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Effect of Joint Position Sense on Shooting Accuracy Performance in Team Sports*

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Research Article
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Abstract

This study investigated the effect of joint position sense (JPS) on shooting accuracy in team sports. JPS and accuracy tests were performed on 90 participants consisting of amateur and elite-level athletes and sedentaries. Participants were analyzed separately according to their gender and the sports branches they participated in. The elbow joint was analyzed in the chest pass test for basketball, the shoulder joint in the cuff pass test for volleyball, and the hip joint in the in-foot pass test for soccer. Pearson correlation analysis showed no significant relationship between JPS error and accuracy error. The two-way analysis of variance was performed to examine the effect of gender and sports variables on shooting accuracy error and JPS error variables. It was found that the gender variable did not have a significant effect on the shooting accuracy error, while the branch variable had a significant effect on the shooting accuracy error. The effect of the gender variable on the position error was significant. On the other hand, the effect of the branch variable on position error was insignificant. In this study, it was revealed that position error was not related to shooting performance. Shooting accuracy errors showed significant differences according to the branches. Position error showed significant differences according to gender. It is thought that accuracy error should be examined in terms of its relationship with other subcomponents of proprioception, such as force and movement speed.
Keywords: Proprioception, Basketball, Volleyball, Soccer

Takım Sporlarında Eklem Pozisyon Duyusunun Atış İsabeti Performansına Etkisi

Öz

Bu çalışmada, takım sporlarında eklem pozisyon duyusunun (EPD) atış isabetine etkisi araştırıldı. Amatör ve elit düzeyde sporcu ve sedanterlerden oluşan 90 (55 erkek 35 kadın) katılımcı üzerinde EDP ve isabet testleri yapıldı. Katılımcılar cinsiyetlerine ve katıldıkları test branşlarına göre ayrı ayrı incelendi. Basketbol için göğüs pası testinde dirsek eklemi, voleybol için manşet pas testinde omuz eklemi ve futbol için ayak içi pas testinde kalça eklemi analiz edildi. Pearson korelasyon analizi EPD hatası ile isabet hatası arasında anlamlı bir ilişki bulunmadığını gösterdi. Cinsiyet ve branş değişkenlerinin atış isabeti hatası ve EPD hatası değişkenlerine olan etkisini incelemek için çift yönlü varyans analizleri yapıldı. Cinsiyet değişkeninin atış isabeti hatasına anlamlı bir etki yapmadığı, branş değişkeninin atış isabeti hatasına anlamlı bir etkisi olduğu bulunmuştur. Cinsiyet değişkeninin pozisyon hatasına olan etkisi anlamlı bulunmuştur. Öte yandan, branş değişkeninin pozisyon hatasına olan etkisi anlamlı bulunmamıştır. Bu çalışmada pozisyon hatasının isabet performansıyla bir ilişkisinin olmadığı ortaya konmuştur. Atış isabeti hataları branşlara göre anlamlı farklılıklar gösterdi. Pozisyon hatası ise cinsiyete göre anlamlı farklılık gösterdi. İsabet hatasının propriyosepsiyonun diğer alt bileşenleri olan kuvvet ve hareket hızı ile olan ilişkileri açısından da incelenmesi gerektiği düşünülmektedir.
Anahtar Kelimeler: Propriyosepsiyon, Basketbol, Voleybol, Futbol

* This study is derived from the Author's Master's thesis entitled "The Effect of joint position sense on shooting accuracy rate" completed under the supervision of the second author..

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INTRODUCTION

Proprioception is a system that provides information to our central nervous system by perceiving the position of our body, speed of movement, and forces affecting movements with peripheral senses (Proske & Allen, 2019). The more accurate and detailed information about the movements and positions of muscles and joints during sports, the more precise and accurate responses can be generated (Knudson, 2013). The position perception component of proprioception is examined with joint position sense (JPS) tests (Han et al., 2016). The ability to be aware of the general and local positions of the body is related to the ability to correctly adjust the position of body parts to avoid injury, target an object more precisely, maintain balance, and achieve optimal muscle coordination (Proske & Allen, 2019; Wang et al., 2016). JPS tests are often used to decide whether to return to sport after injury or to determine injury risk in healthy athletes (Powell et al., 2018).

In the JPS studies conducted on athletes so far, it has been revealed that they can improve their sensory perception level with training techniques that improve proprioception; thus, they can be better protected from injuries (Kaminski et al., 2003; Verhagen et al., 2004). For this purpose, proprioceptive balance and strength exercises are performed to enhance proprioception (Ogard, 2011). However, two critical questions still need to be clarified. What is the criterion for good position perception to return to sport? Does a good position perception contribute to the movement performance required by the sport?

In team sports such as soccer, volleyball, and basketball, shooting accuracy determines the outcome of the competition, while fitness and passing accuracy are also crucial in competition performance (Farley et al., 2020). Applying the desired game tactic with accurate passes and reaching the highest score with a precise shooting rate is essential during the competition. In addition, pass and shot accuracy errors are common due to the limbs being far from the desired joint angle and poor repositioning (Horváth et al., 2023).

Very few studies examine the effect of position perception on movement performance. Existing studies report quite contradictory results. For example, Altun and Özsoy (2023) reported a positive relationship between hip JPS acuity and competition practice score in aerobic gymnastics (Altun & Özsoy, 2023). On the other hand, Tıkız and Altun (2022) showed that hip JPS in aerobic gymnastics was more sensitive under external load, and the sensitivity worsened when no load was applied (Tıkız & Altun, 2022). Han et al., (2014) examined the relationship between ankle JPS and athletic performance in swimmers, badminton players, soccer players, athletic dancers, and aerobic gymnasts. The study reported that athletes had better JPS than non-athletes and that achieved performance was positively influenced by JPS. However, there were no significant differences between the different subgroups of sports (Han et al., 2014). To the best of our knowledge, the relationship between good position perception and shooting accuracy has never been investigated. If there is such a relationship, reducing positional errors with proprioceptive exercises can be used to improve score-oriented competition performance. In addition, the position error averages of healthy athletes with good scores will provide a good criterion for returning to sport.

This study aimed to investigate the relationship between shoulder, elbow, and hip joint position sense and team athletes' pass/shot accuracy rates.

MATERIAL AND METHOD

Research Model

The current study is an experimental research involving relationship analysis.

Population (Participants)

In this study, 90 (55 males / 35 females) students of Manisa Celal Bayar University, Faculty of Sport Sciences, participated voluntarily. Age, height, body weight, body fat percentage, and activity levels of the participants are shown in Table 1.

Table 1. Anthropometric characteristics and activity levels of the participants

(n=90)	Mean	Standard Deviation
Height (cm)	173.24	8.11
Age (year)	21.44	2.15
Body Weight (kg)	69.82	10.95
Body Fat Ratio (%)	16.31	6.86
Tegner Activity Level	6.98	1.53

This study excluded those with orthopedic and neurologic problems of the hip, shoulder, and elbow joints. Participants were asked not to take any medication or engage in strenuous physical activity until two days before the measurements.

Data Collection Tools

The participants' activity levels were assessed according to the Tegner Activity Scale (Tegner & Lysholm, 1985). Before breakfast, body composition was analyzed with InBody 230 (Biospace Ltd., Seoul, Korea) (von Hurst et al., 2016). In JPS tests, joint angles were measured with the validated Clinometer + Bubble Level (Google Play, 0.1^{o} sensitive) smartphone application (Cox et al., 2018; Monreal et al., 2021; Wang et al., 2019; Werner et al., 2014). The smartphone brand used in the tests was Samsung Galaxy A34 (2023).

Research Publication Ethics

This study was approved by Manisa Celal Bayar University Health Sciences Ethics Committee (E-20478486-050.04.04-519794). All participants agreed to volunteer for the investigation by providing written and verbal information about the procedure and aims of the study. Permission to test the athletes and to use the test data in this study was obtained from the participants and the Administration of the Faculty of Sports Sciences of Manisa Celal Bayar University.

Data Collection

Volunteers were divided into two groups based on their athletic status: Athletes (n=41) and non-athletes (n=49). Each group was further divided based on their sport, including volleyball, basketball, and soccer. Before the measurements, two-way calibration of the phone application was performed. Then, JPS measurements were performed in relative angle mode in the app. No more than two trials were allowed to avoid learning effects. Primarily, the hip, shoulder, and elbow joints' range of motion (ROM) was measured. 30% of the ROM was determined as the target angle.

The volunteers were taught the target angle by showing it twice. The researchers waited 4 seconds at each target angle and instructed the volunteer to memorize this angle. They were then asked to find the taught angle with their eyes closed. The volunteers tried the test twice. Participants rested for 60 seconds between joint position detection trials to avoid the effect of fatigue (Dover & Powers, 2003; Niespodziński et al., 2018a). The absolute error score was calculated from the difference between the reproduced and target values, and the lowest error score obtained in two trials was included in the analysis.

In the field test, the volleyball and basketball tests were performed at 4 meters from the wall, and the football test was performed at 6 meters. For volleyball, the shoulder joint position test was used, and the participants were asked to shoot with the forearm pass technique to 3 different target points determined at a height of approximately 2 meters. For basketball, the elbow joint position test was used, and the participants were asked to shoot with the chest pass technique to 3 different target points determined at a height of approximately 2 meters. For football, the hip joint position test was used, and the participants were asked to shoot with the in-foot passing technique to 3 different target points determined at a height of approximately 0.1 meters. They were given two practice shots at each target and asked to make one test shot. The number of centimeters deviated from each target was recorded. The average of the three deviations was taken into account in the analysis. Finally, the deviation of the joint from the target angle was compared with the deviation of the passes from the target points.

All tests were performed after approximately 20 minutes of active warm-up in a sports hall. Before the tests, all participants were asked which extremities they used to kick the ball, and the tests were performed on the dominant extremities (van Melick et al., 2017). All JPS and ROM tests except hip ROM were measured in the standing essential stance position, and the hip ROM test was measured in the supine position. The starting angles in these positions were accepted as 0^{o}. The smartphone was fixed to the lateral part of the thigh, arm, and forearm according to the measured area with two velcro straps, one on the top and one on the bottom, attached to the phone case. For elbow angle measurements, the smartphone was in the direction of the elbow joint rotation axis (humero-ulnar joint) and the lower projection of the radius (lateral malleolus). In shoulder angle measurements, the smartphone was in the direction of the humeral process (major tubercule) and the elbow rotation axis (humero ulnar joint). For hip measurements, the smartphone was placed in the direction of the hip joint rotation axis (approximately 1 cm above the trochanter major) and the knee joint rotation axis (femoral lateral epicondyle).

Data Analysis

The compatibility of the data obtained from the research with the normal distribution was examined with the Kolmogorov-Simirnov test. Since it was determined that the amount of deviation of the received data from the normal distribution was negligible, it was decided to use parametric hypothesis tests. Accordingly, Pearson Correlation analysis was performed to examine the relationship between joint position error and hitting error. A two-way analysis of variance was conducted to investigate the effect of gender and branch on joint position error and hitting error. In the analysis of variance, joint position error and hitting error were entered into the model as dependent variables, while gender and branch were entered into the model as independent variables.

FINDINGS

The JPS, shooting accuracy error averages, and minimum error averages of all participants are shown in Table 2.

Table 2. JPS and shooting accuracy error averages.

Sport Branch	Joint	Measurements	Mean	SD
All n=90	All	JPS Minimum Error	3.33	3.28
		JPS Mean Error	4.54	3.88
		Shooting Accuracy Mean Error	2.82	1.64
		Shooting Accuracy Minimum Error	1.43	1.44
Basketball n=19	Elbow	JPS Minimum Error	5.16	4.31
		JPS Mean Error	7.13	5.18
		Shooting Accuracy Mean Error	1.54	.63
		Shooting Accuracy Minimum Error	.81	.46
Soccer n=42	Hip	JPS Minimum Error	2.43	2.53
		JPS Mean Error	3.43	2.64
		Shooting Accuracy Mean Error	2.51	1.23
		Shooting Accuracy Minimum Error	1.04	1.08
Volleyball n=29	Shoulder	JPS Minimum Error	3.45	3.07
		JPS Mean Error	4.47	3.73
		Shooting Accuracy Mean Error	4.10	1.76
		Shooting Accuracy Minimum Error	2.42	1.78

Table 3. Nonparametric correlations of JPS and shooting accuracy error values

n=90		JPS Mean Error	JPS Minimum Error	Shooting Accuracy Mean Error	Shooting Accuracy Minimum Error
JPS Mean Error	r	1.000	.957**	-.016	.090
	p		.0001	.878	.401
JPS Minimum Error	r	.957**	1.000	.035	.115
	p	.0001		.743	.282
Shooting Accuracy Mean Error	r	-.016	.035	1.000	.696**
	p	.878	.743		.0001
Shooting Accuracy Minimum Error	r	.090	.115	.696**	1.000
	p	.401	.282	.0001	

** p<.01

Pearson correlation analysis showed no significant relationship between joint position and shooting accuracy errors (p>.05) (

Table 3). The relationship was analyzed separately for both minimum and mean error rates.

Table 4. Descriptive statistics data according to the dependent variables of shooting accuracy and JPS minimum error.

			Shooting Accuracy (Minimum deviation distance from target)		Joint Position Sense (Minimum angle of deviation from target)	
Gender	**Sports Branch**	**N**	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**
Male	**Basketball**	12	.83	.49	6.25	4.88
	Soccer	33	.91	.72	2.33	2.71
	Volleyball	10	3.03	2.00	5.10	4.07
	Total	55	1.28	1.31	3.69	3.86
Female	**Basketball**	7	.76	.43	3.29	2.36
	Soccer	9	1.49	1.90	2.78	1.79
	Volleyball	19	2.11	1.62	2.58	2.01
	Total	35	1.68	1.60	2.77	1.99
Total	**Basketball**	19	.81	.46	5.16	4.31
	Soccer	42	1.04	1.08	2.43	2.53
	Volleyball	29	2.42	1.78	3.45	3.07
	Total	90	1.43	1.43	3.33	3.28

The two-way analysis of variance conducted to examine the effect of gender and branch variables (Table 4) on the shooting accuracy error variable showed that gender had no significant effect on shooting error [$F_{(5.84)}$ =.219, p = .641, η^2 = .003. On the other hand, the effect of the branch variable on shooting error was significant [$F_{(2.84)}$ = 12.82, p = .000, η^2 = .234]. The effect of gender × branch interaction was not significant [$F_{(3.86)}$ = 2.43, p = .94, η^2 = .055].

In the two-way analysis of variance conducted to examine the effect of gender and branch variables on the joint position error variable, the effect of the gender variable on position error was found to be significant [$F_{(5.84)}$ = 5.27, p = .024, η^2 = .059] On the other hand, the effect of the sports branch variable on position error was insignificant [$F_{(5.84)}$ = 3.04, p = .053, η^2 = .068]. The effect of gender × major interaction was also not significant [$F_{(5.84)}$ = 2.32, p = .104, η^2 = .052].

DISCUSSION

According to the findings of this study, no significant relationship was found between joint position error and accuracy error. In other words, better joint position sense does not necessarily mean better shooting accuracy. A recent study reported a positive effect of hip JPS acuity on competition practice scores in aerobic gymnastics (Altun & Özsoy, 2023). Another study conducted in aerobic gymnastics showed that hip position sense was measured more acutely under external load, while sensitivity decreased when no load was applied (Tıkız & Altun, 2022). The amount of external load changes the positions taken by the body. Testing a

joint in isolation allows us to obtain more apparent joint-specific test results. On the other hand, in training and competitions, joints are exposed to different loads according to the position of the movement. For example, knee, hip, shoulder, elbow, etc., joint flexion/extension alone is tested without any load on the joint in the JPS test. However, these movements are performed in different body positions in the nature of sport. An example is performing the movement by jumping after dropping from a height. Performing the movements tested by braking / slowing down the limbs or changing the direction of movement, such as accelerating with arm swings or turns, forces the joints to work under different loads. The lack of correlation with accuracy performance in this study may be due to the fact that a single joint movement was tested under unnatural conditions. In addition, aerobic gymnastics is an individual sport developed by training for total body control. This study tested one basic throwing technique of team sports with the ball. Different results may have been obtained due to these other conditions.

Han et al., (2014) examined the relationship between ankle JPS and sportive success in 100 athletes in swimming, badminton, soccer, sportive dance, and aerobic gymnastics. They reported that athletes had better JPS than non-athletes and that it positively affected success performance, but there was no significant difference between the groups (Han et al., 2014). On the other hand, Kaynak et al., (2020) reported that JPS did not affect jump performance (Kaynak et al., 2020). While shot/pass accuracy is more related to the correct application of movement techniques, jump performance is more associated with the amount of force and the acuity to feel and adjust the strength correctly. Previous studies have shown no relationship between force sense and position sense (Kim et al., 2014; Niespodziński et al., 2018b; Phillips & Karduna, 2018).

In the joint position sense test, a small angle error is considered good proprioception, while a large angle error is considered poor proprioception. In addition, the angle criteria determining good and poor proprioception are still unclear. Based on the values obtained in healthy subjects in the related joints, it can be said that joint position sense is good or bad. In this study, the average JPS error rate obtained in hip joint flexion was 2.43º. Tıkız and Altun reported this rate as 3.92º for those over 18 years old and 2.92º for those under 18 years old in the non-elite gymnastics group (Tıkız & Altun, 2022). Altun and Özsoy reported it as 3.67º in elite aerobic gymnasts under 18 (Altun & Özsoy, 2023). The elbow joint flexion JPS error rate of this study was 5.16º. Kaynak et al., reported 2.14º for 30º elbow flexion and 2.10º for 60º (Kaynak et al., 2019). This study's minimum JPS error rate obtained in shoulder joint flexion was 3.45º. No study reporting JPS error in shoulder joint flexion was found in the literature. The error rates obtained are consistent with the literature.

Although there is no relationship between shooting accuracy and gender, there is a significant relationship between shooting accuracy and branch variables. In other words, gender does not affect whether the shooting accuracy is good or bad. However, the shooting accuracy error rate decreases according to the branch type. Especially in the basketball branch, fewer errors are made, while in the volleyball branch, more accuracy errors occur. When joint position errors were analyzed, it was found that position errors were significantly lower according to gender. It was found that the elbow joint position errors of the women who took the basketball test and the shoulder joint position errors of the women who took the volleyball test were much less than the men.

CONCLUSIONS

In this study, it was found that position error was not related to shooting accuracy error. Accuracy error should also be examined regarding its relationship with other subcomponents of proprioception, such as force and movement speed. While performing a sportive movement, multiple muscle and joint groups participate effectively. In this study, only measurements of a single joint, essential in that movement, were taken. It should be evaluated with more joint movements. There may also be differences between individual and team athletes. In this study, participants performed the tasks in a closed skill; it is recommended for further studies to measure joint position sensation on shooting accuracy performance in open skills.

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Researchers' Contribution Rate Statement: The first two authors designed the study and analyzed the data. The third author carried out the measurements and data collection.

Ethical Approval
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