Journal of Sports Research
2025 Vol. 12, No. 1, pp. 24-32
ISSN(e): 2410-6534
ISSN(p): 2413-8436
DOI: 10.18488/90.v12i1.4334

Monitoring of athletes condition: Male handball players body part pain in handball performance

Fatima Tus Johora Mukta[1]
Jannatul Ferdaus Rickta[2]
Md. Yeasir Arafat[3+]

[1,2]*Jashore University of Science and Technology, Bangladesh.*
[1]*Email: ft.johora@just.edu.bd*
[2]*Email: jannat121216@gmail.com*
[3]*Chittagong University of Engineering and Technology, Bangladesh.*
[3]*Email: arafat4232@cuet.ac.bd*

(+ Corresponding author)

Article History
Received: 9 January 2025
Revised: 17 July 2025
Accepted: 25 July 2025
Published: 1 August 2025

Keywords
Body part pain
Handball
Joints
Observation
Performance
Visual analog scale.

ABSTRACT

Handball is a globally popular sport that requires frequent jumping, landing, and rapid directional changes, often resulting in pain or physical discomfort among players. This study observed 13 national-level male handball players during a training camp to assess the impact of body part pain on performance. Pain was monitored over four consecutive days during the second daily practice session. A Visual Analog Scale (VAS) was used to evaluate both pain in specific body parts and self-rated performance aspects such as satisfaction and concentration. Linear mixed modeling was applied to analyze the relationship between pain and performance, accounting for daily individual variation. The results revealed that several players reported high VAS pain scores in the dominant shoulder and elbow, while one athlete reported a maximum score of 10 in the dominant knee. Pain in the ankle joints was also notably high. This study highlights the importance of monitoring physical discomfort during training, as pain in key joints may negatively affect both perceived and actual handball performance.

Contribution/Originality: This study is the first to investigate the daily impact of body part pain on both subjective and objective handball performance among national-level male handball players in Bangladesh during a real training camp, using VAS and wearable sensor data combined with linear mixed modeling.

1. INTRODUCTION

Handball is a globally recognized ball sport that has gained international popularity and is played by both men and women at the Olympic level [1, 2]. The sport has spread to various regions, including the organization of national federations in Asia, Africa, America, Europe, Oceania, and the Caribbean [3]. The standardized measurement of a handball court is 40 meters by 20 meters, and players develop game-related skills with the ball to throw it into the opponent's goal post for a successful score. The game of handball is physically demanding [4]. During the match, physical contact is constantly maintained, particularly around the (6-meter) line or goal area. In addition, fundamental body movements such as jumping, landing, and changing direction are easy during a match. Especially, game-related movements such as jump shots, body faking, high-speed running, and high-energy loads are simple factors in a match. It is a concern that players throw a ball weighing 425-475g at around 100 km/h with both arms. During a match, it typically consists of six to ten high-intensity shots [5]. In this case, upper limb joints are important [6, 7]. Due to the characteristics of this sport, handball is a ball game in which both types of injuries occur regularly [4, 7]. This type of injury permanently damages a player's career [1]. It is important to recognize the warning signs of active injury and address any difficulties before they worsen.

A possible symptom of the latter problem is pain in various parts of the body, such as groin pain and knee pain [8, 9]. In particular, small injuries can accumulate, cause major problems if not treated properly, and last for a long time [1, 10, 11]. Sometimes elite professional handball players do not let their condition prevent them from playing because, if they experience some pain, they may still be able to continue, demonstrating their physical abilities or enduring negative effects [12, 13]. In addition, a mentality of endurance to fulfill in pain is observed among elite players, so players and caregivers need to be sensitized to this [1, 12, 13]. The effect of pain on handball performance may unintentionally be overshadowed by such circumstances [1]. It is therefore important to deeply examine how body pain impacts performance and how daily practice helps the body. To date, no research has indicated how body part pain affects daily practice and performance in national-level handball players in Bangladesh. However, some previous research has evaluated the same topic in other countries. This research study aims to indicate how body part pain harms athletes, resulting in a loss of performance level, affecting daily practice, and hindering performance development. The study seeks to determine how different bodily pains affect perceived and objective performance of handball players during a real training camp for the Bangladesh men's national team. It is a fact that some elite players were selected for the national-level training camp [14]. Furthermore, these athletes train hard and become ready for international competitions in a short amount of time, which makes it very challenging to set up a lengthy and reliable survey period. This study used a comprehensive visual analog scale (VAS) assessment at the conclusion of each practice session to explore the association between body part discomfort and natural or subjective handball performance over a brief investigation period, while acknowledging the limitations of prior research. The hypothesis was that discomfort in a specific body area would make an athlete less focused during training, which would decrease their enjoyment of their body's movement and impair their physical performance.

2. MATERIALS AND METHODS

2.1. Participants

Only twenty-one (21) male national-level handball players were selected for the present study during a training camp for an upcoming competition. The purpose of the research was briefly explained to all participants, but only 13 of the 21 players agreed to participate based on their willingness. These players' usual methods of managing discomfort during the training camp, such as vitamins, drugs, doctor-administered painkiller injections, and massage therapy, were not restricted and were well documented. This study was approved by the Research Ethics Review Committee of the Faculty of Health Sciences at Jashore University of Science and Technology, with written consent obtained from all players.

2.2. Procedure

2.2.1. Survey Process

In training camp, four consecutive practice days of pain evaluation were conducted during the second training session. The second session was the longest, so the researcher selected this session. To ensure reliable measurements, the experimenters conducted interviews with the handball players and recorded the VAS questionnaire and other measurements described below.

2.2.2. Fundamental Data

The participants' age, height, weight (years, cm, kg), years of sports experience, position (goalkeeper, back, pivot, wing), dominant hand (right/left), jumping leg (right/left), and history of regular medicine use within the preceding year were collected at the start of the camp.

2.2.3. Measuring The Degree of Pain Specific Part of the Body

Total ten body parts the elbow, both shoulders, the Achilles tendon, and the ankle were assessed using the VAS. The participants were told that no pain meant 0 and the highest amount of pain meant 10. The players were also allowed to report how painful various body parts were. Two particular game performance items, concentration and happiness with physical attitude, were also measured using VAS with a range of 0 to 10. After practice for the day ended, five minutes later, the VAS questionnaire was completed. In the absence of the researchers, the athletes filled out the VAS questionnaire using a black pencil.

2.2.4. Monitoring Heart Rate and Volume of Physical Activity

Heart rate and body movement intensity were the variables employed in this study to measure focus body performance. To do this, the athletes' heart rates and the acceleration caused by their bodily movements were examined using a heart rate inertial sensor. The sensor was fastened to the player's non-dominant upper arm to avoid interfering with their throwing motion. The heart rate data (sampling frequency: 1 Hz) and acceleration data (sampling frequency: 52 Hz, range ±8 G) from the sensor were measured using the Polar Sensor Logger (https://play.google.com/store/apps/details?id=com.j_ware.polarsensorlogger; viewed on March 19, 2023). The data was then stored on an Android tablet (Galaxy Tab S7, Samsung Electronics Co., Ltd., Seoul, Republic of Korea) for further analysis.

2.3. Evaluations

The written VAS information on subjective handball performance and body part pain was measured independently by three experimenters; the mean of the three experimenters' measurements served as the final VAS score. The accuracy of this value was verified by another experimenter.

2.3.1. Heart Rate data

Only the warm-up period of 15 minutes had heart rate data measured. The same sports trainer led the team in the same warm-up drills during the survey period, which included sprints, dynamic stretching, light jogging, and step work. Because the practice's primary focus changed slightly from day to day, the athletes' physical condition and practice intensity both impacted their heart rates. Using the heart rate during a standardized warm-up, the athletes' physical condition was evaluated for impact. Heart rate insight was acceptable to the maximal heart rate, and proportion of the entire warm-up time (15 min) that was spent in six heart rate zones (<50%, 50–59%, 60–69%, 70–79%, 80–89%, and ≥90%) was computed. This study employed heart rate bands of less than 50% and more than 90% for further statistical analysis. The formula for the maximal heart rate was 220 minus [15].

2.3.2. Acceleration Data

Data on physical acceleration were gathered and analyzed during the warm-up, which lasted 15 minutes. The acceleration signal processing method, recommended by Marutani et al. [16] and Bere et al. [17], was applied in this investigation to evaluate the athletes' body movement intensity. This method assesses the greater and lower magnitude portions of a speed signal independently by matching a hybrid Gaussian design onto the histogram of the suitably processed velocity signal. In short, a 2nd-order Butterworth electronic filter was used to exclude the gravitational acceleration component from multidimensional acceleration information acquired from the inertial sensor after determining the norm of the data [1]. Next, a second-order Butterworth electric filter was used to produce the enveloped signal. The envelope signal was considered to be in the rest period and was not included in the study when it was below 0.3 G for longer than 5 seconds. The encapsulated acceleration signal of the active phase was then captured in a histogram. This research used mixed Gaussian model screening on the acceleration signal histogram because it showed the feature of two local peaks that correlated with small and large body motion vigor. The intensity of body movement was quantified using acceleration values corresponding to the low- and high-magnitude peaks of the fitted mixed Gaussian model. Please check [17] for a visual representation showing how the signal processing technique is presented.

2.4. Statistical Analysis

With a small sample size and a brief survey period during a real training camp, the study's goal was to precisely assess the impact of body part pain on subjective and objective handball performance. A two-step statistical method was applied to achieve this. To determine the validity of our hypothesis and capture the overall link between the subjective and objective variables, this study first employed route analysis.

This study used a linear mixed model to account for the daily fluctuations in each participant's pain condition and its impact on their subjective performance during the survey days, after excluding non-significant variables.

This study applied linear mixed modeling to examine the effect of body part pain on concentration levels while accounting for individual day-to-day variation. The following model was assessed using ImerTest (Version 3.1.3) in R (version 4.2.3).

Concentration = dominant elbow + non-dominant elbow + dominant shoulder + non-dominant shoulder + dominant knee + non-dominant knee + dominant Achilles tendon + non-dominant Achilles tendon + dominant ankle + (1|athlete).

Where (1|Athlete) specifies the grouping of each athlete.

Table 1. Demographic information of the participant.

No.	Age (Y.O.)	Height (cm)	Weight (kg)	Position	Experience (Year)	Dominant Arm/Leg
1	30	180	95.3	CB, RB	15	R/L
2	25	184	80.6	LW, LB	12	L/R
3	27	183	75.1	RB	10	R/L
4	26	178	68.4	CB, RB	11	R/R
5	26	183	85.3	LB, CB	12	L/L
6	32	178	81.2	LW, LB	14	L/L
7	25	182	96.1	RB, PV	12	R/L
8	28	178	82.7	PV, RW	15	R/R
9	29	184	90.2	LW, LB	14	L/R
10	28	186	92.3	RB, RW	12	R/R
11	31	181	72.9	GK	16	R/L
12	30	178	80.7	PV	15	R/R
13	33	185	96.7	RB, CB	16	R/L

Table 2. All participant VAS scores in the dominant body part pain during the entire training camp.

	Dominant knee				Dominant Achilles tendon				Dominant Ankle				Dominant Elbow				Dominant shoulder			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	0	3.2
2	0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.4	0
4	5.4	6.2	4.1	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	3.7	4.2	0	0	0	0	0	0	0	2.6	0	4.9	5.7	7.3	0	0	0	0
6	0	0	0	0	0	0	0	0	2.8	3.6	1.6	2.3	0	0	0	0	0	0	0	0
7	6.6	6.3	4.6	4.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.0	10
8	0	0	0	0	0	0	0	0	0	0	0	0	6.3	7.2	4.5	3.2	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	2.1	2.3	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	5.2	6.8	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.2	9.7	7.2	8.1
13	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0

Note: Indicates the body part pain VAS score range in color.

Table 3. All participant VAS scores in the dominant body part pain during the entire training camp.

	Non-dominant Knee				Non-dominant Achilles tendon				Non-dominant Ankle				Non-dominant Elbow				Non-dominant Shoulder			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	3.6	4.3	5.6	2.4	0	0	0	0	0	0	0	0
6	0	0	5.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	5.6	7.2	4.8	5.2	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	1.2	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.4	3.8
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Indicates the body part pain VAS score range in color.

3. RESULTS

Weight is measured after waking up and is represented as the mean [standard deviation] of four survey days. Positions include goalkeeper (GK), left flank (LW), right wing (RW), left back (LB), center back (CB), right back (RB), and pivot (PV). The dominant arm is the primary hand used for shooting. In a jump shot, the dominant leg is the primary leg used.

3.1. VAS Score for Body Part Pain

Table 2 lists the VAS scores for various body parts' pain, with color grading indicating the magnitude of the VAS scores. The dominant shoulder (6 of 14 participants) was the most common body area to report pain throughout the four days of the study, followed by the dominant knee, dominant elbow, dominant ankle joint, and non-dominant ankle joint (3 of 14 participants). Throughout the survey, only these specific body areas were consistently reported as affected.

Only three participants reported pain in their non-dominant knee, non-dominant Achilles tendon, and non-dominant shoulder. However, the pain in these areas was only temporary rather than persistent throughout the survey duration. During the survey, athlete No. 13's dominant knee and athlete No. 09's non-dominant elbow exhibited notably high pain VAS scores. The VAS score for the dominant Achilles tendon was not included in the study, as no athlete reported discomfort in this area.

Table 4.VAS assessments for satisfaction with one's body and concentration.

Concentration					Satisfaction with body movement			
No	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**
1	4.2	6.4	2.3	2.7	3.2	8.3	4.3	4.7
2	6.5	2.6	3.2	4.1	8.2	3.2	4.6	2.4
3	5.8	6.4	6.8	7.8	8.4	8.4	7.5	7.8
4	8.7	8.8	8.8	7.8	8.7	8.9	8.9	7.8
5	8.6	7.0	8.6	8.8	6.7	6.4	5.2	6.1
6	5.3	7.8	5.4	3.7	6.7	7.6	6.5	5.2
7	4.9	4.6	3.6	3.7	5.1	4.9	3.7	3.6
8	6.6	7.1	7.1	6.5	6.2	6.3	5.4	6.1
9	5.1	3.4	6.2	5.4	5.2	2.3	4.2	6.3
10	5.9	6.5	6.3	4.3	5.8	5.9	5.8	4.9
11	8.5	8.4	9.5	9.2	4.8	6.1	9.5	8.4
12	4.2	8.5	3.1	6.2	5.3	3.1	3.1	3.5
13	5.2	5.9	6.9	7.6	3.1	6.2	5.9	5.9

Table 5. Objective performance metrics for handball assessed using a wearable sensor.

	Body movement vigorousness (High) Unite: G				Body movement vigorousness (Low) Unite: G				<50% HR max Unite: %				>90% HR max Unite: %			
	D1	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**
1	1.2	1.2	1.3	1.1	0.4	0.5	0.4	0.4	5.5	2.2	12.2	16.3	0.6	4.6	2.1	0.1
2	1.2	1.2	0.2	1.0	0.3	0.3	0.3	0.4	0.1	5.6	5.5	5.5	2.1	3.3	0.6	0.0
3	1.3	1.3	0.3	1.2	0.4	0.4	0.5	0.4	11.1	7.5	0.1	0.1	0.6	0.1	0.5	0.0
4	1.5	1.4	0.1	1.2	0.2	0.2	0.4	0.3	4.2	7.2	11.3	11.1	0.5	N/A	22.1	0.5
5	1.2	1.1	0.4	1.1	0.5	0.3	0.4	0.4	4.2	5.2	4.2	4.2	2.1	3.5	0.2	0.0
6	1.3	1.3	0.2	1.0	0.6	0.4	0.3	0.3	7.2	4.2	5.2	4.2	0.2	N/A	5.2	8.2
7	1.1	1.2	0.5	1.3	0.2	0.4	0.3	0.3	6.3	1.2	8.2	7.2	5.2	11.2	12.3	N/A
8	1.3	1.2	0.2	1.0	0.3	0.3	0.3	0.4	5.2	2.3	6.3	6.3	2.3	1.2	1.2	0.0
9	1.4	1.0	0.1	1.4	0.2	0.3	0.2	0.2	11.2	12.1	5.2	5.2	1.2	2.0	5.1	0.0
10	1.2	N/A	0.3	1.0	0.3	0.5	0.4	0.3	5.8	6.4	11.2	11.2	3.1	0.1	0.1	0.0
11	1.2	1.2	0.6	1.2	0.3	0.4	0.4	0.3	5.1	4.2	6.8	5.8	0.1	14.2	15.3	0.3
12	1.4	1.1	0.2	1.0	0.2	0.2	0.4	0.4	6.8	5.2	5.1	5.1	15.3	5.3	2.4	4.3
13	1.4	1.3	0.1	1.2	0.4	0.3	0.3	0.3	6.9	6.8	6.8	6.8	2.4	2.1	1.3	0.0

Note: N/A means some handball players break their concentration in Android tablet during the warm-up time.

In Table 4, VAS assessments for satisfaction with one's body and concentration are presented; and in Table 5, objective performance metrics for handball, assessed using a wearable sensor, are shown.

3.2. Linear Mixed Modeling (LMM)

Based on the results of this study, linear mixed modeling is additionally measured. The results clearly identify that during training camp, maximum player pain occurs in the dominant elbow and affects practice time.

Table 6. Linear mixed model results.

	Estimate	Standard error	Degree of freedom	*t*- Value	*p*- Value
Intercept	6.646	0.652	11.206	9.547	0.00*
D Shoulder	-0.031	0.188	29.743	-0.125	0.45
Nd Shoulder	0.112	0.445	23.815	0.237	0.40
D Elbow	-0.332	0.153	21.731	-2.410	0.01*
Nd Elbow	0.312	0.432	10.721	1.002	0.17
D Knee	-0.162	0.142	12.713	-1.155	0.14
Nd Knee	-0.065	0.221	31.872	-0.125	0.45
D Ankle	0.034	0.218	11.274	0.206	0.42
Nd Ankle	-0.158	0.445	22.121	-0.711	0.24
Achilles Tendon	0.172	0.265	30.828	0.417	0.34

Note: The significant level ($p<0.05$) and D means dominant, Nd means non dominant.

4. DISCUSSION

The research aims to identify how discomfort in various body sections affects handball players in a national training camp. All participating handball players undergo a period of intense training known as the national camp. Therefore, short-term surveillance is necessary to determine players' physical status as accurately as possible. It was predicted that, throughout the training camp, pain in various bodily areas would limit players' range of motion and impact their handball performance.

The pain in different body parts was recorded at varying levels of severity depending on the specific area. In Table 2, several participants reported a dominant shoulder VAS pain score of 9. Additionally, the dominant knee was also a concern, with one participant indicating the highest VAS score of 10. The VAS pain score for the ankle joint is relatively high, which is a concern for both the participating athletes and their coaches. The knee and ankle joints are the two major joints in the body that experience severe orthopedic trauma in handball games [1, 7-9, 17], and inadequate warm-up or recovery usually results in overuse symptoms [7]. A large number of participants reported a high level of pain in the upper body joints because these joints are used more frequently during handball games. In the Tables 2 and 3, it is clearly shown that the maximum pain level for upper body joints is 10, whereas for lower body joints, it is 6.6. This indicates that handball players are more concerned about upper-body joint pain than lower-body joint pain. Additionally, elbow joint pain is a common problem among handball goalkeepers [18-20]. Because of overhead throws, elbow joint pain is a simple factor [21, 22]. In handball games, court players must have good throwing abilities to avoid opponent defenders and goalkeepers [1]. In this situation, players don't always respond to their bodies freely, so they throw the body and ball at risk, which increases injury risk. The non-dominant joint pain and lower part of the body joint are also concerning issues in the handball game. In the present research, as indicated in Tables 1 and 2 lower range of VAS pain score in the knee joint, ankle joint, and Achilles tendon. No dominant joint in the body part of a handball game in every participant is a concerning factor when it becomes involved in high-range activities. At a training camp, athletes train hard daily to achieve peak performance in competitions, but during this time, some injuries occur and affect practice and performance. In this research, participants were not sufficiently concerned about body movement pain, so the hypothesis was not fully supported.

One other disadvantage of this survey study with elite athletes was the absence of a control group. It was challenging to find pain-free athletes who were physically comparable for this kind of comparison. To overcome such restrictions, future research could aim to enlist athletes with a variety of performance levels. Due to the camp schedule's limitations, this study was limited to a short survey, making it unable to track pain variability over an extended period. Utilizing the web-survey method is one way to track body part pain apart from a camp's schedule [23]. This study used the VAS assessment in face-to-face interviews with athletes to precisely quantify their subjective perception of pain despite these research limitations. Furthermore, a four-day period of continuous, high-intensity practice was chosen as the study period to minimize the impact of practice intensity on pain variability. As a result, it is believed that the brief survey period and the small number of athletes recruited do not justify skipping a meticulous examination of the athletes' circumstances.

5. CONCLUSIONS

In conclusion, most players in the present study suffer from body pain, but they are not overly concerned about it. The upper extremity of the body has the highest range of VAS scores for pain, and the lower extremity experiences some concerning pain, but less than the upper extremity. The dominant elbow, shoulder, knee, and ankle are more concerning issues than the non-dominant parts. The dominant shoulder, followed by the dominant knee, the dominant ankle, the dominant elbow, and the non-dominant ankle are the body parts in which the majority of players experienced pain during the four days of the study. In statistical analysis, only the dominant elbow was found to be significant. 01 Table 6. Pain in the upper extremities, linked to the main handball movement of throwing, may diminish athletes' perceived performance, which lowers practice quality even if it has no physical impact on their objective performance.

Funding: This study received no specific financial support.
Institutional Review Board Statement: The Ethical Committee of the Jashore University of Science and Technology, Bangladesh has granted approval for this study on 10 April 2024 (Ref. No. Just/2024/0000725).
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

REFERENCES

[1] I. Ogasawara *et al.*, "Body part pain affects subjective and objective handball performance in japanese male national athletes—results of short-term practical monitoring of athletes' conditions," *Sports*, vol. 12, no. 3.

[2] International Handball Federation, "Member federations," 2024. https://www.ihf.info/federations

[3] J. Raya-González, F. M. Clemente, M. Beato, and D. Castillo, "Injury profile of male and female senior and youth handball players: A systematic review," *International Journal of Environmental Research and Public Health*, vol. 17, no. 11.

[4] C. García-Sánchez, R. M. Navarro, C. Karcher, and A. de la Rubia, "Physical demands during official competitions in elite handball: A systematic review," *International Journal of Environmental Research and Public Health*, vol. 20, no. 4, p. 3353.

[5] A. Barič, S. Hlebš, S. Novak, and P. Brumat, "Epidemiology of injuries in female and male senior Slovenian handball leagues," *The Journal of Sports Medicine and Physical Fitness*, vol. 61, no. 12, pp. 1644-1652, 2021.

[6] K. Asai, J. Nakase, K. Shimozaki, K. Toyooka, K. Kitaoka, and H. Tsuchiya, "Incidence of injury in young handball players during national competition: A 6-year survey," *Journal of Orthopaedic Science*, vol. 25, no. 4, pp. 677-681, 2020.

[7] R. Seil, S. Rupp, S. Tempelhof, and D. Kohn, "Sports injuries in team handball," *American Journal of Sports Medicine*, vol. 26, no. 5, pp. 681-687, 1998.

[8] E. T. Rafnsson, Ö. Valdimarsson, T. Sveinsson, and Á. Árnason, "Injury pattern in Icelandic elite male handball players," *Clinical Journal of Sport Medicine*, vol. 29, no. 3, pp. 232-237, 2019.

[9] M. Mónaco, J. A. G. Rincón, B. J. M. Ronsano, R. Whiteley, F. Sanz-Lopez, and G. Rodas, "Injury incidence and injury patterns by category, player position, and maturation in elite male handball elite players," *Biology of Sport*, vol. 36, no. 1, pp. 67-74, 2019.

[10] M. Arora, S. H. Shetty, and M. S. Dhillon, "The shoulder in cricket: What's causing all the painful shoulders?," *Journal of Arthroscopy and Joint Surgery*, vol. 2, no. 2, pp. 57-61, 2015.

[11] M. D. Kauther, C. Wedemeyer, A. Wegner, K. M. Kauther, and M. von Knoch, "Breakdance injuries and overuse syndromes in amateurs and professionals," *The American Journal of Sports Medicine*, vol. 37, no. 4, pp. 797-802, 2009.

[12] G. Jessiman-Perreault and J. Godley, "Playing through the pain: A university-based study of sports injury," *Advances in Physical Education*, vol. 6, no. 03, pp. 178-194, 2016.

[13] N. L. Malcom, "Shaking it off" and "toughing it out" socialization to pain and injury in girls' softball," *Journal of Contemporary Ethnography*, vol. 35, no. 5, pp. 495-525, 2006.

[14] L. J. Chirosa-Ríos, I. J. Chirosa-Ríos, I. Martínez-Marín, Y. Román-Montoya, and J. F. Vera-Vera, "The role of the specific strength test in handball performance: exploring differences across competitive levels and age groups," *Sensors*, vol. 23, no. 11, p. 5178.

[15] S. M. Fox and W. L. Haskell, "Physical activity and the prevention of coronary heart disease," *Bulletin of the New York Academy of Medicine*, vol. 44, no. 8, pp. 950–967, 1968.

[16] Y. Marutani *et al.*, "Gaussian mixture modeling of acceleration-derived signal for monitoring external physical load of tennis player," *Frontiers in Physiology*, vol. 14, p. 1161182, 2023.

[17] T. Bere *et al.*, "Injury and illness surveillance during the 24th men's handball world championship 2015 in Qatar," *British Journal of Sports Medicine*, vol. 49, no. 17, pp. 1151-1156, 2015.

[18] N. Popovic and R. Lemaire, "Hyperextension trauma to the elbow: Radiological and ultrasonographic evaluation in handball goalkeepers," *British Journal of Sports Medicine*, vol. 36, no. 6, pp. 452-456, 2002.

[19] S. Tyrdal and R. Bahr, "High prevalence of elbow problems among goalkeepers in European team handball-'handball goalie's elbow'," *Scandinavian Journal of Medicine & Science in Sports*, vol. 6, no. 5, pp. 297-302, 1996.

[20] U. Akgun, M. Karahan, C. Tiryaki, B. Erol, and L. Engebretsen, "Direction of the load on the elbow of the ball blocking handball goalie," *Knee Surgery, Sports Traumatology, Arthroscopy*, vol. 16, no. 5, pp. 522-530, 2008.

[21] B. Fritz *et al.*, "Sports imaging of team handball injuries," *Seminars in Musculoskeletal Radiology*, vol. 24, no. 03, pp. 227-245, 2020.

[22] T. Sekiguchi *et al.*, "Coexistence of trunk or lower extremity pain with elbow and/or shoulder pain among young overhead athletes: A cross-sectional study," *The Tohoku Journal of Experimental Medicine*, vol. 243, no. 3, pp. 173-178, 2017.

[23] G. Farì *et al.*, "Musculoskeletal pain in gymnasts: A retrospective analysis on a cohort of professional athletes," *International Journal of Environmental Research and Public Health*, vol. 18, no. 10, p. 5460.