**Normative values of the range of motion of movements at the wrist joint for hockey players: a cross-sectional study**

Valori normativi dell’ampiezza del movimento articolare del polso nei giocatori di hockey: uno studio trasversale

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**SUMMARY**

BACKGROUND: Wrist range of motion (ROM) is used to objectively evaluate treatment outcomes for wrist interventions. Wrist kinetics and kinematics are critical for diagnosing and treating traumatic or degenerative abnormalities in the wrist joint. In field hockey, wrist motions are crucial for selecting excellent shots like hockey wrist shots, snap shots, slap shots, etc. This study aimed to find the normative values of active ROMs (AROMs) of wrist joints for the hockey and non-athletic populations.

METHODS: In this cross-sectional study, purposive sampling was used to recruit 138 participants of both genders between 18 and 25 years of age. Players who played at the national level and played hockey ≥three days per week for the last three months were included. In the sitting position, AROMs were measured using a universal goniometer for flexion, extension, and radial and ulnar deviation. Descriptive statistics were used to find the normative reference values.

RESULTS: The normality of the data was assessed using the Kolmogorov-Smirnov Test, which revealed not normal distribution. No significant differences were observed between hockey and non-athletic populations’ wrist AROMs, the P-value for all movements was >0.05. Within-group analysis was done using the Wilcoxon signed-ranks test, which showed a non-significant (P>0.05) difference between right and left wrist AROMs in both groups.

CONCLUSIONS: The key finding of the study was that flexion (left-side and right-side P-values 0.03, 0.02) was greater than extension (left-side and right-side P-values 0.60, 0.62), but no major changes were seen in the range of dominant and non-dominant hands, P-value >0.05. Female participants had a greater range compared to male participants on the basis of the mean and 95% CI, but no statistical changes were observed on the basis of the p-value (P>0.05).

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**RIASSUNTO**

OBIETTIVO: La flessibilità articolare del polso (range of motion, ROM) viene utilizzata per valutare oggettivamente i risultati dei trattamenti negli interventi a livello del polso. La cinetica e la cinematica del polso sono fondamentali per diagnosticare e trattare alterazioni di origine traumatica o degenerativa a livello dell’articolazione del polso. Nell’hockey su prato i movimenti del polso sono cruciali per selezionare colpi eccellenti come gli snap shot, gli slap shot, ecc. Questo studio si è proposto di trovare i valori normativi di ROM attivi (active ROMs, AROM) dell’articolazione del polso in individui praticanti hockey e non sportivi.

METODI: In questo studio trasversale è stato utilizzato un campionamento mirato per reclutare 138 partecipanti di
A normal wrist range of motion (ROM) is required for all sports and many functional activities. It is the most active part of the upper limb. They are more vulnerable to injury, which leads to decreased ROM and significant functional restrictions.\(^1\)\(^2\) It is susceptible to many traumatic injuries, soft tissue injuries, and degenerative joint diseases that can hinder normal wrist ROM.\(^3\)\(^4\) Non-united and malunion fractures, mainly for dorsal angulation and shortening of the radius, can lead to restricted ROM.\(^5\) Athletes’ injury risk is assumed to be influenced by changes in joint ROM or joint flexibility,\(^6\) and it is controlled by carpal bones and wrist ligaments.\(^7\) In sports, especially hockey players, ulnar-sided wrist pain in the dorsal proximal triquetrum is prevalent mainly during wrist pronation, flexion, and radial deviation. Wrist kinetics and kinematics are critical for diagnosing and treating traumatic or degenerative abnormalities in the wrist joint.\(^8\) These biomechanical variations are partly caused by varying degrees of ligament tension across the arc of movement.\(^9\)

For most occupational and recreational activities, the dart thrower’s arc, radial deviation-extension to ulnar deviation-flexion, is the most stable and regulated action, expressing the functional plane of the wrist.\(^10\)\(^11\)

Hockey is played in 132 nations. It is a fast-paced, aggressive team sport, and in terms of international popularity, it is in the second position after soccer.\(^12\)\(^13\) It is becoming popular in the United States, with the greatest development occurring nationwide among National Collegiate Athletic Association Division III institutions.\(^14\) It is a contact sport, so injury to the head, face, shoulder, arm, thighs, and knee is possible. A study suggested that lower limb injuries are more common in comparison to upper

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### CONCLUSIONI

Il risultato fondamentale del presente studio è rappresentato dal dato secondo cui la flessione (valori del lato sinistro e destro 0,03, 0,02) risulta maggiore dell’estensione (valori P del lato sinistro e destro 0,60, 0,62), ma non sono stati osservati differenze importanti tra mano dominante e non dominante, valore P>0,05. Le partecipanti di sesso femminile sono risultate possedere un range più ampio rispetto ai partecipanti di sesso maschile sulla base della media e dell’IC al 95%, ma non sono stati osservati variazioni statistiche sulla base del valore P (P>0,05).

Parole chiave: Movimento; Valori di riferimento; Atleti; Mano.
limb injuries (51.6%), in which ankle strains and sprains are more common (29%). Compared to female players, male players are more prone to injuries. Even the training protocol has been reported to reduce joint mobility. In a study by Francia et al., significantly reduced joint mobility of the ankle joint was reported following an adapted training protocol in young soccer players.

Normative values help interpret an individual's performance so that it may be directly compared to the reference population. In literature, functional ROM of the wrist is already established which is required for ADLs. But according to sports, ROM is different for every upper and lower limb joint. An analysis of wrist motion was done during basketball shooting, and normative values were established, and they also compared it with dominant and non-dominant hands. In a previously published study, they analyzed wrist ROM in recreational female tennis players with or without lateral elbow tendinopathy. They found wrist flexion was higher in players without elbow tendinopathy. Such normal values are not available for wrist joints in field hockey players. To the best of our knowledge, for field hockey players, normative values are established for shoulder and hip joints, not wrist joints. Therefore, the main objective of this study was to investigate normative reference values for wrist active ROM (AROM) in field hockey and the non-athletic population using a universal goniometer that helps physical therapists interpret normal values in clinical practice as well as after an injury during rehabilitation. This study hypothesized that there are significant differences in AROMs of the wrist joint between hockey players and the non-athletic population, and that AROMs are higher in hockey players compared to the non-athletic population.

Materials and methods

Study design, setting, ethical approval

This was a cross-sectional type of observational study. It was conducted at the Maharishi Markandeswar Institute of Physiotherapy and Rehabilitation (MMIPR), Maharishi Markandeswar (Deemed to be University), Mullana, Ambala, Haryana, India, the Sports Complex of Kurukshetra University, Haryana, and the Hockey Academy of Chandigarh, India. The NORMATIVE VALUES FOR THE WRIST JOINT

VERMA

studied injuries.15 Even the training protocol has been reported to reduce joint mobility. In a study by Francia et al., significantly reduced joint mobility of the ankle joint was reported following an adapted training protocol in young soccer players.16

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Institutional Ethical Committee of the Maharishi Markandeshwar Institute of Medical Sciences and Research approved the study with reference no. IEC-1930. The study was performed in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) and National Ethical Guidance for Biomedical Research involving Human Participants 2017. All methods were performed in accordance with the relevant guidelines, regulations and ethical principles.

**Participants**

Purposive sampling for 138 participants aged 18-25 years (78 males and 60 females) was done from January 2022 to March 2022. Sixty-nine hockey players (42 males and 27 females) and sixty-nine non-athletic people (40 males and 29 females) were recruited. Hockey players included in this study had a firm end-feel at the wrist joints, played hockey at the national level, trained themselves ≥3 days per week plus match play, and played hockey for the last three months. The non-athletic people were also in the age group between 18-25 years, were asymptomatic, and did not participate in any sports activities. All participants had grade 4 or 5 manual muscle testing (MMT) for wrist muscles. Participants with fractures and acute upper limb injuries, carpel tunnel syndrome, radial tunnel syndrome, and intra-articular elbow dysfunction were excluded from the study.

Underweight and obese persons, according to Asian BMI, were also excluded from the study.

**Procedure and sample size calculation**

A universal short-arm goniometer (made of plastic with a 180° goniometer face and a 21 cm arm's length) was used to measure the AROM of the wrists. Before the assessment, the study was explained, and written consent was obtained from every participant. An expert physical therapist (PT) collected all the data before the warm-up of the hockey players. Following the recruitment process, anthropometric measurements (height and weight) and muscle length testing were done. Participants were asked to sit on an arm resting chair with their feet touching the ground. The elbow was at 90° flexion, and the forearm was fully pronated (palm facing downwards). AROM was measured only in the wrist pronated position.

**Partecipanti**

Il campionamento mirato di 138 partecipanti di età compresa tra 18 e 25 anni (78 di sesso maschile e 60 femminile) è stato effettuato tra gennaio 2022 e marzo 2022. Sono state reclutate sessantasei giocatori di hockey (42 uomini e 27 donne) e sessantasei persone non sportive (40 uomini e 29 donne). I giocatori di hockey inclusi in questo studio avevano una buona sensibilità alle articolazioni del polso, giocavano a hockey a livello nazionale, si allenavano 3 o più giorni a settimana oltre alle partite e avevano giocato a hockey negli ultimi tre mesi. Anche le persone non sportive rientravano nella fascia di età compresa tra 18 e 25 anni, non avevano sintomi e non praticavano ad alcuna attività sportiva. Tutti i partecipanti sono stati sottoposti a test muscolare manuale (manual muscle testing, MMT) di grado 4 o 5 per i muscoli del polso. I partecipanti con fratture e lesioni acute degli arti superiori, sindrome del tunnel carpale, sindrome del tunnel radiale e disfunzione intra articolare del gomito sono stati esclusi dallo studio.

**Procedura e calcolo della dimensione del campione**

Per misurare gli AROM dei polsi è stato utilizzato un goniometro universale a braccio corto (realizzato in plastica con quadrante a 180° e lunghezza del braccio di 21 cm). Prima della valutazione, lo studio è stato spiegato e da ogni partecipante è stato ottenuto il consenso scritto. Un fisioterapista esperto (physical therapist, PT) ha raccolto tutti i dati dei giocatori di hockey prima del riscaldamento. Dopo il processo di reclutamento, sono state effettuate misurazioni antropometriche (altezza e peso) e test della lunghezza muscolare. Ai partecipanti è stato chiesto di sedersi su una sedia con braccioli, con i piedi che toccavano il suolo. Il gomito era a 90° di flessione e l'avambraccio era completamente pronato (palm rivolto verso il basso). L'AROM è stato misurato solo in posizione prona del polso, che fornisce range maggiori in tutte le direzioni. Le articolazioni del polso erano in posizione neutra (0° flessione-estensione e deviazione radiale-ulnare).
as it provides greater ranges in all directions.\textsuperscript{23} The wrist joints were in a neutral position (0° flexion-extension and radial-ulnar deviation). The long axis of the third metacarpal and the radius were visually verified to confirm that the wrist joints were in neutral.\textsuperscript{29}

Participants were asked to bring their wrists out of the armrest for flexion-extension and radial-ulnar deviation measurements. This testing posture was maintained throughout the experimental sessions. The volar/dorsal alignment technique is the best goniometric technique and is highly reliable for measuring wrist flexion and extension ROM.\textsuperscript{30} The PT palpated the wrist joint line and the triquetrum at the lateral aspect of the wrist joint. Placed the fulcrum over the triquetrum, the proximal arm (stationary arm) of the universal goniometer along with the lateral midline of the ulna, and the distal arm (movable arm) with the lateral midline of the fifth metacarpal.\textsuperscript{31, 32} After goniometer placement, PT instructed the participants to move the wrist downward (for flexion) without moving the elbow and shoulder joints. The PT also used verbal commands to encourage the individuals to exert maximal effort to reach the end range. All the measured angles were documented on the datasheet.

The same method was used for wrist extension, and it was instructed to move the wrist toward the ceiling. PT palpated the capitate for radial-ulnar deviation and placed the fulcrum over it. Proximal arm (stationary arm) of the universal goniometer along the dorsal midline of the forearm and the distal arm (movable arm) towards the midline of the 3rd metacarpal, and the long axis of the third metacarpal and the radius were visually verified to confirm that the wrist joints were in neutral.\textsuperscript{29}

For the baseline measurement of the AROM of a particular movement, \textsuperscript{21} AROMs were measured in the sequence of flexion-extension followed by radial-ulnar deviation, as shown in figure 1. The study aimed to explore repeatability, which needed a stable physiological condition, so no randomization or blinding in assessment was performed (Figure 1).

G\textsuperscript{*}Power software version 3.1.9.4 was used for sample size calculation. A pilot study was performed with 15 hockey players and 15 non-athletic people. The minimum sample size came out was 116, using the formula \((Z_{\alpha/\delta}/d)^2\) with \(\alpha = 0.05\) and \(\delta = 5,52\) and \(d = 1,00\) to achieve a power of 80% (\(\eta^2 = 0.05\)). The sample size was calculated according to the formula \((Z_{\alpha/\delta}/d)^2\) with \(\alpha = 0.05\) and \(\delta = 5,52\) and \(d = 1,00\) to achieve a power of 80% (\(\eta^2 = 0.05\)). The sample size was calculated according to the formula \((Z_{\alpha/\delta}/d)^2\) with \(\alpha = 0.05\) and \(\delta = 5,52\) and \(d = 1,00\) to achieve a power of 80% (\(\eta^2 = 0.05\)).
where $Z_{\alpha}=1.96$, $\sigma=5.52$, and $d=1.00$. But due to the availability of the sample, 138 participants were included. Participants in the pilot study were not included in further study.

Statistical analysis

All statistical analysis was done using IBM SPSS software version 20. Demographic characteristics and AROM were first examined for normality using the Kolmogorov-Smirnov test (N.>50) and later confirmed by the $z$-value of skewness and kurtosis. The data were not normally distributed ($P<0.05$). Descriptive statistics were calculated to establish normative reference values in participants and reported as the mean (range) and 95% confidence interval. For within-group analysis, a non-parametric test was used because a normal distribution was not observed. With the help of the Wilcoxon Signed-Rank Test, wrist AROMs were compared between two groups (hockey players and non-athletic people). AROM measures were entered as dependent variables, and age and BMI were entered as covariables.

Results

One hundred thirty-eight participants were recruited and divided into two groups for the

Risultati

Sono stati reclutati centotrentotto partecipanti, divisi in due gruppi per l’analisi dei dati. Tutte le valutazioni sono state effettuate in condizioni basali e, trattandosi di uno studio effettuato una sola volta,
data analysis. All the assessments were taken at baseline, and it was a one-time study, which is why exclusion and follow-up were not mentioned.

In hockey players, left and right wrist flexion-extension AROMs were slightly greater than in the non-athletic population. AROM based on hand dominance was also measured using the Mann-Whitney U test, but no significant difference was found (P>0.05). The demographic characteristics of participants are shown in Table I. The normative reference values for wrist AROM were estimated and shown in Table II.

Within-group analysis was done in both groups for differentiating AROM in the left and right wrist using the Wilcoxon signed ranks test; the P-value was >0.05 for all the variables showing a non-significant difference in both wrist AROMs, as represented in Table III. When AROM was compared based on gender, females

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**Table I.**—Demographic characteristics of study participants.

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Hockey players (N=69)</th>
<th>Non-hockey players (N=69)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (range)</td>
<td>95% CI</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>168.30 (152-184)</td>
<td>166.99-169.60</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>58.41 (47-75)</td>
<td>56.93-59.90</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>20.62 (17.7-25.9)</td>
<td>20.15-21.09</td>
</tr>
</tbody>
</table>

CI: confidence interval; cm: centimeter; kg: kilogram; m²: meter square.

**Table II.**—Normative values for hockey and non-hockey.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Hockey</th>
<th>Non-hockey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (Range)</td>
<td>95% CI</td>
</tr>
<tr>
<td>Flexion (left)</td>
<td>79.18 (60-90)</td>
<td>76.87-81.50</td>
</tr>
<tr>
<td>Extension (left)</td>
<td>65.06 (30-80)</td>
<td>62.60-67.53</td>
</tr>
<tr>
<td>Ulnar deviation (left)</td>
<td>31.31 (20-40)</td>
<td>30.71-32.90</td>
</tr>
<tr>
<td>Radial deviation (left)</td>
<td>20.54 (10-35)</td>
<td>19.38-21.69</td>
</tr>
<tr>
<td>Flexion (right)</td>
<td>80.28 (60-100)</td>
<td>78.01-82.55</td>
</tr>
<tr>
<td>Extension (right)</td>
<td>64.27 (35-85)</td>
<td>61.72-66.81</td>
</tr>
<tr>
<td>Ulnar deviation (right)</td>
<td>31.36 (20-40)</td>
<td>30.51-32.40</td>
</tr>
</tbody>
</table>

CI: confidence interval.

**Table III.**—Within-group analysis of hockey and non-hockey participants.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Hockey</th>
<th>Non-Hockey</th>
</tr>
</thead>
<tbody>
<tr>
<td>z-value</td>
<td>p-value</td>
<td>z-value</td>
</tr>
<tr>
<td>Flexion (right) - Flexion (left)</td>
<td>-1.29</td>
<td>0.19</td>
</tr>
<tr>
<td>Extension (right) - Extension (left)</td>
<td>-0.78</td>
<td>0.43</td>
</tr>
<tr>
<td>Ulnar deviation (right) - Ulnar deviation (left)</td>
<td>-0.66</td>
<td>-0.50</td>
</tr>
<tr>
<td>Radial deviation (right) - Radial deviation (left)</td>
<td>-0.36</td>
<td>0.71</td>
</tr>
</tbody>
</table>
had greater AROM in both groups. Female hockey participants had a greater AROM than non-athletic female participants. AROMs are mentioned in the form of the mean (95% CI). For female hockey participants, AROMs were as follows, left wrist flexion 80.76° (76.62-84.91), extension 66.30° (63.22-69.38), ulnar radiation 32.76° (30.91-34.62), RD 21.88° (19.84-23.91) and right wrist flexion 83.84° (80.08-87.60), extension 66.84° (63.32-70.36), deviation ulnare 31.61° (30.41-32.81), RD 20.46° (18.56-22.35).

AROMs for left wrist in non-athletic females were 77.11° (74.03-80.19), 64.82° (60.78-68.86), 31.70° (29.20-34.20), 21.73° (19.24-24.22), and for right wrist were 77.05° (74.07-80.03), 63.97° (60.15-67.78), 30.91° (29.04-32.77), 21.55° (18.55-24.23).

Hockey male participants had a greater AROM than non-athletic male participants, and their AROMs were 78.33° (75.47-81.19), 64.39° (60.91-67.87), 31.29° (29.91-32.67), 19.81° (18.40-21.22), for the left wrist joint and 78.35° (75.56-81.14), 62.87° (59.42-66.32), 31.22° (29.72-32.73), 20.62° (19.31-21.93) for the right wrist joint. AROMs for non-athletic male participants were 73.60° (69.19-78.01), 62.16° (57.27-67.06), 29.63° (27.13-32.13), 19.63° (17.20-22.06) for the left wrist joint and 74.75° (70.75-79.11), 62.76° (58.65-66.87), 31.30° (28.45-34.14), 21.10° (18.63-23.56) for the right wrist joint. Only AROMs were measured to avoid any type of tester's error during passive ROM (PROM), and the literature also supports that AROM measurements are more reliable than PROM.30, 33, 34 A standardized protocol framed by the American Society of Hand Therapists (1992) and the American Academy of Orthopedic Surgeons (1988) was used to guide participants during the measurement and positioning of the goniometer. The instructions were given to participants during measurement to avoid random and total measurement errors.

Discussion

The current study aimed to evaluate the normative reference values of wrist AROMs in field hockey players and the non-athletic population using a universal goniometer. A goniometer has fair to good reliability of the wrist in dart throwing motion35 and is very easy to use in clinical practice.36 ADLs require functional movement of the wrist joint and are well described as 5° flexion, 30° extension, 10° radial, and 15° ulnar deviation.37 In literature, normal values of

NORMATIVE VALUES FOR THE WRIST JOINT

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Discussion

Il presente studio si è proposto di valutare i valori standard di riferimento degli AROM del polso nei giocatori di hockey su prato e nella popolazione non sportiva, utilizzando un goniometro universale. Il goniometro ha un'affidabilità discreta a buona nel movimento di lancia del dardo35 del polso ed è molto semplice da usare nella pratica clinica.36 Le ADL richiedono un movimento funzionale dell'articolazione del polso e sono ben descritte come 5° di flessione, 30° di estensione, deviazione radiale di 10° e deviazione ulnare di 15°.37 In letteratura
the shoulder and hip joints' ROM and muscle strength in field hockey players are already established. The present study is the first to establish normal reference values for wrist AROMs in field hockey players. These norms serve as a standard by which coaches, trainers, researchers, and therapists can evaluate field hockey players. The findings also revealed no statistically significant differences between right and left hands. Furthermore, age and BMI had no statistically significant influence on AROM values. This indicates that the numbers presented here are applicable in clinical practice.

A significant finding of the present study was that wrist flexion was greater than extension. For hockey players, there is not much difference between right and left wrist flexion (80.28º and 79.18º) and extension (64.27º and 65.06º). For the non-athletic population, these values for flexion are 76.06º and 75.46º, and for extension, 63.40º and 63.57º. Previous studies found that extension (76.8º) was greater than flexion (77.5º).²⁸

Few studies support greater wrist flexion, and normative data on wrist function is available in the literature. It was suggested that wrist flexion is greater than extension in males and females 18-29 years of age. Stacy Fan et al.¹⁸ found that flexion was greater than extension in wrist supination, mid-prone (neutral), and pronation in healthy young volunteers aged between 23-30 years, and the maximum difference is seen when the wrist is in pronation. Whereas according to Ann M Lucado et al.,¹⁸ flexion is greater than extension, they analyzed ROM in female recreational tennis players with and without lateral tendinopathy. Their findings for normal individuals are 92.10º, 80.45º, 22.43º, and 43.43º for flexion, extension, radial, and ulnar deviation. In our study, for the non-athletic population, AROMs were 76.06º, 63.40º, 21.34º, and 31.09º for flexion, extension, radial, and ulnar deviation. Here, we can compare the ROMs of tennis and hockey players; tennis players had almost equal ROMs compared to hockey players except for extension and ulnar deviation. For tennis players, ROMs were 80.48º, 79.90º, 20.52º, and 40.48º, for hockey players, AROMs are given in Table II. A study was performed on 29 elite boxers to quantify their wrist angular excursion for jab and hook lead arm shoots. They found extension was greater than flexion (70.1º±14º55.3º±11.2) and ulnar RD was 28.8º±9.4 and 18.8º±6.8 respectively.

Our study found no statistically significant values. This indicates that the numbers presented here are applicable in clinical practice.

A significant finding of the present study was that wrist flexion was greater than extension. For hockey players, there is not much difference between right and left wrist flexion (80.28º and 79.18º) and extension (64.27º and 65.06º). For the non-athletic population, these values for flexion are 76.06º and 75.46º, and for extension, 63.40º and 63.57º. Previous studies found that extension (76.8º) was greater than flexion (77.5º).²⁸

Few studies support greater wrist flexion, and normative data on wrist function is available in the literature. It was suggested that wrist flexion is greater than extension in males and females 18-29 years of age. Stacy Fan et al.¹⁸ found that flexion was greater than extension in wrist supination, mid-prone (neutral), and pronation in healthy young volunteers aged between 23-30 years, and the maximum difference is seen when the wrist is in pronation. Whereas according to Ann M Lucado et al.,¹⁸ flexion is greater than extension, they analyzed ROM in female recreational tennis players with and without lateral tendinopathy. Their findings for normal individuals are 92.10º, 80.45º, 22.43º, and 43.43º for flexion, extension, radial, and ulnar deviation. In our study, for the non-athletic population, AROMs were 76.06º, 63.40º, 21.34º, and 31.09º for flexion, extension, radial, and ulnar deviation. Here, we can compare the ROMs of tennis and hockey players; tennis players had almost equal ROMs compared to hockey players except for extension and ulnar deviation. For tennis players, ROMs were 80.48º, 79.90º, 20.52º, and 40.48º, for hockey players, AROMs are given in Table II. A study was performed on 29 elite boxers to quantify their wrist angular excursion for jab and hook lead arm shoots. They found extension was greater than flexion (70.1º±14º55.3º±11.2) and ulnar RD was 28.8º±9.4 and 18.8º±6.8 respectively.

Our study found no statistically significant
difference between left and right wrist AROMs in the dominant and non-dominant hands. But according to a study, in both males and females, flexion-extension is lower in the dominant hand, and it was also suggested that in females, flexion-extension and RD are greater on the right side and ulnar deviation on the left side. In males, extension is greater on the left side and ulnar deviation on the right side. But a study concluded that there is an almost 10° difference in right and left wrist extension and RD in both AROM and PROM (left wrist ROM=right wrist ROM, P-value <0.001) in 1000 healthy males.39

**Conclusions**

The key finding of the study was that flexion (left-side and right-side p-values 0.03, 0.02) was greater than extension (left-side and right-side P-value 0.60, 0.62) but no major changes were seen in the range of dominant and non-dominant hands, P-values >0.05. Female participants had a greater range compared to male participants on the basis of the mean and 95% CI, but no statistical changes were observed on the basis of the P-value (P>0.05).

**Strengths and limitations of the study**

The strength of the study is as follows: there were an equal number of participants in both groups, AROMs were measured in a pronated position, and only AROMs were measured: Upper limb length was not measured, which is a limitation of the study. In future studies, ROM for the elbow and shoulder should be assessed along with the wrist joint, and ROM should be evaluated based on player position in hockey players.

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Conflicts of interest
The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Author's contribution
Nitesh Verma, Vanadana Esht and Pooja Mehra conceptualized the study, its protocol, and its methodology; Nitesh Verma and Pooja Mehra performed data collection and curation; Nitesh Verma, Vanadana Esht and Pooja Mehra performed the data analysis and interpretation of the results; Nitesh Verma, Vanadana Esht, Pooja Mehraand and Masood Khan wrote the original draft of the manuscript; Mohammed M, Alshehri, Faizan Z. Kashoo, Abdur R. Khan, Mohammad A. Shaphe and Ahmad H. Alghadir revised the manuscript for intellectual content and were involved in supervision. All authors read and approved the final version of the manuscript.

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