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Does knee joint proprioception differ according to age and gender in healthy adults?

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Abstract:

Background: This study aimed to investigate the effects of age and gender on knee joint position sense (KJPS) and movement sense (KJMS) in healthy adults

Methods: General physical activity was evaluated using the International Physical Activity Questionnaire–Short Form (IPAQ-Sf) and the Tegner Activity Scale (TAS). Knee discomfort was measured with the Lysholm Knee Score (LKS), and knee-related symptoms and functional status were assessed using the Knee Osteoarthritis Outcome Score (KOOS). Knee joint position sense (KJPS) was tested at 15°, 30°, 45°, and 60°, while knee joint movement sense (KJMS) was evaluated at 60° and 90°. Participants were categorized by gender (male, female) and age (18–29, 30–44, ≥45 years). Mixed-effects models were applied to analyze numerical data, and post hoc comparisons were conducted using least-squares means with Tukey's correction when appropriate."

Results: The mean scores were KOOS = 96.41 ± 4.79, LKS = 96.41 ± 6.94, and IPAQ-Sf = 1772.02 ± 1332.10. Absolute errors for KJPS angles ranged from 2.58 to 3.42 between genders. KJMS at 60°–90° was measured between 1.82 and 1.95 seconds in males, and between 1.66 and 1.80 seconds in females. Significant differences in KJMS (60°–90°) were observed across age groups ($F = 14.841$, $p < 0.001$) and position-sense angles ($F = 19.645$, $p < 0.001$).

Conclusion: KJPS assessment revealed significant differences in absolute errors by age and gender. Males demonstrated lower errors, while participants aged ≥45 years exhibited greater deviations than younger groups. No gender differences were identified in KJMS. Overall, proprioception declined significantly in the 45+ age group

Keywords: Joint Position Sense, Kinesthesis, Functional Test, Movement System, Age, Sex

1. Introduction

Proprioception, defined as the ability to perceive the position of the body in space, is traditionally divided into two subcomponents: position sense and movement sense. Position sense refers to the ability to identify the static position of a body part, whereas movement sense denotes the perception of body motion [1]. Proprioception originates from mechanoreceptors found in muscles, joint capsules, tendons, ligaments, and skin, and plays a vital role in coordinating movements during both routine daily activities and physically demanding tasks. As a fundamental component of sensorimotor control, it contributes to both feedback and feedforward mechanisms, regulates muscle tone, and is essential for movement sensitivity, joint stability, coordination, and balance [2]. Musculoskeletal disorders may impair proprioception due to factors such as pain, joint effusion, trauma, and fatigue [3,4].

Various mechanoreceptors located within and around the knee joint play an important role in maintaining joint stability. Joint tissues and surrounding muscles provide basic afferent information related to position and movement [5]. Proprioceptive information also plays a role in triggering muscle reflexes that help protect and stabilize the knee joint [6]. The knee joint is subjected to greater load-bearing forces than the shoulder joint. Therefore, optimal synergy among agonist and antagonist muscles, and among tendons and ligaments involved in movement, is important. Any improvement or deterioration in these structures can alter the knee joint's sense of position and motion, thereby influencing stability and force production within the segment. Therefore, accurate knee joint position sense (KJPS) and knee joint motion sense (KJMS) are critical for functional movement and coordination [7]. Many researchers have examined factors that positively and negatively affect knee joint position sense. Regular physical activity and warm-up exercises have been reported to contribute to improved knee joint position sense [8]. This can be explained by exercise-induced adaptations in both peripheral and central mechanisms. Regular physical activity is thought to reduce the latency and increase the amplitude of the stretch reflex [9]. Additionally, repetitive exercise optimizes the efficiency of the gamma-motor neuron pathway, thereby enhancing the central processing of afferent inputs [10]. Consequently, regular exercise is considered beneficial for improving knee proprioception. Conversely, aging has been identified as a factor that impairs KJPS. Advancing age may be associated with a decline in various musculoskeletal and neurological functions [11]. Therefore, studies show that proprioception deteriorates with age.

Cross-sectional studies have found that older adults exhibit decreased static knee joint position sense [12]. This has been linked to both peripheral and central adaptations. Few studies have examined differences in knee joint position sense between young adult males and females. Drawing definitive conclusions is difficult because of conflicting results. Although Fouladi et al. demonstrated that knee position sense in female athletes changes during the menstrual cycle, most other studies report that knee proprioceptive acuity is not affected by gender [13]. Furthermore, epidemiological studies have revealed that certain injuries are more prevalent in female athletes than in male athletes. In this context, if gender-related differences contribute to injury susceptibility, this could reasonably explain the disparity [14]. A previous study examined knee joint position sense in 116 healthy males and females aged 18–65 years and found a decline in KJPS associated with aging and inactivity [15]. However, no preliminary reference values exist for KJPS and KJMS across the adult age range in a healthy population. The creation of such data is necessary to guide clinicians in the effective diagnosis and management of proprioceptive disorders. Proprioception is important because of its potential impact on age- and gender-related outcomes.

A review of the literature reveals that research on proprioception has primarily evaluated knee joint position sense (KJPS), with limited attention to knee joint movement sense (KJMS) [11,12]. In this context, the results of our study are considered significant, as they provide a detailed assessment of KJMS. Although previous studies have shown that KJPS decrease with age and increased physical activity, there is no definitive information on the specific age range in which this decrease occurs. Furthermore, it remains unclear how KJMS in the knee joint is affected. Accordingly, this study aims to evaluate the effects of age and gender on KJPS and KJMS in healthy adults.

2. MATERIALS & METHODS

2.1. Study Design and Participants

This study was designed as an observational comparative study. The study was conducted from February to June 2022 at the Sports Medicine Clinic of Necmettin Erbakan University in Konya, Turkey. Approval was obtained from the Ethics Committee for Research on Drugs and Medical Devices of the Meram Faculty of Medicine, Necmettin Erbakan University, under Decision No. 2018/1409 dated 22 June 2018.

The study was conducted in accordance with the Declaration of Helsinki [16]. Prior to participation, written informed consent was obtained from all individuals to ensure compliance with ethical guidelines and to protect participants' autonomy, confidentiality, and rights throughout the research process. A total of 103 healthy individuals (60 males, 43 females) were included. Inclusion criteria required participants to be between 18 and 65 years of age and to voluntarily agree to participate [17]. Exclusion criteria comprised: (i) neurological disorders, (ii) hearing impairments, (iii) current lower extremity injuries, (iv) history of lower extremity injury within the past six months, (v) previous lower extremity surgery, (vi) use of medications affecting motor control, and (vii) pregnancy or breastfeeding [18].

Sample size calculation was performed using G*Power version 3.1.9.7. An effect size of 0.4, an alpha level of 0.05, and a statistical power of 0.95 were assumed. The required sample size was determined to be 102 participants for a study comprising three groups and a single measurement. Ultimately, 103 participants were recruited, consisting of academic and administrative staff and students of the Faculty of Health Sciences, Necmettin Erbakan University.

2.2 Outcome Measure

Participants were characterized by physical and demographic variables, including gender, age, body mass index, and dominant side. Dominant lower limb was identified by asking participants which limb they used to perform tasks such as kicking a ball or climbing onto a chair [8]. To evaluate physical activity and knee health, participants completed four self-assessment questionnaires. General physical activity was assessed using the International Physical Activity Questionnaire–Short Form (IPAQ-Sf), while the Tegner Activity Scale (TAS) measured activity levels related to sports and exercise. The Knee Injury and Osteoarthritis Knee Osteoarthritis Outcome Score (KOOS) and the Lysholm Knee Score (LKS) were used to screen for undiagnosed knee conditions that could warrant exclusion from the study.

Proprioception was assessed in all participants using knee joint position sense (KJPS) and knee joint movement sense (KJMS). All assessments were conducted by a single researcher and lasted 30–45 minutes. No adverse events occurred during the assessment process.

To examine the effects of age and gender on proprioception, data were stratified by age (18–29, 30–44, and ≥45 years) and gender (female, male). [19]. Results were analyzed by comparing outcomes across these categories.

2.3 Primary Outcomes

Participants' proprioception was assessed using knee joint position sense (KJPS) and knee joint movement sense (KJMS). For KJPS, participants were asked to reproduce knee joint positions at target angles of 15°, 30°, 45°, and 60° [20]. They were seated in the dynamometer chair with knees flexed to 90°, and the popliteal fossa positioned 5 cm from the edge of the seat to allow the legs to dangle comfortably. The arm of the isokinetic device was fixed to the foot. To eliminate visual input, participants wore eye masks, and to minimize ankle sensory input and stabilize the joint, an ankle splint inflated to 20 mmHg was applied, with the ankle fixed at 90°. During active knee extension, the dynamometer stopped movement at each target angle, where participants remained for 10 seconds before returning to the starting position (90°) and resting for another 10 seconds. They were then asked to actively reproduce the target angle. This procedure was repeated for all four angles [21]. The difference between the target and reproduced angles was recorded as an absolute error. Each angle was tested three times, and the meaning of the repetitions

For KJMS, participants were positioned on an isokinetic dynamometer with lumbar support, with the knee flexed at 90°, as in the KJPS assessment. The device passively moved the knee joint from 90° to 0° at a velocity of 0.1°/s. Participants verbally indicated when they first perceived movement. The difference between the starting angle and the perceived angle was recorded in both degrees and time units. The same procedure was repeated with the knee flexed at 60°. Each test was performed three times for both ranges (90°–0° and 60°–0° second), and the mean values were recorded for both angle and duration second [22]. Knee joint proprioception was assessed using an isokinetic dynamometer (Cybex Humac 2009®/Norm™ CSMi) [23].

2.4. Secondary Outcomes

The IPAQ-Sf, developed in 1996 by Dr. Michael Booth in Australia, is a reliable and valid questionnaire to examine population health and physical activity levels and the relationship between them [24]. The scale consists of four separate sections and a total of seven questions. It includes items on physical activity lasting at least 10 minutes during the past 7 days.

Physical activity levels are determined using the MET method. 1 MET corresponds to 3.5 mL O_2 per kg per minute at rest [25]. The total METs expended are calculated by determining how many days per week and for how long each person engages in each of these three physical activities. Sağlam et al. [26] conducted a study of the validity and reliability of this scale in Turkish.

The TAS is a 10-level scoring system assessing daily activities and sports participation. It is scored from 0 (for those who have stopped the activity due to injury or dysfunction) to 10 (for those who play professional sports at the national team level). TAS is a 10-item tool that assesses activity levels in competitive or recreational sports and in occupational activities. It assesses the patient's work and sports activity levels using an 11-level scale; higher scores indicate greater physical activity [27].

The validity and cultural adaptation of the Turkish version of the LKS were reported by Çelik et al. Its validity has also been demonstrated for other knee disorders. The LKS is an 8-item questionnaire originally designed to assess knee function after knee ligament injuries [28]. Items assessed by the LKS include pain, support type, instability, locking, swelling, limping, stair-climbing, and squatting. Each item is scored on a 0–100 scale with higher LKS scores indicating lower symptom levels and better functional status (91–100 = excellent, 84–90 = good, 65–83 = fair, <65 = poor) [28].

KOOS was developed in 1995 to assess knee-related symptoms and functional status [29]. It consists of five subscales: pain, other symptoms, functional status related to activities of daily living, functional status related to sports and leisure activities, and knee-related quality of life. It consists of 42 questions and takes approximately 10 minutes to complete. Each subscale is scored from 0 to 100 (0 indicates a serious problem; 100 indicates no problem). A change of 10 points or more is considered clinically meaningful [30]. KOOS has been reported to reduce participant burden about 70% and to make routine clinical use more efficient and cost-effective. KOOS, including scoring guides, is available free of charge to academic users [29,30].

2.5 Statistical Analysis

Descriptive statistics for continuous variables were expressed as mean ± standard deviation, while categorical variables were summarized as frequencies and percentages. Mixed-effects models were used to analyze numerical variables. Post hoc comparisons were performed using least squares means (with Tukey's correction when necessary) [31]. Data were analyzed using R version 4.5.1 (R Core Team, 2025). $p < 0.05$ was considered statistically significant [32].

3.Results

This study included 103 participants with a mean age of 35.71 ± 12.45 years and a mean body mass index of 25.43 kg/m^2. The majority of partipants were male (58.25%); 95.15% were right-side dominant; 50.49% had a university education; and 63.11% had an activity level of 1 (Table 1).

Mean scores were as follows: KOOS:96.41 ± 4.79, LKS = 96.41 ± 6.94, and IPAQ-Sf = 1772.02 ± 1332.10 (Table 1). In this study, constant error values for KJPS angles were ±1 in both genders. The absolute errors for KJPS angles ranged from 2.58 to 3.42 across genders (Table 2). KJMS angles of 60°–90° were 1.82–1.95 in males and 1.66–1.80 in females (Table 2).

Significant associations were observed between age groups and both constant error in KJPS ($F = 4.914$, $p = 0.009$) and position sense angles ($F = 3.915$, $p = 0.009$) (Table 3; Figure 1). Significant relationships in absolute error in KJPS were found for age groups ($F=5.345$, $p=0.006$), gender ($F=3.978$, $p=0.049$), position sense angles ($F=3.858$, $p=0.010$), and the interaction between position sense angles and gender ($F=3.288$, $p=0.021$) (Table 3; Figure 2). Significant differences in KJMS at 60°–90° angles were observed between age groups ($F = 14.841$, $p < 0.001$) and between position-sense angles ($F = 19.645$, $p < 0.001$) (Table 3; Figure 3).

KJPS angles show consistent errors and significant differences in paired comparisons between D30° and D60° ($p = 0.004$). KJPS angles showed a significant difference between D30° and D60° among females in the Tukey post hoc test ($p = 0.042$; Table 4). There was a significant difference in the constant error in KJPS angles between the 18–29 and 45+ groups, and between the 30–44 and 45+ groups ($p = 0.026$ and $p = 0.012$, respectively) (Table 4). There was a significant difference in the absolute error of KJPS angles in the pairwise comparison between D15° and D60° ($p = 0.005$). In females, the Tukey test for KJPS angles showed significant differences between D15°-D60° and between D30°-D60° ($p = 0.001$ and $p = 0.015$, respectively) (Table 5). There is a significant relationship between the absolute error of the KJPS angles and the age groups 18–29 years and ≥45 years ($p = 0.007$, Table 5).

Significant relationships were observed among KJMS angles D60°–D90° ($p < 0.001$; Table 5). The Tukey test applied to KJMS angles showed no significant difference between D60° and D90° for either gender ($p = 0.843$ and 0.678, respectively; Table 5). Significant relationships were observed between KJMS (18–29) and KJMS (45+), and between KJMS (30–44) and KJMS (45+) ($p = 0.000$ and $p = 0.000$, respectively) (Table 5).

4. Discussion

This study identified age- and gender-related differences in knee joint proprioception in healthy adults. The absolute errors for KJPS angles of 15°, 30°, 45°, and 60°, assuming a constant error of ±1°, ranged from 2.58° to 3.42°. In the study by Salwa et al. (2019), the mean absolute angular error measured with an isokinetic dynamometer in participants with patellofemoral pain was 6.65° ± 1.76° at the 20° test position and 5.66° ± 2.70° at the 60° test position. The mean difference between the two positions was 0.995°. A significant difference in absolute error was found between the two positions ($p=0.039$) [33]. Busch et al. (2022) found that the median constant, absolute, and variable angular errors across all participants and sessions were 5.2° (6.9°), 6° (5.8°), and 0.99° (0.2°), respectively [34]. Alshahrani et al. (2022) found significant differences in KJPS of 20°, 40°, and 60° between patients with knee osteoarthritis and asymptomatic participants ($p < 0.001$) [35]. The absolute errors in this study are similar to those reported by Salwa and by Busch et al. In our study, a significant difference in the constant error between D30 and D60 was observed in KJPS, but not at other angles. A literature review indicates that KJPS has been evaluated from multiple perspectives, and no significant differences were observed among them [33-35].

Age-related findings

This study demonstrated significant age-related differences in knee joint position sense (KJPS). Participants aged ≥45 years exhibited greater absolute errors compared with younger groups, indicating a decline in position sense with age. These findings are consistent with previous studies, such as Rivero et al. (2010), who reported higher absolute angular errors in older adults compared with young adults [36]. Age-related declines in proprioception may be attributed to neuromuscular changes, including reduced muscle strength, impaired force control, and altered signal integration at the supraspinal level [37–39].

Gender-related findings

Significant gender differences were observed in KJPS, with females demonstrating higher absolute errors than males. Lee et al. (2023) found that, although the average differences in KJPS measurements at 30° and 50° were greater in females than in males, the differences were not statistically significant [40]. Karkousha et al. (2016) found that, among healthy adolescents, males had a higher average knee joint position perception in active KJPS [41]. KJPS accuracy differed significantly between female and male participants (males = 3.54 ± 1.20; females = 4.76 ± 1.29) ($p < 0.05$) [40]. In their study on gender differences, Azevedo et al. (2021) found no difference in KJPS between male and female participants (both football players and untrained participants) in terms of absolute, relative, and variable angular errors ($p > 0.05$) [8]. Our findings align with the latter, suggesting that reduced muscle strength and ligamentous laxity may contribute to altered proprioceptive input in females. These differences may partially explain the higher incidence of knee injuries among females. However, the unequal gender distribution in our sample (20% more males) may have influenced these results, and future studies should address this limitation [42].

KJMS findings

Knee joint movement sense (KJMS) values ranged from 1.82 to 1.95 seconds in males and 1.66 to 1.80 seconds in females. Significant differences were observed across angles and age groups, but not between genders. Salwa et al. (2019), comparing the general characteristics of females and males with patellofemoral pain, found no significant difference in absolute angular error (p = 0.833) [33]. Busch et al. (2022) found no significant difference in KJMS between the dominant and non-dominant legs in both males and females (p = 0.289) [34]. Liu et al. (2024) determined that the mean movement-perception times of 14-year-olds were 1.43 ± 0.39 seconds for males and 1.43 ± 0.40 seconds for females. A significant difference was found between genders (p = 0.022) [43]. Our results are consistent with those reported in the literature. According to Li et., the difference in motion perception between genders is thought to be due to the adolescent age of the study participants.

Measurements in this study were performed unilaterally. Bilateral measurements could have caused confusion when presenting results and interpreting analyses. A review of the literature indicates that a unilateral proprioceptive test may not be sufficient to assess a person's overall proprioceptive ability [44,45]. This is an important point for future research. This situation is mentioned in the limitations section of our study.

4.1 Limitatios

The single-center design of our study precludes the use of specific randomization methods for participants. Furthermore, a unilateral measurement was performed on the dominant side in our study. Future studies should examine knee joint position sense and lower-extremity movement sense across age groups older than 45 years. Additionally, the reasons why knee joint position and movement senses are poorer in males could be investigated in greater detail.

5. Conclusion

Significant differences in absolute error during the assessment of knee joint position sense (KJPS) were observed across age and gender. When stratified by gender, males exhibited lower errors, while participants aged ≥45 years demonstrated larger deviations in position sense compared with younger groups. Furthermore, assessment of knee joint movement sense (KJMS) revealed significant differences between age groups but not between genders.

This study demonstrated that age and gender are important factors influencing knee joint proprioception, and that variations in these factors affect proprioceptive function. Given that proprioception declines in individuals aged ≥45 years, regular physical activity may be recommended for this population. Interventions aimed at improving physical activity and quality of life may help mitigate age-related declines in proprioception and reduce the risk of potential health problems.

Abbreviations

IPAQ-Sf International Physical Activity Questionnaire –Short Form
TAS Tegner Activity Scale
LKS Lysholm Knee Score
KOOS Knee Outcomes Osteoarthritis Score
KJPS Knee joint position sense
KJMS Knee Joint Movement Sense

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Author contributions

Conceptualization: G.B.K, G.Y., S.A., M.Ç.; Analysis of data: G.B.K, G.Y., S.A., M.Ç; Drafting of paper: M.Ç.; Review/approval of final paper: all authors.

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Data availability

This data will be provided upon request for research purposes.

Declarations

Ethics approval and consent to participate

Approval was obtained from the Necmettin Erbakan University Meram Faculty of Medicine Ethics Committee for Research on Drugs and Medical Devices. (Decision Number: 2018/1409, Meeting Date: 22.06.2018).

Consent for publication

Consent for publication'

Competing interests

The authors declare no competing interests.

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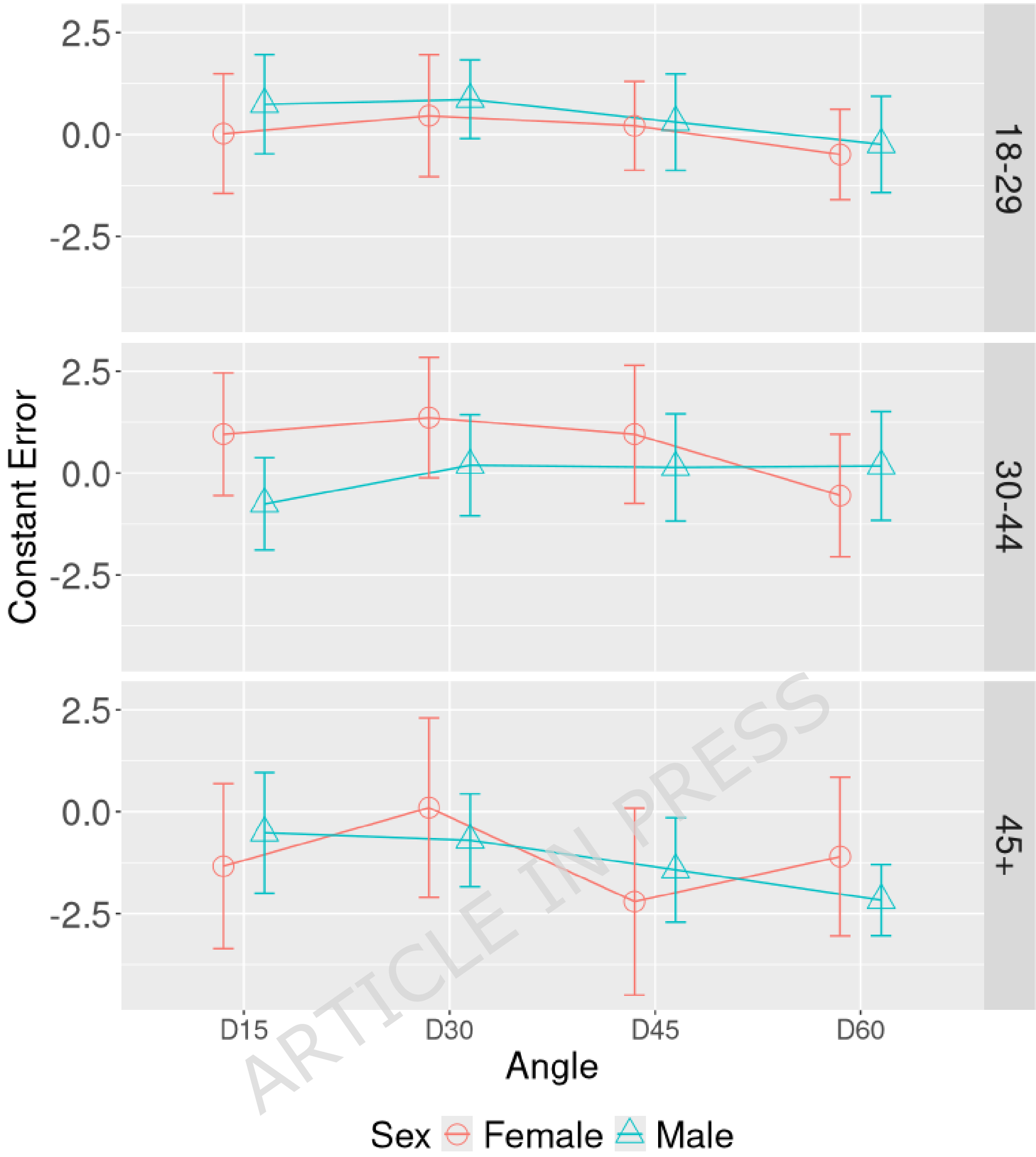

Figure 1: Demonstration of angular changes in knee joint position sense according to age and gender with constant error

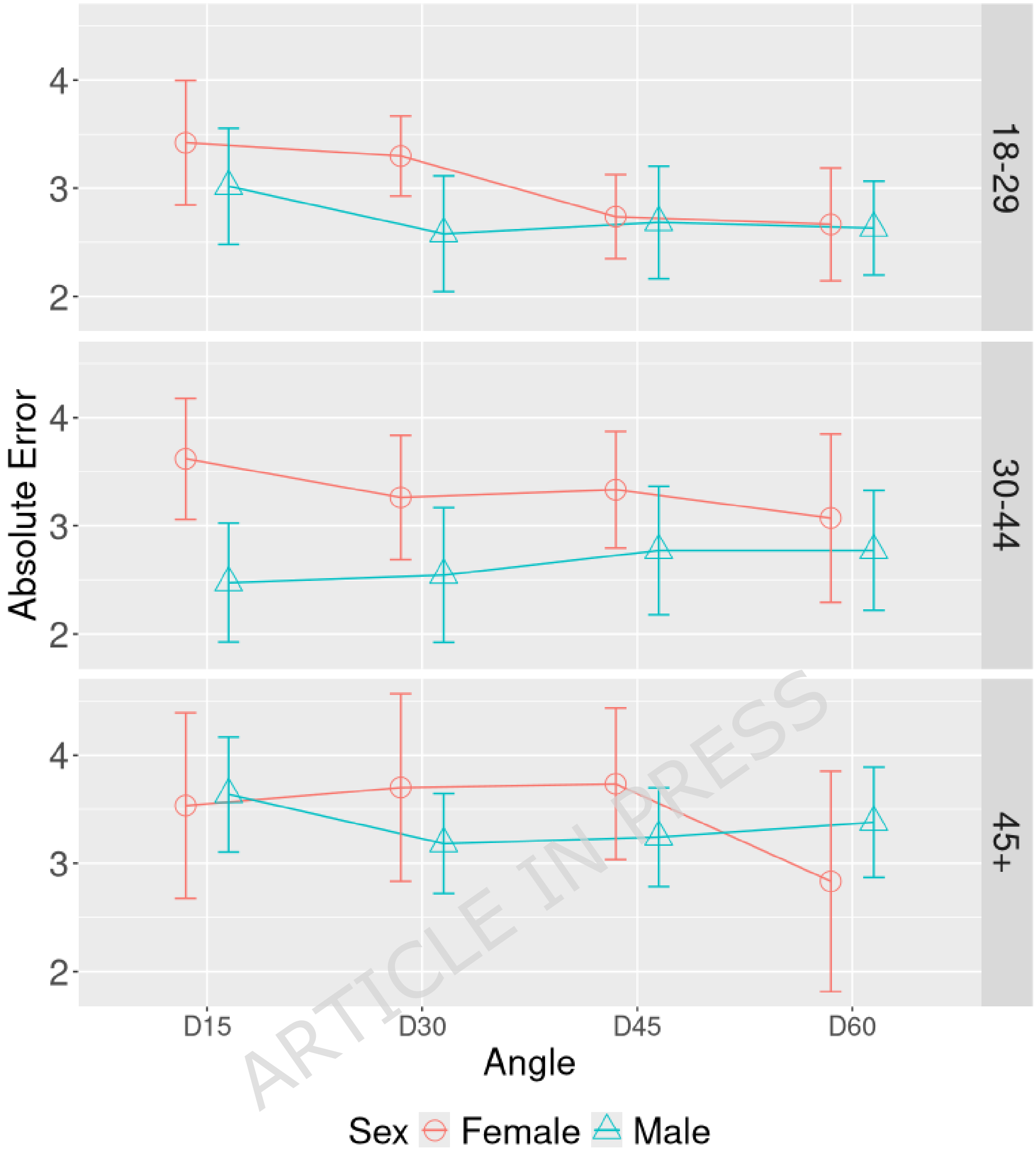

Figure 2: Demonstration of angular changes in knee joint position sense according to age and gender with absolute error

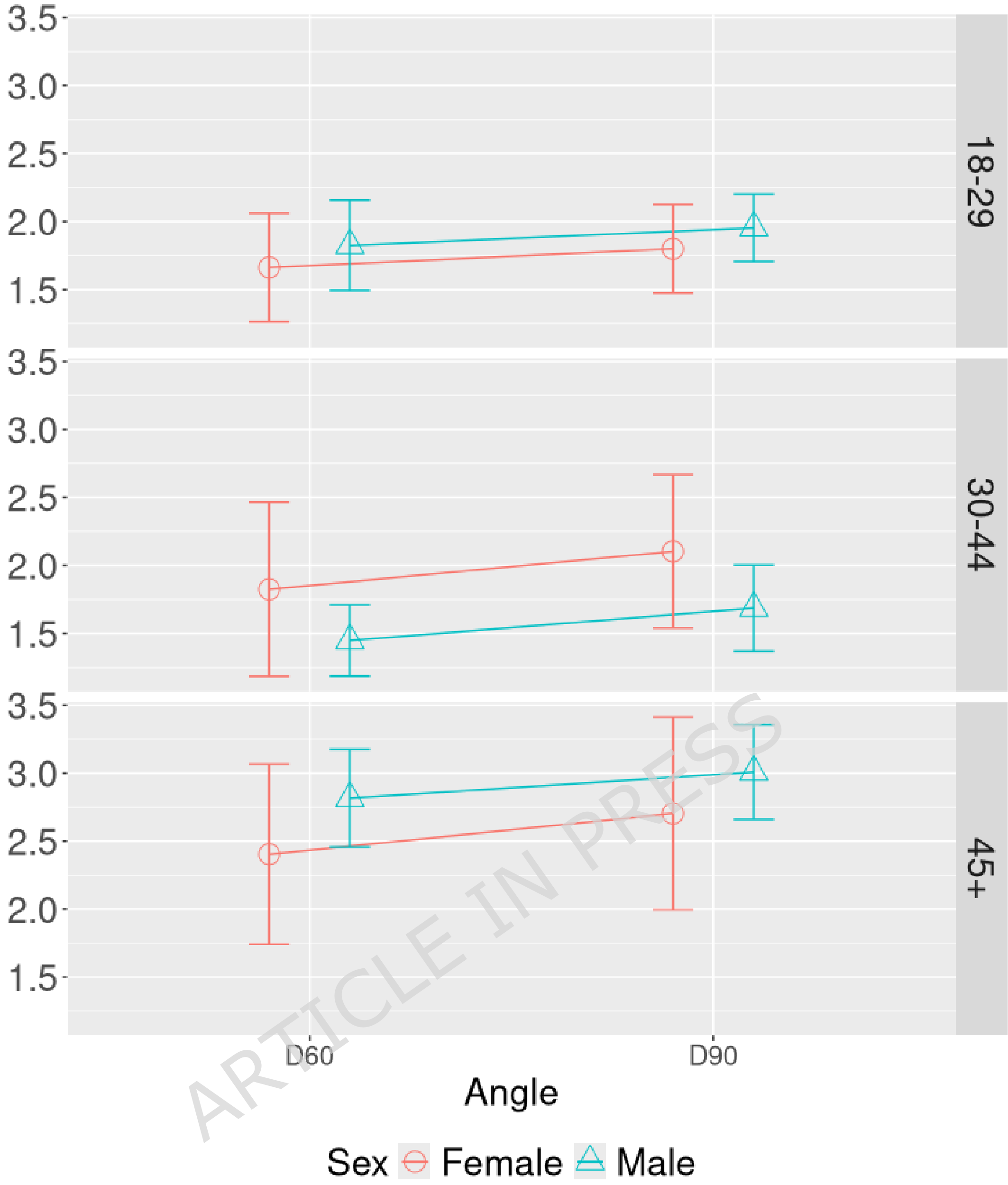

Figure 3: Demonstration of angular changes in knee joint motion sense according to age and gender

Table 1. Physical and sociodemographic characteristics of the participants (n=103).

Physical characteristics		Mean±SD Average	n (%) (18-29 age)	n (%) (30-44 age)	n (%) (Ages 45 and over)
Age (Year)		35.71±12.45	38 (36.89)	33 (30.04)	32 (31.07)
Height (cm)		170.69±8.39			
Weight (kg)		74.33±14.22			
BMI (kg/m^2)		25.43±4.12			
KOOS		96.41±4.79			
LKS		96.05±6.94			
IPAQ-Sf		1772.02±1332.10			
Sociodemographic characteristics		**n (%)**			
Dominant side	Right	98 (95.15)			
	Left	5 (4.85)			
Gender	Female	43 (41.75)			
	Male	60 (58.25)			
Education Level	Primary school	5 (4.85)			
	Middle school	3 (2.91)			
	High school	16 (15.53)			
	University	52 (50.49)			
	University and above	27 (26.21)			
Tegner Activity Scale	1	65 (63.11)			
	2	35 (33.98)			
	3	3 (2.91)			

n: The number of participants, SD: Standard Deviation, BMI: Body Mass Index, KOOS: Knee Injury and Osteoarthritis Outcome Score, LKS: Lysholm Knee Scale, IPAQ-Sf: International Physical Activity Questionnaire–Short Form,

Table 2. Evaluation of knee joint position sense according to age an gender (n=103).

Knee Joint Position Sense Angles (Constant Error)	**Gender**	**Age (Year)** Mean±SD (18-29 age)	Mean±SD (30-44 age)	Mean±SD (Ages 45+)
15 Degree	Male	0.74±2.52	-0.75±2.35	-0.52±3.34
	Female	0.02±3.04	0.95±2.60	-1.33±2.83
30 Degree	Male	0.86±2.00	0.19±2.57	-0.70±2.57
	Female	0.46±3.10	1.36±2.56	0.10±3.08
45 Degree	Male	0.30±2.45	0.14±2.72	-1.42±2.88
	Female	0.21±2.26	0.95±2.93	-2.20±3.21
60 Degree	Male	-0.25±2.45	0.18±2.76	-2.17±1.96
	Female	-0.49±2.29	-0.55±2.60	-1.10±2.72
(Absolute Error)				
15 Degree	Male	3.02±1.11	2.47±1.14	3.64±1.20
	Female	3.42±1.20	3.62±0.97	3.53±1.20
30 Degree	Male	2.58±1.11	2.54±1.29	3.18±1.04
	Female	3.30±0.77	3.26±1.00	3.70±1.21
45 Degree	Male	2.68±1.08	2.77±1.23	3.24±1.03
	Female	2.74±0.81	3.33±0.93	3.73±0.93
60 Degree	Male	2.63±0.90	2.77±1.15	3.38±1.15
	Female	2.67±1.08	3.07±1.35	2.83±1.43
Knee Joint Movement Sensation Angles				
60 Degree	Male	1.82±0.69	1.45±0.55	2.82±0.81
	Female	1.66±0.83	1.82±1.11	2.40±0.93
90 Degree	Male	1.95±0.51	1.69±0.66	3.01±0.78
	Female	1.80±0.67	2.10±0.98	2.70±0.99

n: The number of participants, SD: Standard Deviation

Table 3. Position Sense According to Joint Angles Constant Error, Absolute Error ve Movement Sense Mixed Model Result (n=103)

Knee Joint Position Sense Angles				
Constant Error	NumDF	Df	F value	Pr(>F)
Age Group	2	97.000	4.914	**0.009**
Gender	1	97.000	0.409	0.524
BMI (kg/m^2)	1	97.000	0.266	0.607
Position sense angles	3	303.000	3.915	**0.009**
Position sense angles ve gender	3	303.000	0.175	0.913
IPAQ-Sf	1	97.000	1.570	0.213
Absolute Error				
Age Group	2	97.000	5.345	**0.006**
Gender	1	97.000	3.978	**0.049**
BMI (kg/m^2)	1	97.000	0.895	0.346
Position sense angles	3	303.000	3.858	**0.010**
Position sense angles ve gender	3	303.00	3.288	**0.021**
IPAQ-Sf	1	97.000	0.639	0.426
Movement Sense Angles				
Age Group	2	97.000	14.841	**0.000**
Gender	1	97.000	0.107	0.744
BMI (kg/m^2)	1	97.000	2.474	0.119
Movement sense angles	1	101.000	19.645	**0.000**
Movement sense angles ve gender	1	101.000	0.134	0.715
IPAQ-Sf	1	97.000	0.991	0.322

n: The number of participants, NumDF: Number Degree of Freedom, Df: Degree of Freedom, BMI: Body Mass Index, IPAQ-Sf: International Physical Activity Questionnaire–Short Form, $p < 0.05$.

Table 4. Pairwise comparisons of position sense according to joint angles (n=103)

Knee Joint Position Sense Angles (Constant Error)						
Constrast	**(Angle)**	**Estimate**	**SE**	**Df**	**t.ratio**	**p. value**
D15-D30		-0.466	0.326	303.000	-1.429	0.482
D15-D45		0.153	0.326	303.000	0.468	0.966
D15-D60		0.641	0.326	303.000	1.966	0.203
D30-D45		0.618	0.326	303.000	1.897	0.231
D30-D60		1.108	0.326	303.000	3.395	**0.004**
D45-D60		0.488	0.326	303.000	1.498	0.440
Tukey CLD |	**(Gender)**					
D15-D30	Female	-0.659	0.497	303.000	-1.325	0.548
D15-D45	Female	0.116	0.497	303.000	0.234	0.995
D15-D60	Female	0.659	0.497	303.000	1.325	0.548
D30-D45	Female	0.775	0.497	303.000	1.559	0.404
D30-D60	Female	1.318	0.497	303.000	2.649	**0.042**
D45-D60	Female	0.543	0.497	303.000	1.091	0.695
D15-D30	Male	-0.272	0.421	303.000	-0.646	0.917
D15-D45	Male	0.189	0.421	303.000	0.449	0.970

D15-D60	Male	0.622	0.421	303.000	1.478	0.452
D30-D45	Male	0.461	0.421	303.000	1.095	0.693
D30-D60	Male	0.894	0.421	303.000	2.124	0.148
D45-D60	Male	0.433	0.421	303.000	1.029	0.733
Constrast	**(Age)**					
(18-29)-(30-44)		-0.024	0.436	97.000	-0.055	0.998
(18-29)-(45+)		1.318	0.499	97.000	2.639	**0.026**
(30-44)-(45+)		1.342	0.459	97.000	2.923	**0.012**

n: The number of participants, SE: Standard error, Df: Degree of freedom, D15: 15 degrees position sense, D30: 30 degrees position sense, D45: 45 degrees position sense, D60: 60 degrees position sense.

Table 5. Pairwise comparisons of position sense and movement sense according to joint angles (n=103)

Knee Joint Position Sense Angles (Absolute Error)						
Constrast	**(Angles)**	Estimate	SE	Df	t.ratio	p. value
D15-D30		0.208	0.119	303.000	1.751	0.299
D15-D45		0.252	0.119	303.000	2.128	0.147
D15-D60		0.398	0.119	303.000	3.361	**0.005**
D30-D45		0.045	0.119	303.000	0.377	0.982

D30-D60		0.191	0.119	303.000	1.610	0.375
D45-D60		0.146	0.119	303.000	1.233	0.606
Tukey CLD	**(Gender)**					
D15-D30	Female	0.132	0.181	303.000	0.728	0.886
D15-D45	Female	0.349	0.181	303.000	1.928	0.218
D15-D60	Female	0.674	0.181	303.000	3.728	**0.001**
D30-D45	Female	0.217	0.181	303.000	1.200	0.627
D30-D60	Female	0.543	0.181	303.000	3.000	**0.015**
D45-D60	Female	0.326	0.181	303.000	1.800	0.275
D15-D30	Male	0.283	0.153	303.000	1.850	0.252
D15-D45	Male	0.156	0.153	303.000	1.016	0.740
D15-D60	Male	0.122	0.153	303.000	0.798	0.855
D30-D45	Male	-0.128	0.153	303.000	-0.834	0.838
D30-D60	Male	-0.161	0.153	303.000	-1.052	0.719
D45-D60	Male	-0.033	0.153	303.000	-0.218	0.996
Constrast	**(Age)**					
(18-29)-(30-44)		-0.147	0.206	97.000	-0.711	0.757
(18-29)-(45+)		-0.731	0.237	97.000	-3.089	**0.007**
(30-44)-(45+)		-0.584	0.217	97.000	-2.685	0.023
Knee Joint Movement Sensation Angle						
Constrast (Angle)						
D60*-D90*		-0.204	0.046	101.000	-4.432	**0.000**
Tukey CLD (Gender)						
D60* Female-Male		0.035	0.165	113.380	0.212	0.843
D90* Female-Male		0.069	0.165	113.380	0.417	0.678

Constrast (Age)					
(18-29)-(30-44)	0.139	0.187	97.000	0.747	0.736
(18-29)-(45+)	-0.898	0.214	97.000	-4.201	**0.000**
(30-44)-(45+)	-1.037	0.196	97.000	-5.278	**0.000**

n: The number of participants, SE: Standard error, Df: Degree of freedom, D15: 15 degrees position sense, D30: 30 degrees position sense, D45: 45 degrees position sense, D60: 60 degrees position sense, D60*: 60 degrees movement sense, D90*: 90 degrees movement sense.