

ARAŞTIRMA / RESEARCH

Investigating the Relationship of Age, Gender, and Lateralization with Elbow Joint Proprioception

Yaş, Cinsiyet ve Lateralizasyonun Dirsek Eklem Propriosepsiyonu ile İlişkisinin İncelenmesi

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Abstract

Objective: Decreased or impaired proprioceptive sense may cause abnormal loading, increased risk of injury, and risk to personal safety. The aim of this study is to examine the relationship between elbow joint proprioception with age, gender, and dominance.**Material and Method:** One hundred and twenty nine asymptomatic individuals aged 18-65 years were included in the study. Elbow joint proprioception measurement was performed with joint position sense error measurement.**Results:** The mean age of the individuals was 30.80±13.29 years. 79 of them were female and 50 of them were male. 9 individuals were left-dominant, and 120 individuals were right-dominant. According to the data, age was associated with joint position sense error measurement (JPSE) in 70°, gender, and dominant side was associated with JPSE in 110° (p<0.01).**Conclusion:** There is a decrease in proprioceptive precision with increasing age. Male and left-dominant individuals have lower joint position sense errors. These findings indicate that age, hemisphere lateralization, and gender can modulate the perception and representation of movement.**Keywords:** Proprioception, elbow, joint position sense, lateralization.

Öz

Amaç: Azalmış ya da bozulmuş proprioseptif duyu, anormal yüklenme ve artmış yaralanma riskine neden olup kişisel güvenliği tehlikeye atabilmektedir. Bu çalışmanın amacı, dirsek eklem propriosepsiyonu ile yaş, cinsiyet ve dominantlığın ilişkisini incelemektir.**Gereç ve Yöntem:** Çalışmaya 18-65 yaş arası 129 asemptomatik birey dahil edildi. Dirsek eklem propriosepsiyon ölçümü eklem pozisyon hissi hatası ölçümü ile gerçekleştirildi.**Bulgular:** Bireylerin yaş ortalaması 30,80±13,29 yıl olup 79'u kadın, 50'si erkekti. 9 birey sol, 120 birey sağ dominant idi. Verilere göre yaş 70° deki, cinsiyet ve dominant taraf 110° deki eklem pozisyon hissi hatası ile ilişkili bulunmuştur (p<0,05).**Sonuç:** Yaş ilerledikçe proprioseptif keskinlikte azalma görülmektedir. Erkek bireyler ve sol dominant bireylerin eklem pozisyon hissi hataları daha düşüktür. Bu bulgular, yaş, hemisfer lateralizasyonu ve cinsiyetin çeşitli yapısal ve fonksiyonel nedenlerle hareketin algılanması ve temsilini modüle edebileceğini göstermektedir.**Anahtar kelimeler:** Propriosepsiyon, dirsek, eklem pozisyon hissi, lateralizasyon.

1. Introduction

Proprioception refers to the perception of body segments and positions (1,2). It is one of the sensory parts of neuromuscular control, and essential for performing motor tasks smoothly and in a coordinated manner, maintaining upright posture and balance, and managing interactions with the environment (1–3). The success of functional joint movements depends on the kinesthetic and proprioceptive properties of the musculoskeletal structures of the joints. The sense of proprioception is the dominant factor in transforming spatial information received through vision into movements that result in muscle strength and joint torques (4). Proprioceptive information has been shown to be critical for the control and coordination of purposeful multi-joint movements and controlling the

joint interaction torques produced proximally, especially when visual information about the hand is not available (5). Afferent information from receptors localized in the capsule, ligaments, tendons, muscles, and skin is processed at different levels in the central nervous system (spinal cord, brainstem, cortex, and cerebellum), and the response is reflex activation of stabilizing muscles to achieve proper joint balance and stability (1,6).

Musculoskeletal tissues and innervating mechanoreceptors are often damaged after trauma. Additionally, after surgery, various changes occur in the motor scheme due to cortical deafferentation, anesthesia, and immobilization (7). Decreased or impaired proprioceptive sense may cause abnormal loading and increased risk of injury and may endanger personal safety (1,8). Individuals

who have functional problems in afferent conduction experience significant problems in arm and hand functions (3). However, the improvement or recovery of proprioception is often neglected by clinicians, which may cause delays in recovery of functions, recurrence of symptoms or suboptimal functional levels (5,6). Elbow joint proprioception is particularly important for fine and delicate tasks of the upper extremity (1). In addition, impairment of proprioceptive input at the elbow causes more impairment in endpoint positioning of arm movements than impairment of proprioceptive input at the shoulder (9).

Aging has been found to be associated with numerous regressions in the neuromuscular system and musculoskeletal system, including muscle activations and motor control (10). In addition, gender-related changes in proprioception have also been reported by other researchers (11). Female gender is accepted as an individual risk factor for the development of musculoskeletal pain, especially in the shoulder, neck, and elbow (12,13). One of the factors that may contribute to the higher injury rate in women is possible differences in neuromuscular control (12). However, despite the importance of proprioceptive feedback for coordinated hand and arm control, which is critically used in activities of daily living and in maintaining functional independence, the examination of proprioception sensation in the elbow joint is still very new (3,9). Changes in joint position sense acuity, depending on age, gender, and dominance, require further characterization of the elbow. Comparing proprioceptive acuity at the elbow with dominance may provide a better understanding of how the central nervous system uses this information to control hand movement (14). The aim of this study is to examine the relationship between elbow joint proprioception with age, gender, and dominance.

2. Materials and Methods

Ethical permissions were obtained from Dokuz Eylül University Non-Interventional Research Ethics Committee with the date 12.04.2021 and the decision number 2021/12-36. Individuals over the age of 18 were included in the study, and informed consent was obtained from the individuals. Within the scope of the study, demographic data of the participants, such as age, gender, and dominant arm, were recorded. Elbow joint proprioception measurement was performed with joint position sense error measurement.

2.1. Participants

129 asymptomatic individuals aged 18-65 years were included. Inclusion criteria were being between 18-65 years old, not having any previous neurological, rheumatological, or psychiatric disorders, not having any pain, symptoms, disorders or operations related to the upper extremity and neck and being Turkish literate. Individuals who did not meet the above criteria and did not agree to participate in the study were excluded from the study.

2.2. Outcome criteria

2.2.1. Joint Position Sense Error Measurement (JPSE)

The most widely used measure of proprioception is joint position sense error, which is defined as awareness of the position of different body parts for both passive and active movements in the open or closed chain (6). Elbow JPSE is measured using a task that requires the participant to

reproduce the elbow joint angle presented previously (15). The JPSE assessments were done with the volunteer's eyes closed, and the room was quiet.

The subjects performed the test while lying flat on their backs on a standard hospital bed, their shoulders adducted, elbows extended, wrists extended, forearms supinated, eyes closed, and head and neck in a neutral position.

Reference positions (70° and 110° of elbow flexion) were presented passively and allowed to be memorized for 10-15 seconds (9).

When the individual was ready, they were asked to bring their elbow to the previous memorized position. They stopped and informed the assessor when they believed they had arrived at the preset goal angle, and the elbow flexion was evaluated at this time. To avoid fatigue and related mistakes in the JPSE, there were around 5 seconds of rest in between trials and up to 2 minutes between bouts. The individuals were permitted to flex and extend their elbows for all of the tests for the estimated positions until they felt that their arms had reached the estimated position (16,17). A universal goniometer was used for the JPSE measurements.

The amount of angle that the individual deviates from the desired angle will be recorded as the score. Each measurement was performed 3 times, and the average of these deviation angles was recorded. All of the measurements were made on the dominant side elbows of the individuals (9).

2.3. Statistical analysis

The analysis of all the data obtained was performed using the "SPSS 26.0 for Windows" statistical program. The normality of the data showed was examined with the Shapiro-Wilk test. Continuous variables were expressed as mean \pm standard deviation. Intragroup correlation analyzes were evaluated with Spearman Correlation Analysis. The statistical significance level was accepted as $p < 0.05$. The correlation level is accepted as low if the coefficient is less than 0.3, moderate if it is between 0.3 and 0.5, and strong if it is greater than 0.5 (18).

3. Results

129 individuals participated in the study. The demographic data of the individuals are presented in Table 1. The relationships of age, gender, and dominance with joint position sense error are given in Table 2. According to the data, age had a low association with JPSE at 70°, and gender and dominant side had a low association with JPSE at 110° ($p < 0.05$).

Table 1. The Demographic Data of the Individuals

Variables	Mean \pm St. dev./Number
Age -years	30.80 \pm 13.29
Gender (female/male)	79/50
Dominant side (right/left)	120/9

St. dev: Standard deviation

4. Discussion

The aim of this study was to examine the relationship of elbow joint proprioception with age, gender, and dominance. According to the results of the study, age was found to be associated with JPSE in 70°, gender and the dominant side were found to be associated with JPSE in 110°.

Table 2. The Relationships of Age, Gender, and Dominance with Joint Position Sense Error

Variables	70°		110°	
	r	p	r	p
Age	0.232	0.008*	-0.017	0.850
Gender	-0.121	0.174	0.179	0.042*
Dominance	0.035	0.692	-0.189	0.032*

*p<0.05, Spearman analyses

Age was associated with JPSE at age 70°. JPSE increases with the age. Age-related changes in the peripheral and central nervous systems are a natural consequence of human growth and development. Peripheral changes in proprioceptor size and number change throughout life and affect the quality of the position signal supplied to the brain (19). Aging is linked to multiple changes in the neuromuscular system that are accompanied by a general deterioration in motor function, as shown by a reduction in maximum muscle force and force control accuracy, as well as an increase in center of pressure excursions during unperturbed upright standing. Proprioceptive perception and postural control have been demonstrated to be affected by changes in muscle spindles and their afferents, as well as the integration of the signal at the supraspinal level, in older individuals (20). Spindle responses are probably impacted by changes in muscle architecture that occur with aging. Intrafusal fibers and fusimotor neurons may be lost along with other muscle fibers and motoneurons during sarcopenia (21). Our findings are also supported by other studies in the literature (22,23).

However, this result was not repeated for 110°. JPSE errors in the elbow joint tend to decrease as the degree of flexion increases. At higher degrees of flexion, more mechanoreceptors are activated, more accurate position estimation is possible, and JPSE errors are reduced (14,24). Studies also show that different skin stretch patterns affect finger, elbow, and knee position and motion perception. Cutaneous afferent activity shows a predominantly linear relationship with skin stretch; this suggests that activity for many cutaneous receptors increases as the joint approaches a position with greater degrees of flexion where the skin is more stretched (14,25). Therefore, JPSEs at 110° are compensated and do not increase as much as increases in age.

Gender has been associated with JPSE at 110°. JPSE was higher in the female gender. While this difference did not reach significance level at 70°, it reached 110°. Hand preference and gender contribute to regional differences in sensory and motor cortical activation and movement representation, which may result from a combination of structural and functional differences and information processing specific to each hemisphere and gender. (26). Altered joint osteo- or arthrokinematics may lead to altered biomechanics such as hyperlaxity and increased carrying angle. It is possible that the altered motor responses, such as diminished fine motor control, abnormal electromyography results, and modifications in force output, are connected to hyperlaxity (27). The carrying angle plays a role in the fine-tuning of muscular lever arms in forearm movements by determining the spatial position of muscular insertions at the forearm. The carrying angle is larger at the elbow extension and decreases as the elbow flexes (28). Additionally, increasing the carrying angle

may cause instability in the elbow joint and pain during activities (29). The difference between the genders of JPSE may have been more evident with the decrease in the extra afferent information it provides as the carrying angle decreases at a higher degree of flexion.

Right-dominant individuals have more JPSE errors than those with left-side dominance. While this difference did not reach a significance level at 70°, it reached 110°. This may be because the right hemisphere is more developed in sense perception, interpretation and interpretation, and awareness (30). No study has compared the proprioceptive acuity of right-dominant and left-dominant individuals, so this study is a first in this regard.

4.1. Limitations

Although joint position sense error measurement is one of the most used and reliable methods in the literature for measuring proprioception, its reliability was not found to be excellent and is determined to be at a good level. Therefore, this situation should be considered when interpreting or comparing the results. Additionally, we only measured flexion and extension of the elbow. Future studies should investigate elbow proprioception in pronation and supination movements.

5. Conclusion

Proprioceptive acuity decreases with age. Male and left-dominant individuals have lower joint position sense errors. These findings show us that age, hemisphere lateralization, and gender can modulate the perception and representation of movement in the central and peripheral nervous systems. Therefore, the demographics of the individuals need to be considered when comparing or interpreting the assessment results.

6. Contribution to the Field

Age, hemisphere lateralization, and gender can modulate the perception and representation of movement. The demographics of the individuals need to be considered when comparing or interpreting the assessment results.

The Ethical Aspect of the Research

Ethical permissions were obtained from Dokuz Eylül University Non-Interventional Research Ethics Committee with the date 12.04.2021 and the decision number 2021/12-36. Individuals over 18 were included in the study, and informed consent was obtained from the individuals.

Conflict of interest

The authors report no conflicts of interest.

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Authorship Contribution

Concept: KSK, BÜ; **Design:** KSK, BÜ; **Supervision:** KSK, BÜ; **Data Collection/Processing:** KSK; **Analysis/ Interpretation:** KSK, BÜ; **Literature Review:** KSK, BÜ; **Manuscript Writing:** KSK, BÜ; **Critical Review:** KSK, BÜ.

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