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**RESEARCH ARTICLE /** Araştırma Makalesi **Open Access/**Açık Erişim

# The Reliability and Validity of Kinovea Software in Assessing Change of Direction Performance in Youth Soccer Players: A Comparative Analysis with Witty Gate System

## Genç Futbolcularda Yön Değiştirme Performansının Değerlendirilmesinde Kinovea Yazılımının Güvenilirliği ve Geçerliliği: Witty Gate Sistemi ile Karşılaştırmalı Bir Analiz

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## Abstract

The aim of this study was to investigate the reliability and validity of Kinovea, a video motion analysis software, on rapid change of direction (COD) performance in young football players. A total of 30 amateur soccer players with a mean age of 16.67 ± 0.8 years (95%IC: 16.99–16.35), mean height of 1.75 ± 0.06 meters (95%IC: 1.78–1.73), mean body mass of 66.03 ± 7,28 kg (95% IC: 68.70–63.36), mean body mass index (BMI) of 21.33 ± 1.67 (95% IC: 21.94–20.72) and mean sports age of 6.12 ± 1.70 years (95% IC: 6.75–5.50) participated in this study. COD data were obtained using the Witty gate photocell system and a simultaneous video recording system. Data were analysed using JASP Team statistical program. Pearson correlation test was applied for the relationship between two different measurement methods, while Bland-Altman analysis was applied for the agreement of the methods. High levels of correlation (r = 0.981, p <.001) and reliability (Kinovea ICC = 0.864–0.935; Witty ICC = 0.914) were found between Witty and Kinovea systems. According to Bland-Altman analysis, a small but systematic difference was observed between the two systems (bias =-0.042 s, 95% CI: - 0.071 to- 0.014), and the Witty system measured 0.73% lower times than Kinovea. These results show that Kinovea can be a valid and reliable alternative to the Witty system.

**Keywords:** Change of Direction, Reliability-Validity, Kinovea

## Öz

Bu çalışmanın amacı, genç futbolcularda hızlı yön değiştirme (COD) performansında video hareket analiz yazılımı olan Kinovea'nın güvenilirliğini ve geçerliliğini araştırmaktı. Çalışmaya yaş ortalaması 16,67 ± 0,8 yıl (95% GA: 16,99–16,35), boy ortalaması 1,75 ± 0,06 metre (95% GA: 1,78–1,73), vücut ağırlığı ortalaması 66,03 ± 7,28 kg (95% GA: 68,70–63,36), vücut kitle indeksi (VKİ) ortalaması 21,33 ± 1,67 (95% GA: 21,94–20,72) ve spor yaşı ortalaması 6,12 ± 1,70 yıl (95% GA: 6,75–5,50) olan toplam 30 amatör futbolcu katılmıştır.
COD verileri, Witty kapı fotohücre sistemi ve eşzamanlı video kayıt sistemi kullanılarak elde edilmiştir. Veriler JASP Team istatistik programı ile analiz edilmiştir. İki farklı ölçüm yöntemi arasındaki ilişki için Pearson korelasyon testi, yöntemlerin uyumu için ise Bland-Altman analizi uygulanmıştır. Witty ve Kinovea sistemleri arasında yüksek düzeyde korelasyon (r = 0,981, p < .001) ve güvenilirlik (Kinovea ICC = 0,864–0,935; Witty ICC = 0,914) bulunmuştur. Bland-Altman analizine göre, iki sistem arasında küçük fakat sistematik bir fark gözlenmiş (bias = -0,042 sn, 95% GA: -0,071 ila -0,014), Witty sistemi Kinovea'dan %0,73 daha düşük süreler ölçmüştür. Bu sonuçlar, Kinovea'nın Witty sistemine geçerli ve güvenilir bir alternatif olabileceğini göstermektedir.

**Anahtar Kelimeler:** Yön Değiştirme, Güvenilirlik-Geçerlilik, Kinovea

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# Introduction

Football is characterised by the frequent occurrence of many high-intensity actions (sprinting, jumping, acceleration, deceleration, etc.) that are important in the game (Stølen et al., 2005). Especially in recent years, it has become a more intermittent game form, and the frequency of explosive actions has increased (Jones et al., 2013; Tenga et al., 2010; Yel et al., 2023). In football, high-intensity activities like sprinting, acceleration, and deceleration are in a three-dimensional environment, and in this respect, the significance of change of direction running performance (COD) arises. COD performance typically takes place every 2-4 seconds on the game field (Brughelli et al., 2008). Therefore, it is clear that footballers must be able to perform explosive movements with changes of direction, which are fundamentally essential in order to improve their performance (Tous-Fajardo et al., 2016). The valid and reliable measurement of COD abilities, e.g., those that are considered to be very important in the ball and non-ball activities of the game, is regarded as a key factor to maximize variables to determine and enhance the performance of athletes and to arrange the training calendar of the athletes (Dugdale et al., 2020; Faude et al., 2012). A large number of tests can be used to measure the COD performance of footballers. A battery of change of direction tests, including the ubiquitous Illinois, T-test and Zig-Zag test, have also been found to be effective measures to assess COD capabilities in football (Altmann et al., 2019; Negra et al., 2017). Change of direction test reliability and validity have become necessities to monitor performance in footballers, to objectively quantify development, and to develop individualized training (Pojskic et al., 2018; Çakır et al., 2023 ).

Research literature shows the importance of validity and reliability in COD ability measurement in sports science (Loturco et al., 2019; Peña-González et al., 2021). For COD measurement, several timing-based technologies such as electronic timing gates, infrared photobeam cells, radar guns, and stopwatches have been used in the literature (Balsalobre-Fernández et al., 2019; Haugen & Buchheit, 2016; Samozino et al., 2016; Uluca et al., 2024).

Electronic timing gates are generally considered to be the gold standard tool for measurement of time events (Sheppard & Young, 2006). That notwithstanding, one of the main limitations to the application of the technology is that it is costly (Balsalobre-Fernández et al., 2019). Additionally, although there have been mobile applications developed for measurement of the tests under focus, the applications are not free (Balsalobre-Fernández et al., 2019; Öniz et al.). To this end, the current research was conducted to examine the reliability and validity of the COD test on soccer players through the Kinovea program, which is a free movement analysis software.

# Materials and Methods

### Research Model

This study has a methodological and correlational design based on quantitative research method. In the study, the intraclass reliability of the Zig-Zag Change of Direction (COD) test was evaluated with the intraclass correlation coefficient (ICC) over the test-retest applications, and the agreement between the two measurements was examined with the Bland-Altman analysis. In addition, the relationships between the COD test results and other variables were analysed using the Pearson correlation coefficient. In this respect, the study presents a mixed structure that examines both the reliability analysis of the measurement tool and the relationship between the variables.

### Participants

The number of participants was determined using G*Power 3.1 software. Assuming that the expected ICC was 0.85, the alpha level was 0.05, and the power was 0.80, the required sample size was determined to be 21 participants (Bujang & Baharum, 2017). In addition, based on the sample size calculation method suggested by Walter, Eliasziw, and Donner (1998) (Walter et al., 1998); assuming that the lowest acceptable ICC value was 0.70, the expected ICC value was 0.90, the alpha level was 0.05, and the statistical power was 90%, it was determined that at least 24 participants were needed for the reliability analysis (Vancampfort et al., 2015). However, in order to increase the reliability of the study, 30 football players were included in this study. Voluntary consent forms were obtained from the participants and their legal heirs.

### Data Collection

### Height and Body Mass

The height of the athletes participating in the study was measured in cm with a steel stadiometer with a sensitivity of 0,1 cm, while barefoot, and their body mass was measured in kg with a digital scale with a sensitivity of 0,1 kg. The participants were measured barefoot, wearing shorts and a t-shirt. The athletes' BMI measurements were calculated using the formula of the ratio of their body weight to the square of their height ($kg / m^2$).

### Change of Direction Running Test (Zig-Zag Test)

Change of direction running was applied on a grass field to determine change of direction performance (COD). According to the test protocol, three slaloms were placed 5 meters apart in a 100 ° angle Zig-Zag at 20 meters. Athletes completed the test by passing three slalom intervals at the highest speed, starting from 0.5 meters behind the starting photocell. Each athlete applied the test twice with a 3-minute rest interval, and the obtained values were recorded (Adıgüzel et al., 2024). The test values were recorded simultaneously with both the Witty gate (Microgate, Bolzano, Italy, http://www.microgate.it) photocell device and the Apple iPhone 15+ camera [720 pixels at 240 frames per second, video support] positioned on a tripod at a height of 90 cm, 10 meters away in the horizontal plane. After the videos were recorded, the data was transferred to the Kinovea [version 2023.1] software. The time the participant passed through the exit and finish doors was determined with the stopwatch in the Kinovea software.

### Statistical Analyses

Statistical analyses were performed using the JASP Team (2025) (Version 0.19.3) program (Team, 2025). The demographic characteristics of the participants were analysed with descriptive statistics. The results are given as arithmetic mean±standard deviation ($\bar{x}$±SS). The Kolmogorov-Smirnov test was applied for the normality distribution of the data. The relationship between the COD (Change of Direction) Zig-Zag test results was analysed with the Pearson Correlation Coefficient. Values less than 0.25 indicate little or no relationship, values between 0.25 and 0.50 indicate moderate, values between 0.50 and 0.75 indicate moderate to good relationships, and values greater than 0.75 indicate good to excellent relationships (Portney & Watkins, 2009). Since the same test was applied to the same group twice, the intraclass reliability of the test was determined by the intraclass correlation coefficient (ICC) (with 95% CI). Bland-Altman analysis was applied to evaluate the agreement between the two measurement methods,

the mean difference between the measurements (bias) and the distribution of this difference within acceptable limits (Bland & Altman, 1986).

# Result

Demographic information of participants

**Table 1:** Demographic information of participants

| Variable | n | X ± SS | [95% CI] |
|---|---|---|---|
| Age (year) | 30 | 16.67 ± 0.8 | 16.99-16.35 |
| Weight (m) | 30 | 1.75 ± 0.06 | 1.78-1.73 |
| Body mass (kg) | 30 | 66.03 ± 7.28 | 68.70-63.36 |
| BMI | 30 | 21.33 ± 1.67 | 21.94-20.72 |
| Spor age (year) | 30 | 6.12 ± 1.70 | 6.75-5.50 |

When the data regarding the demographic characteristics of the participants were examined, it was determined that their mean age was 16.67 ± 0.8 years (95% CI: 16.99–16.35), their mean height was 1.75 ± 0.06 m (95% CI: 1.78–1.73), their mean body mass was 66.03 ± 7.28 kg (95% CI: 68.70–63.36), their mean body mass index (BMI) was 21.33 ± 1.67 kg/m² (95% CI: 21.94–20.72) and their mean sports age was 6.12 ± 1.70 years (95% CI: 6.75–5.50). These data show that the participant group had a homogeneous structure. [Table 1].

### Findings on Reliability, Validity and Correlation for Assessing Change of Direction (COD) Performance

When the measurement results of the participants' Zig-Zag change of direction (COD) test were examined, Kinovea$^{1st}$ measurement mean was 5.41 ± 0.41 seconds (95% CI: 5.26–5.56), Kinovea$^{2nd}$ measurement mean was 5.38 ± 0.40 seconds (95% CI: 5.38–5.53), Witty$^{1st}$ measurement mean was 5.44 ± 0.38 seconds (95% CI: 5.29–5.60) and Witty$^{2nd}$ measurement mean was 5.44 ± 0.37 seconds (95% CI: 5.30–5.58). The mean COD time for the Kinovea system was found to be 5.40 ± 0.39 seconds (95% CI: 5.25–5.54), and the mean COD time for the Witty system was found to be 5.44 ± 0.38 seconds (95% CI: 5.30–5.59). As a result of the reliability analyses, the ICC value for Kinovea measurements was calculated as 0.864 (95% CI: 0.737–0.963), and for Witty measurements as 0.914 (95% CI: 0.898–0.938). In the evaluation made on the mean values, the intraclass correlation coefficient (ICC) of the Kinovea system was 0.935 (95% CI: 0.908–0.948), indicating a high level of reliability. These results show that both systems offer a high level of repeatability and reliability in terms of COD measurements. [Table 2].

**Table 2:** Reliability Metrics for Assessing Change of Direction (COD) Performance.

| Variable | $\bar{X}$ ± SS | %95 CI | ICC [95% CI] |
|---|---|---|---|
| Kinovea $^{1st}$ (s) | 5,41±0,41 | 5,26-5,56 | 0,864 |
| Kinovea $^{2nd}$ (s) | 5,38±0,40 | 5,38-5,53 | [0,737-0,963] |
| Witty $^{1st}$ (s) | 5,44±0,38 | 5,29-5,60 | 0,914 |
| Witty $^{2nd}$ (s) | 5,44±0,37 | 5,30-5,58 | [0,898-0,938] |
| Kinovea average (s) | 5,40±0,39 | 5,25-5,54 | 0.935 |
| Witty average (s) | 5,44±0,38 | 5,30-5,59 | [0.908-0.948] |

In the change of direction test results, a statistically significant and very strong correlation was found between Witty and Kinovea systems (r = 0.981, p < .001). [Table 3; Figure 1].

**Table 3:** Performance Witty and Kinovea Pearson's Correlation.

| | Pearson's r | p |
|---|---|---|
| Witty - Kinovea | 0.981*** | < .001 |

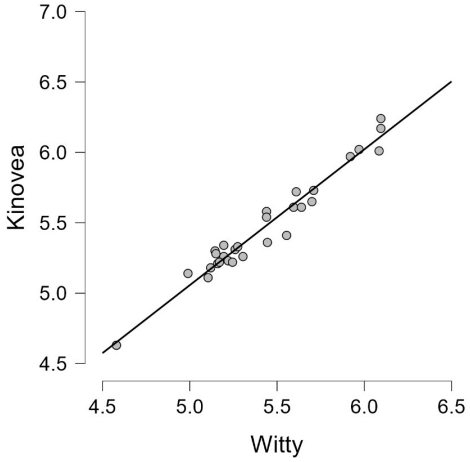


**Figure 1**. Correlation Analysis of Mean Values Between Witty and Kinovea Measurements

According to the Bland-Altman analysis used in the evaluation of the measurement agreement and reliability of the Witty-Wireless Photocell System and Kinovea video analysis systems, a small but systematic difference (bias =-0.042 s, 95% CI =-0.071=-0.014) emerged between the two methods. The Witty photocell system was found to be 0.73% lower compared to Kinovea. [Table 4]. The differences between COD times obtained by the Wity Photocell and Kinovea methods are seen to be randomly distributed, which reveals that the differences do not show a systematic trend. The same situation was observed in the analysis of the logarithmically transformed data. [Figure 2].

**Table 4:** Agreement Between Witty and Kinovea Measurements: Bland-Altman Analysis.

| Bias & Limits | Point Value | Lower 95% CI | Upper 95% CI |
|---|---|---|---|
| Mean difference + 1.96 SD | 0.107 | 0.057 | 0.156 |
| Mean difference | -0.042 | -0.071 | -0.014 |

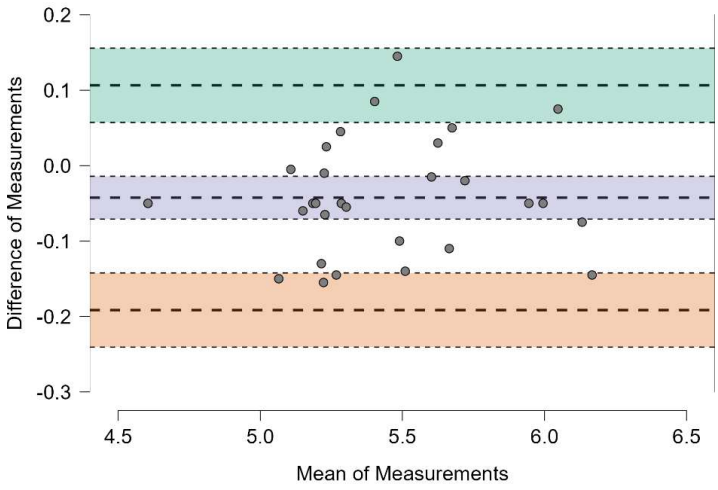


**Figure 2.** Bland–Altman Plot for Comparison of Average COD Times Measured by Witty and Kinovea

## Discussion

Change of Direction (COD) measurements were made simultaneously with Kinovea video analysis software and the Witty wireless photocell system. A high level of internal consistency (ICC> 0.86) was achieved between Kinovea and Witty systems; mean COD time was measured as 5.40 ± 0.39 s for Kinovea and 5.44 ± 0.38 s for Witty. According to the Pearson correlation analysis results, a very high level of positive correlation was found between the two systems ($r = 0.981$, $p < .001$). This shows that the measurement results of the two systems are quite close to each other. According to Bland-Altman analysis, there is a small but systematic difference between Kinovea and Witty systems (bias =-0.042 s, 95% CI =-0.071=-0.014). The majority of the measurement differences are within acceptable limits, and the differences are randomly distributed. This shows that there is no significant directional deviation between the systems. According to the Bland-Altman analysis, it is noted that the majority of the differences of measurement are obtained from the wity photocell, and the kinovea video analysis results are acceptable and that a systematic deviation exists at a low level (Hopkins, 2000).

Concepts of validity and reliability are key to the evaluation of any measure instrument, whether software such as Kinovea. Validity refers to the degree to which a test measures what it purports to measure and comes in various forms, including content validity, criterion-related validity, and construct validity. A good validity assessment should attend to more than one dimension, such as content validity (Zhi-hong et al., 2016). The same applies to software used in movement analysis measurements, such as Kinovea software.

Test performance variation can lead to misjudgment of athlete capabilities or flaws and influence individual and team performance (Tachibana et al., 2019). Therefore, tests that provide accurate measurements are a necessity to validate these critical performance assessments. Test-retest reliability, which is found in the evaluation of various tools designed to measure performance data, parallels the requirements for reliable motion capture systems such as Kinovea (Grgić et al., 2020; Grigg et al., 2017). Studies on video analysis-based COD are available in the literature. Among these studies, a mobile application, CODtimer, which is video-based, yielded reliable and valid results when compared to the Witty gate photocell system (Balsalobre-Fernández et al., 2019).

Again, in the validity and reliability study of a mobile application (mysprint), the results obtained were found to have excellent correlation (r = 0.989–0.999) with the wity photocell system and a very high intraclass correlation coefficient. In addition, the Kinovona motion analysis program has measured serve ball speed reliably and validly in tennis (Öztürk et al., 2023). As methodologies, technologies and methods used to evaluate the effectiveness of different training protocols in sports and competitions advance, there is a need for continuous validation (Calvo et al., 2020). With technological advances, increasing video resolutions and fps values of mobile devices can provide more insights into evaluating functional capabilities of programs such as Kinovea software.

These results show that there is a good agreement between the two methods and that Kinovea computer software can also be used as an alternative to the photocell system. Therefore, a high level of reliability and agreement between the Witty photocell system and the Kinovea video analysis system existed. Kinovea software can be used as a valid and reliable alternative to the Witty gate photocell system for practical use.

## Conclusion and Recommendations

According to these results, the sports scientists and coaches can quantify the change of direction performances of the players using the Kinovea program, which possesses high levels of reliability and validity, and develop training programs accordingly. It should also be noted that mobile applications that have been developed in accordance with technological progress can also be used as proper and feasible substitutes in COD measurements, but photocell systems provide greater reliability. It is recommended that photocell systems be preferred in order to evaluate athlete performance accurately and reliably, and design training programs.

Although evaluating fast direction changes with video analysis programs is promising, caution should be exercised in this process. Factors such as distance from the subject during video shooting, lighting conditions, camera angles and resolution of the video capture equipment can affect the reliability of the measurements collected

## Kısaltmalar / Abbreviations

| | |
|---|---|
| SS | Standard Deviation |
| X | Mean |
| p-value | Probability Value |
| s | Second |
| COD | Change of Direction |
| 95%CI | Confidence Interval |
| n | Number of Participants |
| ICC | Intraclass Correlation Coefficient |
| kg | kilogram |
| m | meter |

## Beyanlar / Declarations

### Etik Onay ve Katılım Onayı / Ethics approval and consent to participate

Bu çalışmanın hazırlanması ve yazım sürecinde, "Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi" kapsamında bilimsel, etik ve atıf kurallarına uyulmuştur; toplanan veriler üzerinde herhangi bir tahrifat yapılmamış olup, bu çalışma başka bir akademik yayın ortamında değerlendirilmek üzere gönderilmemiştir. Makaleyle ilgili doğabilecek ihlallerin sorumluluğu yazara aittir. Çalışma, Çukurova Üniversitesi Tıp Fakültesi Klinik Olmayan Araştırmalar Etik Kurulu tarafından onaylanmıştır (Tarih: 18 Nisan 2025, Toplantı No: 154)

During the preparation and writing process of this study, scientific, ethical and citation rules were followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive"; no falsification was made on the collected data, and this study was not sent for evaluation to any other academic publication environment. The responsibility for any violations that may arise regarding the article belongs to the author. The study was approved by the Çukurova University Faculty of Medicine Non-Clinical Research Ethics Committee (Date: 18 April 2025, Number of meetings: 154).

## Veri Ve Materyal Erişilebilirliği / Availability of data and material

Bu çalışmanın bulgularını destekleyen veriler, makul talepler üzerine sorumlu yazardan temin edilebilir. Veri seti yalnızca akademik amaçlar için erişilebilir olacak ve verilerin herhangi bir kullanımı, orijinal çalışmayı referans gösterecek ve katılımcıların gizliliğini koruyacaktır.

The data that support the findings of this study are available from the corresponding author upon reasonable request. The dataset will be accessible only for academic purposes, and any use of the data will recognize the original study and maintain the confdentiality of the participants.

## Çıkar Çatışması / Competing interests

Yazarlar, bu makalede sunulan çalışmayı etkileyebilecek herhangi bir çıkar çatışması veya kişisel ilişkiye sahip olmadıklarını beyan etmektedirler.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Yazar Katkıları / Authors' Contribution Statement

Tüm yazarlar çalışmaya eşit katkıda bulunmuştur. Tüm yazarlar makalenin son halini onaylamıştır. All authors contributed equally. All authors approved the final version of the article.

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