INSIGHTS-JOURNAL OF

HEALTH AND REHABILITATION

CORRELATION OF CARRYING ANGLE OF ELBOW WITH HAND DOMINANCE, BODY MASS INDEX, LENGTH OF FOREARM AND GRIP STRENGTH IN FEMALE BADMINTON PLAYERS

Original Research

Nafeesa Ishfaq[1]*, Omair Khan[2], Aqsa Lakhani[3], Bushra Mukhtar[4], Malaika Shahzad[5], Muhammad Behzad Ali[6], Sana Muneeb[6], Warda Afifa[7]

[1]Department of Physical Therapy, Faculty of Allied Health Sciences, Kohat University of Science and Technology, Kohat, KP, Pakistan.

[2]Cureway Rehabilitation Center, Najran, Saudi Arabia.

[3]Centre of Autism Training & Rehabilitation, Sindh and Adaptive Fitness Academy, Sindh, Pakistan.

[4]Physiotherapist Ashraf Medical Center, Government College University Faisalabad (GCUF), Faisalabad, Pakistan.

[5]Physiotherapist, Government College University Faisalabad (GCUF), Faisalabad, Pakistan.

[6]Clinical Physiotherapist, Health Physio Clinic, Multan, Pakistan.

[7]Physiotherapist, University of Sargodha, Sargodha, Pakistan.

Corresponding Author: Nafeesa Ishfaq, Department of Physical Therapy, Faculty of Allied Health Sciences, Kohat University of Science and Technology, Kohat, KP, Pakistan, drnafeesapt@gmail.com

Acknowledgement: The authors gratefully acknowledge the participation of all female badminton players who contributed to this study.

Conflict of Interest: None Grant Support & Financial Support: None

ABSTRACT

Background: The carrying angle of the elbow, formed by the intersection of the arm and forearm in full extension and supination, plays an essential role in upper limb biomechanics. It facilitates arm swing clearance during gait and contributes to load-bearing efficiency. This anatomical parameter, along with wrist joint mobility, may have functional relevance to grip strength and body mass index (BMI), particularly in athletic populations such as badminton players.

Objective: To evaluate the relationship between carrying angle and wrist angles with BMI and grip strength among female badminton players.

Methods: A cross-sectional study was conducted involving 140 female badminton players aged 15 to 30 years. Participants were recruited from local institutions using convenience sampling. Data were collected using a structured questionnaire, and anthropometric measurements were taken. Carrying angle and wrist angles (flexion, extension, radial and ulnar deviation) were assessed using a goniometer. Grip strength was measured using a calibrated dynamometer. BMI was calculated from height and weight. Data were analyzed using SPSS version 20, with Pearson correlation and ANOVA applied to determine associations.

Results: Among participants, 46.4% were aged 15–20 years, and 53.6% were aged 21–25 years. The majority (82.1%) had a carrying angle between 10–15°, and 91.4% exhibited wrist flexion between 61–80°. Grip strength ranged from 20–25 kg in 60.7%, while 63.6% had a BMI between 15–20. Among those with carrying angles of 10–15°, 75 participants had BMI of 15–20, and 35 had BMI <15. No statistically significant correlation was found between carrying angle and grip strength (p=0.350), or BMI (p=0.672).

Conclusion: The findings suggest that most female badminton players exhibit a normal carrying angle and healthy BMI. While no significant correlation was observed, consistent biomechanical patterns indicate the influence of physical activity on musculoskeletal alignment and body composition.

Keywords: Body Mass Index, Carrying Angle, Female Athletes, Grip Strength, Musculoskeletal Physiology, Range of Motion, Wrist Joint.

INTRODUCTION

The carrying angle of the elbow, defined as the acute angle formed between the median axes of the arm and forearm in a fully extended and supinated position, plays a crucial biomechanical role in the upper limb. This angle facilitates the clearance of the forearm from the hips during ambulation and aids in carrying objects efficiently (1). It is most accurately assessed when the elbow is fully extended, the forearm is supinated, and the shoulder externally rotated (2). A normal carrying angle ranges from 10° to 15° in females and 5° to 10° in males, with deviations classified as cubitus varus when the angle is less than 5°, and cubitus valgus when it exceeds 15° (3). Several studies have investigated associations between the carrying angle and anthropometric as well as demographic variables such as age, sex, handedness, weight, and height (4). Among the Indian population, shorter individuals were observed to have a more pronounced carrying angle compared to taller individuals, suggesting that stature may influence this anatomical parameter (5). A moderate increase in carrying angle has been observed with skeletal development, highlighting its dynamic nature across the life span from childhood to adulthood (6). Notably, an inverse correlation has been found between the carrying angle and the length of the forearm, further emphasizing the anatomical variability associated with upper limb proportions (7). Understanding the biomechanical significance of the carrying angle is essential, particularly in clinical and occupational health contexts. As the forearm in full extension and supination naturally deviates laterally from the arm—referred to as the cubital angle—this deviation becomes critical in functional tasks such as lifting and swinging the arms during walking (8). This angle is anatomically influenced by the elevation of the medial trochlear ridge and the obliquity of the coronoid's superior articular surface, contributing to the asymmetry between the medial and lateral elbow joint contours (9). Measurement of this angle, first described by Potter (10), has become a standard parameter in orthopedic and anatomical evaluations. While it typically disappears in pronation and decreases during elbow flexion, it is best appreciated in the supinated and extended limb (11).

In conjunction with structural analysis, the assessment of grip strength (GS) serves as an important functional correlate of upper limb integrity. GS is a direct reflection of forearm and hand muscle performance, influenced by the interaction between flexor and extensor muscle groups (10,11). Clinically, it serves as a marker for muscular health, functional capacity, and is frequently utilized in rehabilitation and therapeutic monitoring (12). Diminished grip strength may be indicative of musculoskeletal impairments, and its reliable measurement aids in evaluating the efficacy of interventions and risk of disability (13). Despite extensive anatomical and functional insights, a limited number of studies have investigated the correlation between carrying angle and grip strength, particularly in the context of anthropometric variables. Understanding this relationship may have significant implications for musculoskeletal health assessment, rehabilitation, and ergonomic design. Therefore, the present study aims to investigate the relationship between carrying angle and grip strength, while also exploring their association with age, gender, height, weight, and forearm length.

METHODS

A cross-sectional analytical study was conducted to evaluate the relationship between carrying angle, wrist angle, grip strength, and body mass index (BMI) in female badminton players. The study employed a non-probability convenience sampling technique to recruit a total of 140 participants. Data were collected from four educational institutions in Kohat: Government Girls Post Graduate College (GGPGC; n=45), Government Girls Degree College No.3 (GGDC No.3; n=34), Government Girls High School & College (GGHSS; n=28), and Islamia Girls College (IGC; n=33). Female students who were active badminton players were included in the study. Inclusion criteria comprised healthy participants aged between 18 and 25 years who were actively engaged in recreational or collegiate-level badminton for at least the past six months. Exclusion criteria included individuals with a history of upper limb musculoskeletal injury, congenital limb deformities, recent fractures, or any diagnosed neuromuscular disorder that could impact grip strength or joint alignment. Data collection involved direct measurement of anthropometric and functional variables (3,5). The carrying angle was measured in a standardized anatomical position with the elbow fully extended, forearm supinated, and shoulder externally rotated using a manual goniometer. Wrist angle was also recorded in neutral wrist position. Grip strength was evaluated using a calibrated hand dynamometer, with participants seated and their elbow flexed at 90°, forearm in neutral position, and wrist slightly extended as per standardized protocol. BMI was calculated from measured height and weight using the formula weight (kg) divided by height squared (m^2).

All measurements were performed by trained assessors to ensure consistency. Quantitative variables such as age, BMI, grip strength, carrying angle, and wrist angle were analyzed and presented as mean ± standard deviation. Pearson's correlation coefficient was employed to explore the relationship between carrying angle and wrist angle with grip strength and BMI. Data were entered and analyzed using SPSS version 20. Statistical significance was set at $p<0.05$. Ethical approval was obtained from the institutional ethical review board prior to commencement of the study. All participants were informed about the nature and purpose of the study, and written informed consent was obtained from each respondent. Confidentiality and voluntary participation were assured throughout the research process.

RESULTS

The study included 140 female badminton players, of whom 46.4% were aged 15–20 years, and 53.6% fell in the 21–25 age group. The majority (49.3%) had a body weight between 51–60 kg, while 43.6% weighed between 40–50 kg, and only 7.1% were in the 61–70 kg range. In terms of height, 99.3% of the participants were between 1 and 2 meters tall. Regarding their playing history, 71.4% had been playing badminton for up to 2 years, while 28.6% had more than 2 years of experience. Additionally, 53.6% played for more than 140 minutes weekly, whereas 46.4% played for up to 140 minutes. The most commonly observed carrying angle was between 10–15 degrees, found in 82.1% of the participants, while 17.9% had angles between 16–20 degrees. For wrist flexion, 91.4% of respondents had a range between 61–80 degrees, while wrist extension between 61–80 degrees was observed in 65.7% of respondents, with 30.7% showing greater than 80 degrees. Wrist radial deviation between 21–40 degrees was reported in 68.6% of respondents, while 31.4% had less than 20 degrees. Similarly, 82.1% of participants had wrist ulnar deviation greater than 20 degrees. The distribution of body mass index (BMI) showed that 63.6% of participants had a BMI between 15–20, 32.1% had a BMI less than 15, and only 4.3% exceeded a BMI of 20. Regarding grip strength, 60.7% of participants demonstrated a grip strength between 20–25 kg, 26.4% had grip strength between 26–30 kg, and 12.9% exceeded 30 kg.

Cross-tabulations revealed that among those with a BMI between 15–20, 60 respondents had been playing badminton for up to 2 years and 29 for more than 2 years. In those with a body weight of 51–60 kg, 65 had a BMI between 15–20, while among those weighing 40–50 kg, 41 had a BMI of less than 15. Respondents playing for more than 140 minutes weekly had a higher percentage (50%) with BMI between 15–20 compared to 39% in the group playing up to 140 minutes. Among participants with a carrying angle between 10–15 degrees, 75 had a BMI between 15–20 and 35 had a BMI below 15. A majority (128) had wrist flexion between 61–80 degrees, of which 83 had a BMI of 15–20. Most participants with wrist extension between 61–80 degrees (n=92) also had a BMI between 15–20 (n=60). For wrist radial deviation between 21–40 degrees, 65 respondents had a BMI between 15–20, and 28 had a BMI below 15. A similar trend was observed in ulnar deviation, where 73 participants with >20° ulnar deviation had a BMI between 15–20. Participants with a BMI between 15–20 demonstrated the highest grip strength distribution, with 51 having a grip strength of 20–25 kg. Among those with a carrying angle of 10–15 degrees, 67 showed grip strength between 20–25 kg.

Pearson correlation analysis showed no statistically significant relationship between carrying angle and grip strength ($r = -0.080$, $p = 0.350$), or between carrying angle and BMI ($r = -0.036$, $p = 0.672$). A weak negative correlation was found between wrist flexion and BMI ($r = -0.182$, $p = 0.031$), and a weak positive correlation between wrist flexion and wrist extension ($r = 0.188$, $p = 0.026$). Wrist extension showed no significant correlation with BMI ($r = -0.114$, $p = 0.182$) or grip strength ($r = -0.112$, $p = 0.186$). The analysis of group-wise differences in BMI and grip strength across carrying angle categories (10–15°, 16–20°, and >20°) using one-way ANOVA revealed no statistically significant differences. For grip strength, the F-value was 0.69 with a corresponding p-value of 0.50, indicating that grip strength did not significantly vary across different carrying angle groups. Similarly, for BMI, the F-value was 0.15 with a p-value of 0.86, suggesting no significant variation in BMI among the groups stratified by carrying angle. These findings suggest that neither grip strength nor BMI is significantly influenced by the carrying angle in this sample of female badminton players. This highlights that the observed trends in the crosstabulations may not translate into statistically meaningful differences when group variance is formally tested.

Table 1: Demographic and Physical Characteristics of Respondents

Parameter	Category	Frequency	Percent
Age	15-20 years	65	46.4
	21-25 years	75	53.6
Weight	40-50 kg	61	43.6

Parameter	Category	Frequency	Percent
	51-60 kg	69	49.3
	61-70 kg	10	7.1
Height	1-2 meters	139	99.3
	Outlier	1	0.7
BMI	<15	45	32.1
	15-20	89	63.6
	>20	6	4.3
Grip Strength	20-25 kg	85	60.7
	26-30 kg	37	26.4
	>30 kg	18	12.9

Table 2: Duration of Badminton Play among Respondents

Parameter	Category	Frequency	Percent
Duration (Years)	Up to 2 years	100	71.4
	More than 2 years	40	28.6
Duration (Minutes per Week)	Up to 140 minutes	65	46.4
	More than 140 minutes	75	53.6

Table 3: Joint Angle Distribution among Respondents

Parameter	Category	Frequency	Percent
Carrying Angle	10-15°	115	82.1
	16-20°	25	17.9
Wrist Flexion	≤60°	6	4.3
	61-80°	128	91.4
	>80°	6	4.3
Wrist Extension	≤60°	5	3.6
	61-80°	92	65.7
	>80°	43	30.7
Wrist Radial Deviation	≤20°	44	31.4
	>20°	96	68.6
Wrist Ulnar Deviation	≤20°	25	17.9
	>20Â°	115	82.1

Table 4: BMI Distribution by Duration and Weight Factors

Parameter	Group	<15	15-20	>20
Duration (Years)	Up to 2 years	37	60	3
	More than 2 years	8	29	3
Weight	40-50 kg	41	18	2
	51-60 kg	4	65	0
	61-70 kg	0	6	4
Duration (Minutes per Week)	Up to 140 mins	23	39	3
	More than 140 mins	22	50	3

Table 5: BMI Distribution by Joint Angles

Parameter	Group	<15	15-20	>20
Carrying Angle	10-15°	35	75	4
	16-20°	10	13	2
	>20°	0	1	0
Wrist Flexion	≤60°	0	5	1
	61-80°	41	83	4
	>80°	4	1	1
Wrist Extension	≤60°	1	3	1
	61-80°	28	60	4
	>80°	16	26	1
Wrist Radial Deviation	≤20°	17	24	3
	21-40°	28	65	3
Wrist Ulnar Deviation	≤20°	8	16	1
	>20°	37	73	5

Table 6: Grip Strength Distribution by BMI and Carrying Angle

Parameter	Group	20-25 kg	26-30 kg	>30 kg
Body Mass Index	<15	31	7	7
	15-20	51	28	10
	>20	3	2	1
Carrying Angle	10-15°	67	32	15
	16-20°	18	4	3
	>20°	0	1	0

Table 7: Descriptive Statistics of Key Variables

Variable	Mean	Standard Deviation	N	
Carrying Angle (°)	1.18	0.384	140	
Wrist Flexion (°)	2	0.294	140	
Wrist Extension (°)	2.27	0.521	140	
Body Mass Index	1.72	0.537	140	
Pearson Correlation Matrix				
Variable	Carrying Angle (°)	Wrist Flexion (°)	Wrist Extension (°)	Body Mass Index
Carrying Angle (°)	1	0.127	0.044	-0.036
Wrist Flexion (°)	0.127	1	0.188	-0.182
Wrist Extension (°)	0.044	0.188	1	-0.114
Body Mass Index	-0.036	-0.182	-0.114	1

Table 8: Descriptive Statistics Including Grip Strength

Variable	Mean	Standard Deviation	N
Carrying Angle (°)	1.18	0.384	140
Wrist Flexion (°)	2	0.294	140
Wrist Extension (°)	2.27	0.521	140

Variable	Mean	Standard Deviation	N	
Grip Strength (kg)	1.52	0.714	140	
Correlation Matrix Including Grip Strength				
Variable	Carrying Angle (°)	Wrist Flexion (°)	Wrist Extension (°)	Grip Strength (kg)
Carrying Angle (°)	1	0.127	0.044	-0.08
Wrist Flexion (°)	0.127	1	0.188	0.034
Wrist Extension (°)	0.044	0.188	1	-0.112
Grip Strength (kg)	-0.08	0.034	-0.112	1

Table 9: ANOVA Results by Carrying Angle

Variable	F-value	p-value
Grip Strength	0.689	0.503
BMI	0.147	0.862

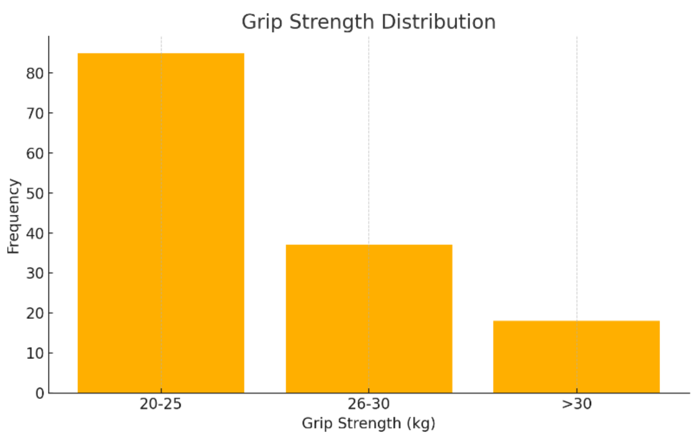

Figure 1 Grip Strength Distribution

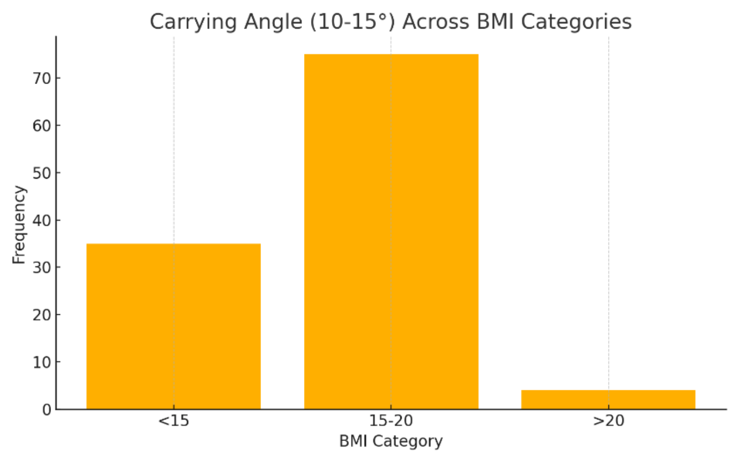

Figure 2 Carrying Angle (10-15°) Across BMI Categories

DISCUSSION

The present study investigated the relationship between carrying angle, wrist angles, body mass index (BMI), and grip strength among female badminton players, focusing primarily on individuals aged 15 to 25 years. The findings revealed that the majority of participants fell within the younger age range, with most maintaining a body weight between 40–60 kg and BMI predominantly within or near the lower limit of the normal range (14). This trend aligns with existing literature, which emphasizes the favorable impact of regular athletic activity, such as badminton, on weight maintenance and metabolic health. The data supported the notion that active engagement in sports contributes to better physical fitness and healthier anthropometric profiles in young females (15). Carrying angle measurements predominantly ranged from 10–15°, a finding consistent with established anatomical norms in healthy females, as reported in previous anatomical and orthopedic research (16,17). Additionally, grip strength was most frequently observed in the 20–25 kg range, which is in line with previous studies noting that female athletes tend to demonstrate moderate to high grip strength depending on sport type and upper limb involvement. The absence of significant group-wise differences in grip strength or BMI across carrying angle categories suggests that, within this athletic cohort, structural elbow configuration did not substantially influence functional grip force or weight-to-height proportionality (18.

The distribution of wrist kinematics, including flexion, extension, radial deviation, and ulnar deviation, also followed physiological patterns expected in a physically active population. The majority of respondents exhibited wrist flexion and extension angles between 61–80°, with ulnar and radial deviations also clustering around normative functional ranges. These parameters are crucial in racket sports such as badminton, where repeated wrist movement is integral to performance (19). Notably, BMI remained consistently within

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

the 15–20 range across most subgroups, suggesting that frequent physical activity may contribute to maintaining a stable and healthy BMI, even in the presence of biomechanical variations in joint angles. Although correlational analysis revealed no statistically significant associations between carrying angle and either BMI or grip strength, the overall trends demonstrated biomechanical harmony among regularly active individuals (20,21). This supports the perspective that habitual physical activity may compensate for minor anatomical variations, promoting uniformity in strength and body composition. However, such conclusions must be approached with caution due to certain limitations inherent in the study design. The use of non-probability convenience sampling restricts the generalizability of findings, and the cross-sectional nature of the study precludes causal inferences. Furthermore, the absence of more advanced statistical techniques, such as multivariate regression or analysis of covariance (ANCOVA), limits the depth of analysis regarding confounding factors such as age, training intensity, or hand dominance.

Another limitation was the unequal group sizes across categories of carrying angle, particularly the minimal representation of participants with angles exceeding 20°, which may have skewed inferential results. Additionally, while grip strength was measured, no dynamic strength assessments or endurance metrics were included, which could have provided a more comprehensive understanding of functional upper limb performance. Despite these constraints, the study's strength lies in its focus on an underexplored population—female badminton players—and its integration of structural and functional musculoskeletal measures in relation to anthropometry. Future research should aim to incorporate a longitudinal design, larger and more diverse sample sizes, and broader geographical representation. Including male athletes or comparing multiple sports may also enrich the scope of interpretation (22). Additionally, exploring the influence of training intensity, skill level, and ergonomic factors on carrying angle and grip strength could offer deeper insights into the musculoskeletal adaptations of athletes. A multidimensional approach integrating kinematic analysis, electromyography, and physiological biomarkers would also strengthen the evidence base for understanding the interplay between structure and function in sports physiology.

CONCLUSION

This study concluded that playing badminton has a constructive influence on musculoskeletal health and body composition, particularly among young female athletes. By exploring the relationship between carrying angle, wrist angles, grip strength, and BMI, the research highlighted meaningful associations that reflect how regular athletic activity supports optimal biomechanical alignment and physical fitness. The consistent patterns observed in joint angles and strength measures suggest that badminton may contribute not only to improved upper limb function but also to the maintenance of a healthy body profile. These findings offer practical insight for sports professionals, physiotherapists, and trainers aiming to enhance performance and prevent injury through targeted training and anatomical understanding.

AUTHOR CONTRIBUTION

Author	Contribution
Nafeesa Ishfaq*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Omair Khan	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Aqsa Lakhani	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Bushra Mukhtar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Malaika Shahzad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Behzad Ali	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Sana Muneeb	Contributed to study concept and Data collection Has given Final Approval of the version to be published
Warda Afifa	Writing - Review & Editing, Assistance with Data Curation

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

REFERENCES

1. Breulmann FL, Lappen S, Ehmann Y, Bischofreiter M, Lacheta L, Siebenlist S. Treatment strategies for simple elbow dislocation - a systematic review. BMC Musculoskelet Disord. 2024;25(1):148.
2. Marinelli A, Graves BR, Bain GI, Pederzini L. Treatment of elbow instability: state of the art. J isakos. 2021;6(2):102-15.
3. Meng J, Liu W, Gao S. A traumatic elbow injury. Bmj. 2023;380:e072395.
4. Ohl X, Siboni R. Surgical treatment of terrible triad of the elbow. Orthop Traumatol Surg Res. 2021;107(1s):102784.
5. Pipicelli JG, King GJW. Rehabilitation of Elbow Instability. Hand Clin. 2020;36(4):511-22.
6. Tay JQ. Re: The versatility of the double fascicular transfer in reconstruction of elbow flexion paralysis: Intermediate term follow-up and patient-related outcome measures. J Plast Reconstr Aesthet Surg. 2023;87:403-4.
7. Lui TH, Tam KWK. Post-traumatic weakness of elbow extension. Bmj. 2022;376:e069022.
8. Schiffman B, Hanel D. The One Bone Forearm. Hand Clin. 2020;36(4):531-8.
9. Lauder A, Richard MJ. Management of distal humerus fractures. Eur J Orthop Surg Traumatol. 2020;30(5):745-62.
10. Ahmed AF, Rayyan R, Zikria BA, Salameh M. Lateral epicondylitis of the elbow: an up-to-date review of management. Eur J Orthop Surg Traumatol. 2023;33(2):201-6.
11. Deely DM, Morrison WB. Imaging the Postoperative Elbow. Semin Musculoskelet Radiol. 2021;25(4):628-36.
12. Hamada D, Inokuchi K, Morii H, Yamanaka Y, Sakai A, Sawano M. Hinged elbow fixation and treatment of unstable elbow dislocation with ipsilateral arteriovenous shunts: A case report. J Orthop Sci. 2023;28(6):1461-6.
13. Herman ZJ, Edelman DG, Ilyas AM. Heterotopic Ossification After Elbow Fractures. Orthopedics. 2021;44(1):10-6.
14. Iamaguchi RB, Rosa de Rezende M. Functional Free Muscle Transfer for Reconstruction of Traumatic Adult Brachial Plexus Injuries. Hand Clin. 2024;40(2):259-67.
15. Blanquero J, Elkins MR. Elbow, wrist and hand disorders. J Physiother. 2021;67(1):3-4.
16. Theodorou DJ, Theodorou SJ, Gelalis ID. Elbow deformity: Transcondylar fracture of the distal humerus vs. congenital anomaly. Injury. 2023;54(11):111050.
17. Del Core MA, Koehler D. Elbow Arthritis. J Hand Surg Am. 2023;48(6):603-11.
18. Birinci T, Kaya Mutlu E, Altun S. The efficacy of graded motor imagery in post-traumatic stiffness of elbow: a randomized controlled trial. J Shoulder Elbow Surg. 2022;31(10):2147-56.
19. Rubenstein J, Harvey AW, Vincent D, Winston P. Cryoneurotomy to Reduce Spasticity and Improve Range of Motion in Spastic Flexed Elbow: A Visual Vignette. Am J Phys Med Rehabil. 2021;100(5):e65.
20. Rasulić L, Lepić M, Samardžić M. Commentary: Nerve Graft Length and Recovery of Elbow Flexion Muscle Strength in Patients With Traumatic Brachial Plexus Injuries: Case Series. Oper Neurosurg (Hagerstown). 2021;21(2):E165-e6.
21. Zhu Y, Luo C, Wang X. A commentary on 'Clinical results of a 10-year follow-up of surgical treatment for elbow stiffness in rheumatoid arthritis: A case series'. Int J Surg. 2024;110(9):5843-4.
22. Olach M, Jost B, Spross C. [59/m and 86/f-Pain and restricted motion of the elbow joint : Preparation for the medical specialist examination: part 35]. Orthopade. 2021;50(Suppl 1):98-106

