005; 15(4): 271-276.
10. Mellion MB. Neck and back pain in bicycling. Clin Sports Med. 1994; 13(1): 137-164.
11. Schulz SJ, Gordon SJ. Riding position and lumbar spine angle in recreational cyclist: A pilot study. Int J Exerc Sci. 2010; 3(4): 174-181.
12. Beach T, Parkinson R, Stothart P, et al. Effects of prolonged sitting on the passive flexion stiffness of the in vivo lumbar spine. Spine J. 2005; 5(2): 145-154.
13. Polga D, Beaubien B, Kallemeier P, et al. Measurement of in vivo intradiscal pressure in healthy thoracic intervertebral discs. Spine (Phila Pa 1976). 2004; 29(12): 1320-1324.
14. Harrison DE, Colloca CJ, Harrison DD, et al. Anterior thoracic posture increases thoracolumbar disc loading. Eur Spine J. 2005; 14(3): 234-242.
15. Asplund C, Webb C, Barkdull T. Neck and back pain in bicycling. Curr Sports Med Rep. 2005; 4(5): 271-274.
16. Clarsen B, Krosshaug T, Bahr R. Overuse injuries in professional road cyclists. Am J Sports Med. 2010; 38(12): 2494-2501.
17. Marsden M, Schwellnus M. Lower back pain in cyclists: A review of epidemiology, pathomechanics and risk factors. Int Sport Med J. 2010; 11(1): 216-225.
18. Fintelman DM, Sterling M, Hemida H, et al. Optimal cycling time trial position models: aerodynamics versus power output and metabolic energy. J Biomech. 2014; 47(8): 1894-1898.
19. Jobson SA, Nevill AM, George SR, et al. Influence of body position when considering the ecological validity of laboratory timetrial cycling performance. J Sports Sci. 2008; 26(12): 1269-1278.
20. Gnehm P, Reichenbach S, Altpeter E, et al. Influence of different racing positions on metabolic cost in elite cyclists. Med Sci Sports Exerc. 1997; 29(6): 818-823.