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**Original Research**

# Validity and Reliability of Kinovea Software in Evaluation of Shoulder Joint Position Sense in Female Volleyball Players

**Shirin Yazdani[1*], Hadiseh Eftekhari[2], Mohammad Khaffafpour Komeili[3]**

*1. Department of Motor Behavior, Faculty of Physical Education and Sports Sciences, University of Tabriz, Tabriz, Iran. E-mail: sh_yazdani@tabrizu.ac.ir, ORCID: 0000-0003-2485-9752.*

*2. Department of Motor Behavior, Faculty of Physical Education and Sports Sciences, University of Tabriz, Tabriz, Iran. Email: eftekhari.h1399@ms.tabrizu.ac.ir, ORCID:0009-0008-8830-0468.*

*3. Department of Motor Behavior, Faculty of Physical Education and Sports Sciences, University of Tabriz, Tabriz, Iran. Email: khaffaf.m1400@ms.tabrizu.ac.ir, ORCID: 0009-0000-4179-1169.*

## ABSTRACT

The aim of this study was to evaluate the validity and reliability of the kinovea software in assessing the position sense of shoulder joint in female volleyball players. Methods: 15 females of women's volleyball team of University of Tabriz (19-23 aged) participated at this study voluntarily. The active flexion and abduction range of motion of the shoulder joint at three different angles of 45, 80 and135 degrees were assessed using goniometer and photography (kinovea software) methods. All tests were done in both eyes open and eyes closed conditions. The reconstruction angle and reconstruction error were calculated and used for proprioception analysis. The obtained data were analyzed using spss26 software and Pearson correlation method with significance level of 0.05. To evaluate the validity of kinova software, the correlation between the results of kinovea and goniometer was calculated. The test-retest method was also used in the investigation of reliability of kinova measurements. The results showed significant positive correlations between the two measurement methods in all three flexion angles of shoulder joint while open and closed eyes conditions. A similar result was seen in shoulder abduction. Also, the results showed that kinovea measurements had high reliability for investigating the proprioception of shoulder joint ($P<0.05$). Conclusion: The kinovea software is a valid and reliabel method to measure the shoulder joint position sense. So, the use of kinovea software is recommended at medical and rehabilitation centers and sport's environments as a free open access and suitable method for position sense measurement of shoulder joint.

**Keywords**: Kinovea software, Joint position Sense, Shoulder joint, Abduction, Flexion

**Corresponding Author:**Shirin Yazdani. Associate Professor, Department of Motor Behavior, Faculty of Physical Education and Sports Sciences, University of Tabriz, Tabriz, Iran. E-mail: sh_yazdani@tabrizu.ac.ir Tel:+989144035737

## INTRODUCTION

The shoulder joint is one of the most important joints in the body which has the highest degree of freedom and range of motion. Appropriate range of motion (ROM) could prevent injuries [1-3] and plays an important role in various sports such as volleyball. Spike, service and defense on the net are among complex and very skillful movements in volleyball, in which strong forces are applied during these movements, and may put excessive stresses on the shoulder joint complex [4]. For this reason, in volleyball players, the shoulder joint must be both enough loose to allow a lot of external rotation of the shoulder joint and also be enough stable to prevent partial dislocations of the shoulder joint [4, 5]. The shoulder joint relies more on the muscle control to maintain stability in its mid-range of motion [2, 6]. Proper muscle control requires the transmission of accurate proprioceptive information to the central nervous system. Proprioception is a specialized development of the tactile sensation by which a person understands the movement and position of his body parts [7, 8]. Proprioception receptors are located in the skin, muscles, joints, as well as ligaments and tendons. They can convert mechanical information into nervous signals and provide useful information to the central nervous system about the position of the joints in relation to each other in the space to maintain the balance of the body [9]. There are different tools and methods for measuring the position sense of the joints, which are mainly based on the evaluation of the range of motion and the angle of the joint and the reconstruction of the angle. To evaluate active range of motion (ROM) of different joints, visual estimation, Leighton flexometer, electrogoniometer, and standard goniometer are widely used, but each of these methods has advantages and disadvantages [10]. For example, the visual estimation method has weak reliability. Layton flexometer is a suitable device for measuring the range of motion of the shoulder joint, but it is not available for everyone and everywhere, expensive and need for an experience. Electrogoniometer also is one of the most important tools for measuring joint range of motion due to its high accuracy. But due to the high cost and difficulty of analysis, it is less used. Among these methods, the standard goniometer is another suitable tool for measuring the shoulder joint ROM. It has some advantage such as relatively reasonable price, easy transportation and no need to further analysis. But this method is two-dimensional, and the goniometer must be used by an expert who is familiar with the anatomy of the body [11]. More accurate and wider measurement of joint range of motion can be obtained by using more advanced systems. These systems are suitable for biomechanics or motion analysis laboratories, as they require a lot of space and cost and require specialized personnel [12, 13]. An ideal measurement system is a device that is cheap and can be easily used without the need for sensors attached to the body [14]. Kinovea is a free software that is used for static and dynamic analysis and has many applications in sports science, physiotherapy, occupational therapy, ergonomics and anthropometry. It is also suitable for coaches and physical education teachers. It is easy to use and does not require physical sensors during analysis [14].

In previous studies, it has been determined that the video capture method and Kinovea software is very reliable for measuring shoulder joint rotation ROM and could replace with the goniometric method [15]. Considering that joint proprioceptive assessment plays an important role in preventing sports injuries, and Kinovea software can be used as a cheap and widely used method in assessing range of motion and proprioception, but the validity and reliability of Kinovea measurements in evaluating joint position sense is not well understood yet. Therefore, the current research was conducted with the aim of investigating the validity and reliability of the Kinovea software in measuring shoulder joint proprioception.

## MATERIAL AND METHODS

### Participants

This research was conducted by purposeful sampling method. The studied population consisted of female volleyball players in Tabriz city, among them 15 female volleyball players with mean age height and weight of 21.63±2.1 years old, 170.57±5.6 cm and 59.15±4.3 participated at this study voluntarily. Based on the result of the G*power software, with the effect size of 0.66, power of 0.9 and α error probability of 0.05, 15 subjects were sufficient for this study. The subjects included at this study if they had: a) at least 2 years of experience in club teams, b) right-handed people [16], c) no history of surgery, fracture, dislocation

or any inflammation in the shoulder complex, d) no presence of neuromuscular and painful disorders in shoulder girdle and spine and e) no history of taking sleeping pills, sedatives and pain relievers. The subjects were excluded if they had joint rheumatism and diabetes [17].

## Instruments and Examinations

At first, the purpose of the study and all the work steps were fully explained to the subjects, and the subjects were asked to read and sign the written consent form. The participants were asked to wear light clothes to allow better identification of bony markers on their bodies and to prevent movement restrictions. Before recording each measurement, the tested movements were practiced three times so that the participants were familiar with the tests and movements. For proprioception analysis, the active reconstruction angle and reconstruction error was measured during active flexion and abduction range of motions of the shoulder joint at three different angles of 45, 80 and135 degrees using photography method (a camera (Canon EOS 850)) (Kinova software) and a goniometer (metal standard, made in Switzerland country with error coefficient of 1 degree). Kinovea software was used to calculate the angles by the photography method. In the method of recording movement using a camera, first, the relevant landmarks were marked with black markers [18]. The landmarks were attached to the outer edge of the acromion, the lateral epicondyle of the elbow, and between the lower radioulnar joint [18]. Then the camera was placed at a distance of 185 centimeter from the subjects' standing position on a tripod at a height of 100 centimeter [19]. The place of tripod was determined on the ground using a tape to maintain the same distance between the camera and the wall in all tests. To perform flexion movements, the subject was asked to stand next to the wall with the right side facing the camera and the left side facing the wall. Then the examiner placed the subject's hand in a 45 degrees' flexion angle and kept it at the target angle for 10 seconds to remember the angle. After returning the subject's hand to the initial position (next to the body) after 5 seconds, he was asked to take his hand to the mentioned angle while his eyes open and hold it for 10 seconds. Then, after a minute of rest, the subject was asked to raise his hand to the specified angle, and the person's movement was recorded by the camera. At the same time as performing each test and recording the movement using a camera, the range of motion of the joints was also measured using a goniometer. Three repetitions were done in this way, and in the same way, the measurements were repeated at the angles of 80 and 135 degrees of flexion and 45, 80 and 135 degrees of abduction. For the abduction range of motion assessment, the subject was asked to stand next to the wall facing the camera. All tests were done in both eyes open and eyes closed conditions. An eye patch was used to eliminate visual feedback in blindfold measurements of joint position sense [20]. After recording the movements by the camera, using Kinovea software, the amount of reconstruction angle was measured and the reconstruction error was calculated. To determine the reliability of the Kinovea software, the correlation between the reconstruction angle (the reconstruction error) calculated by the Kinovea software with reconstructed angle (the reconstruction error) measured using a goniometer was calculated. The test-retest method was used to determine the validity of shoulder joint proprioceptive tests using Kinovea software. In this way, all participants were measured twice with an interval of one week one and the reconstruction angles were recalculated using kinova software.

## Statistical Analysis

The Shapiro-Wilk test was used to check the normality of the data. After confirming the normality of the data, Pearson's correlation coefficient was used to check the reliability and validity of Kinovea software and Goniometer data. All statistical analyses were done using SPSS 26 software. The significance level of the test was set at 0.05.

# RESULTS

### Validity results

Tables 1 and 2 respectively show the results of the mean reconstructing angle and mean reconstruction error of shoulder joint while three different 45, 80 and 135 degrees of flexion and abduction of glenohumeral joint with eyes open and eyes closed. The results showed that in the eyes open condition, in all three angles of 45, 80 and 135 degrees of the shoulder joint flexion, there are significant positive correlations between

reconstruction errors calculated using Kinova and goniometer methods (table 3). This indicate that in all three degrees of 45, 80 and 135 of shoulder flexion, the measurements obtained from the Kinovea software are highly valid (P<0.05). The similar results were seen in closed eyes conditions and in all three shoulder flexion angles, the measurements obtained from Kinovea had high validity (P<0.05) (Table 3).

**Table 1: The mean and SD of reconstruction angle and reconstruction error of shoulder flexion at three different angles of 45, 80 and 135 degrees in open and closed eyes using Kinovea software and Goniometer**

| Tools | | Shoulder flexion | 45 Degree | 80 Degree | 135 Degree |
|---|---|---|---|---|---|
| Goniometer | open-eye | Reconstruction angle | 12.40 ± 50.93 | 3.98 ± 77.53 | **5.97 ± 123.6** |
| | | Reconstruction error | 5.93 | -2.46 | **-11.4** |
| | eyes closed | Reconstruction angle | 7.8 ± 48.47 | 2.14 ± 78.8 | **6.1 ± 126.4** |
| | | Reconstruction error | 3.47 | -1.2 | **-8.6** |
| Kinovea | open-eye | Reconstruction angle | 12.21 ±50.6 | 3.75 ±77.53 | **6.26 ± 123.33** |
| | | Reconstruction error | 5.6 | -2.46 | **-11.66** |
| | eyes closed | Reconstruction angle | 8.06 ± 48/8 | 1.98 ± 78.93 | **6.07 ± 125.73** |
| | | Reconstruction error | 3.8 | -1.06 | **-9.26** |

**Table 2: The average measurements of shoulder joint position sense during reconstruction of shoulder abduction at three angles of 45, 80 and 135 degrees in the conditions of eyes open and eyes closed using Kinovea and Goniometer software**

| Tools | | Shoulder flexion | 45 Degree | 80 Degree | 135 Degree |
|---|---|---|---|---|---|
| Goniometer | open-eye | Reconstruction angle | 9.73 ± 47.4 | 4.03 ± 77.8 | **8.43 ± 119.2** |
| | | Reconstruction error | 2.4 | -2.2 | **-15.8** |
| | eyes closed | Reconstruction angle | 10.11 ± 48.73 | 3.28 ± 78.27 | **6.30 ±123.73** |
| | | Reconstruction error | 3.73 | -1.73 | **-12.27** |
| Kinovea | open-eye | Reconstruction angle | 9.54 ±47.33 | 4.07 ±77.93 | **8.40 ±119.13** |
| | | Reconstruction error | 2.23 | -2.07 | **-15.87** |
| | eyes closed | Reconstruction angle | 10.07 ± 48.67 | 3.14 ± 78.2 | **6.19 ± 122.8** |
| | | Reconstruction error | 3.67 | -1.8 | **-12.2** |

In evaluating the validity of Kinova measures while performing the shoulder abduction in open and closed eyes conditions, the results showed that the correlations obtained in all angles and conditions were significant and there are positive correlations between Kinovea and goniometer measurements (P<0.05). Table 3 shows these results.

**Table 3. The amount of correlation coefficient between the sizes of reconstruction error calculated using goniometer and Kinovea software in different degrees of 45, 80 and 135 degrees of arm flexion and arm abduction in eyes open and eyes closed conditions**

| movement | | | 45 Degree | 80 Degree | 135 Degree |
|---|---|---|---|---|---|
| **Shoulder flexion** | opened eyes | **r** | 0.994 | 0.987 | **0.981** |
| | | **P** | *0.0001 | *0.0001 | ***0.0001** |
| | closed eyes | **r** | 0.993 | 0.955 | **0.985** |
| | | **P** | *0.0001 | *0.0001 | ***0.0001** |
| **Shoulder abduction** | opened eyes | **r** | 0.991 | 0.992 | **0.997** |
| | | **P** | *0.0001 | *0.0001 | ***0.0001** |
| | closed eyes | **r** | 0.998 | 0.991 | **0.990** |
| | | **P** | *0.0001 | *0.0001 | ***0.0001** |

p = p-value
r = correlation coefficient
*= represents significant correlation

The test-retest method was used to evaluate the reliability of Kinovea measurements. The results related to the two different sessions measurements are shown in Table 4. Based on the obtained results, in both eyes open and eyes closed conditions and in all shoulder flexion angles, significant positive correlations were observed between the amount of flexion angle reconstruction error in two measurement sessions, and during shoulder flexion, Kinovea measures were highly reliable (P<0.05).
Also, the results showed that during the reconstruction of the shoulder abduction angle, high reliability of measurements were observed in all conditions(P>0.05) (Table 4).

**Table 4: The amount of correlation coefficient between the reconstruction error calculated using Kinovea software on two occasions at different degrees of 45, 80 and 135 degrees of shoulder flexion and shoulder abduction in the opened eyes and closed eyes conditions**

| movement | | | 45 Degree | 80 Degree | 135 Degree |
|---|---|---|---|---|---|
| **Shoulder flexion** | opened eyes | **r** | 0.997 | 0.961 | **0.997** |
| | | **P** | *0.0001 | *0.0001 | ***0.0001** |
| | closed eyes | **r** | 0.995 | 0.945 | **0.987** |
| | | **P** | *0.0001 | *0.0001 | ***0.0001** |
| **Shoulder abduction** | opened eyes | **r** | 0.998 | 0.972 | **0.986** |
| | | **P** | *0.0001 | *0.0001 | ***0.0001** |
| | closed eyes | **r** | 0.840 | 0.945 | **0.980** |
| | | **P** | *0.0001 | *0.0001 | ***0.0001** |

p = p-value
r = correlation coefficient
*= represents significant correlation [21]

## DISCUSSION

The aim of the present study was to investigate the validity and reliability of the Kinovea software in assessing the position sense of the shoulder joint in female volleyball players. The results showed that the Kinovea software is highly valid for assessing the position sense of shoulder joint in volleyball players. In accordance to the findings of the present study, Fernández-González et al. (2020) showed that the Kinovea software was a valid and reliable method for evaluating hip, knee and ankle joints range of motion in the initial contact phase of gait. In their study, the kinematic data were recorded using VICON motion system and digital video cameras. The intra-rater reliability showed a good correlation for hip, knee and ankle angles ,(ICC < 0.85), [21]. Also, Moral Moz et al. (2015) claimed that the Kinovea program is a very valid and objective method for measuring hip and knee joint angles in evaluating hamstring flexibility [22]. Furthermore, the results of Noor et al (2018) supports our results regarding high validity (0.97) of image capture technique for all movements of shoulder joint at angles of 30, 45, 65, and 70 degrees [23].
Also, the results of the present study showed that the method of measuring shoulder joint position sense using Kinovea software has good reliability. In agreement with our results, Abdollahi et al (2021) reported excellent reliability of the tests for shoulder internal and external rotation and elbow flexion movements in relative and absolute errors (≥0.92) [18]. Also, the results of Noor et al., (2018) confirming our results about high reliability of image capture method. They reported high reproducibility (0.99) in examining the absolute and relative reconstruction error of the shoulder joint in each of the angles of 30, 45, 65 and 70 degrees of shoulder joint rotation using image capture method [23]. In another study by Elwardany et al. (2015), the intra-examiner and inter-examiner reliability of the Kinovea computer program in assessing the range of motion of the neck in the sagittal plane of healthy participants was reported high [24]. Moreover, high reliability of image capture technique for the knee joint in sitting and prone positions were reported by Relph et al (2015), [25]. These results in agreement with the findings of our study.
In contrast to the results of this study, Irving et al (2016) showed poor to moderate reproducibility results for goniometer and photography. They investigated the reliability of measuring the position sense of knee joint in standing position at angles of 20, 40, 75, and 100 degrees with a goniometer and image capture technique [26]. They attributed the poor-to-moderate reproducibility obtained in their study to the long interval between the two measurements and the fact that each angle was photographed only once. Also, in the assessment of joint position sense using goniometer, weak to moderate reproducibility for wrist joint position sense in 20 and 45degree extension and flexion angles has been reported, and the 20 degrees' flexion angle was more reliable than all positions [27]. These results were not consistent with the results of the present study. Furthermore, little reliability has been reported in the assessment of joint position sense using the isokinetic device [28]. The inconsistency of the findings of the present study with the above-mentioned studies can be attributed to the subjects, the measured joint, the used device and the investigated angles.
In general, the results of current research showed that the Kinovea software has high validity and reliability for the assessment of position sense of shoulder joint in flexion and abduction movements. It has several advantages; it is an open access free software that widely and easily could be use in different medical and rehabilitation centers and sport's environments. It is providing an acceptable level of accuracy in angular and linear measurements obtained via digitization of x- and y-axis coordinates. Among other advantages of this software is the simplicity of working with it, as well as it's availability and easy transportation. Thus, it could be used as simple alternative to universal goniometry, electro goniometry and other expensive devices for assessment of proprioception and kinematic data.

## CONCLUSION

Kinovea software has excellent validity and reliability for assessment of shoulder joint position sense. Emerging Kinovea software could provide innovative and easily applicable approaches in shoulder joint position sense assessment.Thus, it is recommended that this software could be replace by other expensive instruments for measuring shoulder joint properioception. This study was done on the validity and reliability of Kinova software for assessment of just shoulder joint position sense, and the validity and reliability of this software for the assessment of other joints posion sense is unclear. So, the evaluation of validity and reliability of kinova software for the assessment of range of motion and position sense of different joints of body is strongly recommended in future studies.

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# روایی و پایایی  نرم افزار کینوا در ارزیابی حس وضعیت مفصل شانه در والیبالیست‌های دختر

شیرین یزدانی[1*]، حدیثه افتخاری[2]، محمد خفاف پور کمیلی[3]

۱-گروه رفتار حرکتی، دانشکده علوم ورزشی و تربیت بدنی، دانشگاه تبریز، تبریز، ایران

۲- گروه رفتار حرکتی، دانشکده تربیت بدنی و علوم ورزشی، دانشگاه تبریز

۳- گروه رفتار حرکتی، دانشکده تربیت بدنی و علوم ورزشی، دانشگاه تبریز

**چکیده**

حس عمقی در حس حرکت و محل قرارگیری مفصل، در کنترل حرکت و مکانیسم عصبی-عضلانی نیز نقش دارد و با توجه به عملکرد مهم حس عمقی حائز اهمیت است تا ابزارها و روش های مناسب اندازه‌گیری آن مورد بررسی قرار گیرد. یکی از ابزارهای نوین اندازه‌گیری، نرم افزار کینوا می‌باشد. هدف تحقیق حاضر بررسی روایی و پایایی نرم افزار کینوا در بررسی حس وضعیت مفصل شانه والیبالیست‌ها می‌باشد. در این تحقیق ۱۵ نفر از تیم والیبال بانوان دانشگاه تبریز (سن ۱۹-۲۳)  به روش نمونه گیری هدفمند و در دسترس انتخاب شدند. برای بررسی حس عمقی مفصل شانه ابتدا دامنه حرکتی فعال فلکشن و ابداکشن مفصل شانه در سه زاویه ۴۵ ،۸۰ و ۱۳۵ به صورت چشم باز و چشم بسته با استفاده از روشهای گونیامتر و عکسبرداری (تحلیل این تکنیک با استفاده از نرم افزار کینوا) مورد اندازه گیری قرار گرفت سپس با استفاده از روش بازسازی فعال، زاویه بازسازی و خطای بازسازی در هر یک از حرکات یاد شده محاسبه و برای تحلیل حس عمقی مورد استفاده قرار گرفت. داده های به دست آمده با استفاده از  نرم افزار spss26و روش همبستگی پیرسون مورد تحلیل قرار گرفت. برای بررسی روایی همبستگی بین نتایج دو روش کینوا و گونیامتر محاسبه گردید. در بررسی پایی اندازه های کینوا نیز از روش آزمون-آزمون مجدد استفاده شد. سطح معنی داری آزمون ۰/۰۵ در نظر گرفته شد. نتایج نشان دادند که در شرایط چشم باز در هر سه زاویه فلکشن ۴۵، ۸۰ و ۱۳۵ درجه مفصل شانه، همبستگی مثبت معنی داری بین دو روش اندازه گیری در هر سه درجه ۴۵، ۸۰ و ۱۳۵ فلکشن بازو  وجود دارد. در ابداکشن بازو نیز نتیجه مشابهی دیده شد. همچنین نتایج نشان دادند که در هنگام اجرای فلکشن و همچنین ابداکشن بازو اندازه های کینوا از پایایی بالایی برای بررسی حس عمقی برخوردار بودند (P<۰/۰۵). نتیجه گیری: با توجه به همبستگی بالای به دست آمده بین نتایج اندازه های کینوا با گونیامتر و همچنین بین نتایج آزمون – آزمون مجدد اندازه های کینوا می توان گفت که نرم افزار کینوا دارای روایی و پایایی لازم برای اندازه گیری حس وضعیت مفصل شانه می باشد و استفاده از نرم افزار کینوا به عنوان یک روش ارزان و مناسب برای اندازه‌گیری حسی- عمقی مفاصل توصیه می گردد.

**کلمات کلیدی:** نرم افزار کینوا، حسی عمقی، مفصل شانه، ابداکشن، فلکشن