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# Prevalence and Incidence Rate of Musculoskeletal Disorders in Elite Female Handball players: A Systematic Review

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## ABSTRACT

**Introduction:** Handball is perilous Olympic contact sports played on land. It is considered risky due to its multifactorial and tactile components along with negligence towards the use of protective gear. The game, despite having an offensive manoeuvre, has gained a great substantial popularity amidst the youth making it the second most popular team sport at the Olympics (2016). Musculoskeletal disorders are common to the sport. They are the leading contributor to disability worldwide and significantly limit mobility and dexterity, leading to early retirement from game.
**Purpose of Study:** The purpose of this study is to review a series of articles (n=19) to understand the prevalence and incidence rate of musculoskeletal disorders in elite female Handball players.
**Type of Study:** The following is a Systematic Literature Review.
**Result:** The research provides an establishment of the fact that the incidence and prevalence of musculoskeletal disorders are higher in female handball team players.

***Key Words:*** Handball; Prevalence; Incidence; Prevention; Rehabilitation; Female players Injuries.

## INTRODUCTION

Handball is considered a treacherous game due to its nimbleness and vehement playing tactics. Elite handball is a dynamic contact sport with one of the highest injury rates among all Olympic sports [1], and is considered to be in top 5, in games which are said to enthral injuries. Handball is indebted about its acquitted rules and regulations for play to, The European Federation, fédérationinternationale de Handball (1946), which is the world governing body for the sport.

Handball has been known since 1917 and was internationally played from 1925-30. The first international games for women were played in 1930. Handball was introduced in the Olympics in 1972 as sports whilst the women teams were introduced in 1976 in Montreal. [1]

In defiance of existing quality papers on various issues recognized in handball, there is insufficient and inconclusive data about prevalence and incidence rates of injuries and their maneuver. This eccentric course of data for the aforementioned topic propelled us to commence our investigation to determine the incidence and prevalence rate of injuries in elite female handball players.

Predominantly researches have been done in regions of Iran, European nations [2, 3, 4]: Norway [1, 5, 6, 7, 8, 9], Athens [10, 11] , Sweden [12, 13], to understand the pattern and mechanism behind the recorded high rates of injuries. However, little work has been done in direction of prevalence and incidence rate of the musculoskeletal diseases in female handball players. This is an integrative review based on studies done

from 1997 till 2020 that reported musculoskeletal injuries in female handball players. (Refer to Table 1,Figure 2)

Handball is considered as the mother of ball games because of its analogy with various other ball games such as basketball, netball and football [1, 2]. Injuries are prejudiced to different levels of play and the position of players [14].

We, in our efforts, have tried to envelope the prevalence and incidence rate of musculoskeletal diseases, which vary as they occur suddenly and are short-lived, like fractures, sprains and strains, to lifelong conditions, related to ongoing pain and disability reported in female elite handball teams, in our review. (Table 2 and 3) [2, 4, 11].

Prior work done in the field has provided great help with understanding the course and correlation of various injuries and their pattern in handball players. With limited data available for elite female handball players the effect of speed and explosive nature of game has been accounted for [11].

According to Myklebust et al (1997) ACL injuries are highly prevailing in the female team handball players along with higher rates up to 1.8 times more than male counterparts incidences due to high intensity and contact while defense in prospective study [9]. Another study conducted by Wedderkopp et al (1997) found that 196 (93%) were traumatic injuries and 16 (7%) were overuse injuries, 32% of injuries occurred in offence whilst 56% in offence. An overall injury incidence of 40.7/1000 hours of game, with the backs having the highest incidence (54.8/1000 hours) and the wings the lowest (23.6/1000 hours)aiding the positional injury rate due to contact while defence [4].

Dimitriz Hatzimanouil et al (2015) reported a contradicted thought with their observational study stating the similar aggregation of injuries in both genders. They also accredited a finding about male being more prone to ligament injuries whereby females reported higher numbers of muscular strains [11].

According to Kamran Shadanfar (2011), incidence of match and training injuries in women were 42.85 and 1.86 injuries per 1000 hour player. Women were found to have acute injuries 1.66 times more than men [13]. With its increased popularity among the young generation Rasuli et al (2012) have found handball as pathogenic leading to higher percentage of head and face bruises (60%) along with knee and ankle sprains as the most commonly observed [2]. They found that 44.46% injuries were to muscles and while bones suffered 7.9%, the injuries during the game outnumbered the ones during practice sessions. Fine structure and low physical power is stated as two main causative factors of high incidence rate in women players [4].

Another observational study done by Salman (2014) differentiated injuries in two types: acute and overuse injuries. He also concluded to find, no as such difference in incidence of injuries with respect to gender or age of the players [15].

Some of the research work done by Paula tunas, 2015 and Dimitris, 2015 report that handball players have often opted out of game due to injury, causing absenteeism from the practice sessions [2, 3]. Some of the researches have stated few ways to prevent the injury incidences with pre planned regimens to help improve the balance, neuromuscular control and proprioception [6]. Steffen K et al, 2017 with their prospective study explained use of wobble disc to prevent ACL injuries incidences among team handball players [16]. (Further Refer to Table 2 and 3).

Understanding the cause and mode of injury in team handball players will help us develop an evidence based plan to prevent a high rate of incidence in female elite players. The objective of this study was to perform an integrative review of the high prevalence and incidence of musculoskeletal injuries in female elite team handball players.

## METHODOLOGY

Data Sources and Strategy: This is an integrative review based on the following sources of information: PubMed /MEDLINE, Embase, SPORTDiscus and Scopus, for observational and experimental research available in conjunction to our inclusive criteria.

Eligibility Criteria: Refer to Figure 1.

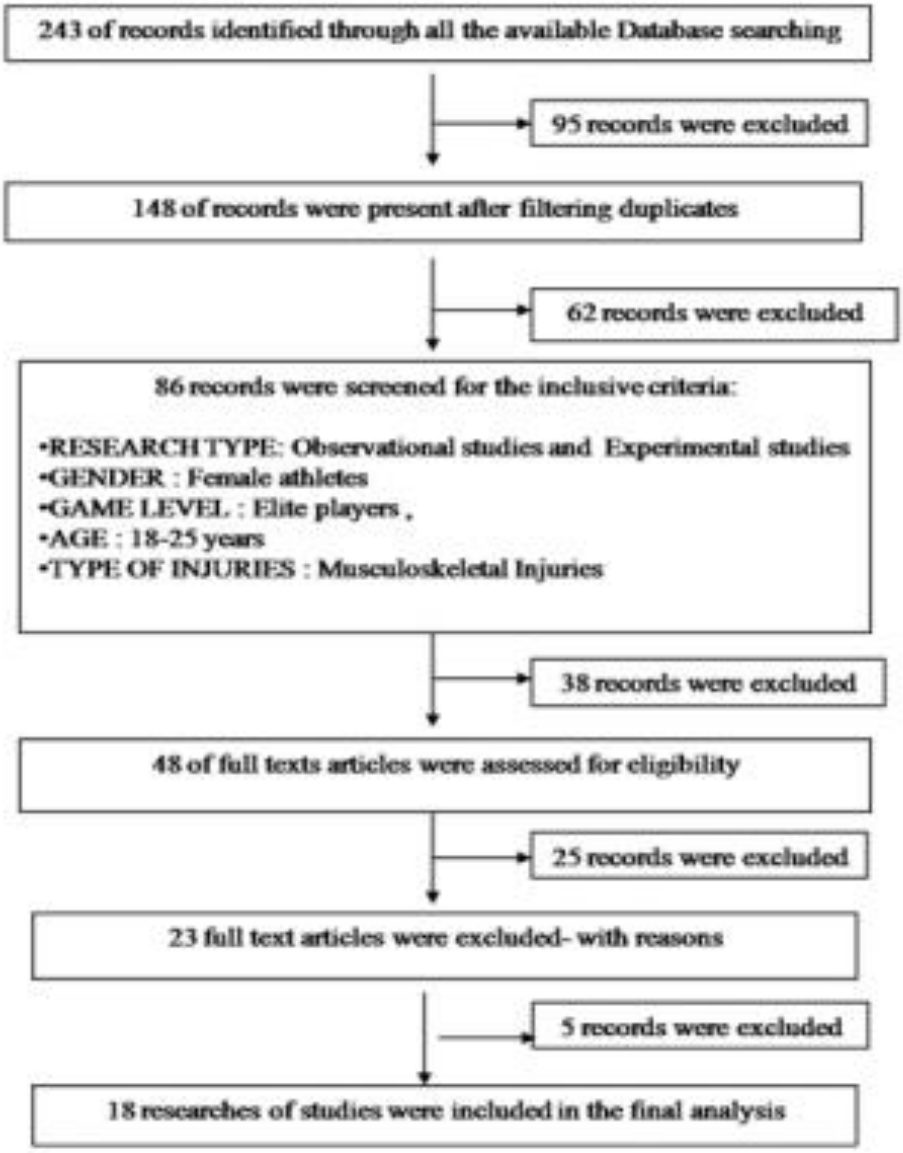


**Figure 1: Flow Chart of the Study.**

(Figure 2 shows the evolution of studies published on our topic for every 6-year period along the last 23 years while the diagrammatic flow chart represents our study retrieval process performed which is reported in Figure 1.)

**Study Selection:** Refer to Figure 2. (Date of Publication of selected studies.)

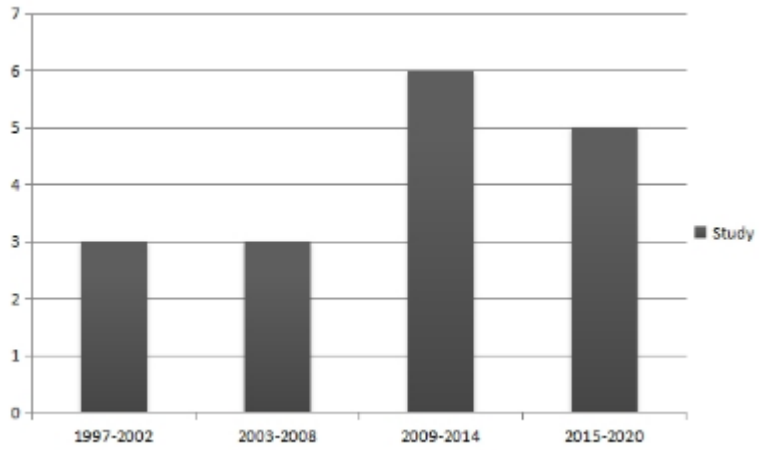


**Figure 2: Selected studies with period of publication.**

**Data Extraction:** Four independent investigators (AB, KG, PM and DK) extracted key data from the included articles in a standardized MS word database and a fourth independent investigator (MA) validated the data extraction.

**Study Quality Assessment:** The Downs and Black assessment tool [17] and JBI critical appraisal tool [18] was used to assess the methodological quality of the included studies. Once again, all disagreements were resolved via third party adjudication performed by a third author.

**Prevalence and incidence in male and female**

The overall gender-related risk for acute and overuse injuries in top-level handball athletes between the sexes vary drastically [4, 14, 15]. Women Iranian professional handball players are 2.03 times more prone to injuries than men [13]. Common injuries reported by female handball players are located at shoulder, back, pelvis, knee, lower leg, especially Achilles tendon and ankle (Refer Table 2-4). However, ACL injury is most common amongst females [11]. In handball players ACL injuries are reported 5-fold [6, 9, 13] and 30-fold higher in women as compared to men during competition than during training [9, 13]. Moreover, Iranian women professional handball players reported greater percentage of finger injuries when compared to men which were two-fold higher [13]

In contrast, other studies state that there are no significant differences in the prevalence and incidence of injuries between men and women [11, 15]. The gender-related risk for MSD injuries requires evidence-based injury prevention training programs for enhancing athlete performance, especially among females. However, we found some gender differences in the specific anatomical locations of injuries as well as in specific injuries in sports. (Refer Table 2 and 3)

**Etiopathogenesis**

Handball is a team contact game in which players dribble, pass, and throw the ball with their hands, trying to make it end up as many times as possible in the opponents' goal. It is played indoors or outdoors by both sexes and all ages: young children, juniors, and seniors. [13]

Handball is a high intensity sport with frequent and harsh physical contacts between the players.

It has been an Olympic sport since 1972. [15]

Handball is a ball game with passing being the primary way to move the ball. It is typically played in a 40m by 20m court with a 6m goal area (circle) on each side.

In Handball, each team has 6 court players (left, right, center backcourt; left, right wing; circle runner) and a goalkeeper.

Each game is played in 30 minute halves (60 minutes in total) with one 60 second time-out per half. The main aim is to throw the ball into the opponents' goal while defending one's own goal from attack.

One-point is awarded for a successful scoring event. [19]

High speed [2, 15, 20] combined with rapid direction changes, cutting movements, and frequent jumps result in high loads on the lower extremities. In addition, the large numbers of throws and passes, as well as hard body tackles, in many cases directly to the shoulder, make the shoulder region vulnerable for both acute and overuse injuries. [20]

One paper refers to the speed and nature of handball pathogenic. [2]

Players' typical movement patterns consist of rapid accelerations and decelerations, cutting movements, hopping, and 1-leg and 2-leg landings. [6]

The game has reported a high risk of injury for both genders. [11]

The concept of "Disabling the opponent at any cost" is the main factor [13] leading to collisions and thus injuries. [20]

**Throwing Mechanics**

While throwing, there is 'Whip-like' transfer of momentum from body to ball via the elbow, forearm and hand.

The back, trunk and hips are the centers of rotation and act as a transfer link.

Throwing occurs in 5 phases:

1. **Wind-up/Preparation Phase (500-1000ms)**
   In this phase the rhythm to throw is created. Hips are flexed to raise the COG. Major forces are created in the lower half of the body with shoulders relatively inactive. The phase ends with the hip and shoulder flexed to 90 degrees.
2. **Cocking phase (500-1000ms)**
   In this phase all body segments contribute to the throw. The shoulder is abducted with maximum external rotation. The anterior capsule and the internal rotators are fully stretched. The scapula is retracted maximally and the acromion elevates. The shoulder muscles are less active than the periscapular muscles. Tensile forces increase in abdomen, hip extensors and spine. The Cocking phase ends with planting of lead legs
3. **Acceleration phase (50ms)**
   This is the most explosive phase from amongst the four. High forces are generated at the glenohumeral articulation. The rotator cuff is active to keep the humeral head in the glenoid cavity. Large muscles outside RC cause acceleration of the arm. Enormous forces are generated on the elbow. This phase ends with ball release.
4. **Deceleration phase/follow-through (350ms)**
   Not all forces are used to throw the ball. Very high forces pull the glenohumeral joint forward after ball release. Large forces are seen in posterior shoulder structures and the intrinsic and extrinsic shoulder muscles. Eccentric contraction of RC external rotators decelerate rapid internal rotators. The torso decelerates to accelerate the arm. The elbow flexors are also highly stressed and limit elbow extension.

**Causes**

Various factors can be causative of injury in handball.

The major factors are:

- Contact with opponent players [2, 3, 10, 11, 13, 15]; more in men due to contact [13]
- Gender differences [9, 10]; more injuries in women [9]
- Previous injury. [13, 22]
- Playing position; backcourt players had a significantly higher prevalence [4, 8, 21]; attackers are more prone [4, 8]; goalkeepers present with least injury [9]
- Repetitive stress on biological tissues [11, 12, 20]
- High game velocity [2, 4, 20, 21]
- Less muscle strength [5, 8, 9, 13, 15, 21]
- Low H:Q ratio [15, 22]
- Menstrual changes [2, 9, 13]

- Lack of protective equipment [2, 3]
- Lack of sport specific training [2]
- Poor Postural control [6, 16]
- Poor proprioception [4, 8]
- Intensity of play [4, 15]
- Level of skill [8, 9]
- Improper shoes [4]
- Experience [8]
- Improper landing [8]

Other common factors are age [13], joint range of motion [13], cardio-respiratory capacity [13], quality of trainings by coaches [13], floor type [4, 8, 13], weather [13], level of competition [3, 13], and psychological factors [12, 13, 21]. Many causes have been noted for higher injuries in females. (Refer to Table 4)

Female players have demonstrated a higher relative workload compared with male players. [12, 21]

There have been seen:

1-Anatomical differences; Due to a wider pelvis, females have an increased angle between the long axis of the femur and the tibia (Q angle), and this increased angle may account for increased female injury rates. Also females have smaller femoral notches than males. A narrow femoral notch may predispose the female knee to ACL injury, perhaps because a narrower notch leads to a smaller, weaker ACL. [8, 9, 13]

2-Hormonal influences on ligamentous integrity and neural function; Decreased ligament strength or altered neuromuscular control mechanisms due to cyclic changes in female hormones may be possible contributors to the increased knee injury rates in female athletes.[13]

3-Neuromuscular imbalances; some athletes allow the knee ligaments, rather than the lower extremity musculature, to absorb a significant portion of the ground reaction force during sports maneuvers. This results in high valgus knee moments and high ground-reaction forces. Typically, during single leg landing, pivoting, or deceleration, as often occurs during knee ligament injury, the female athlete allows the ground-reaction force to control the direction of motion of the lower extremity joints, especially the knee joint. This lack of dynamic muscular control of the joint leads to high forces on the knee ligaments. On the other hand female athletes tend to activate their knee extensors preferentially over their knee flexors to control knee stability when performing high-torque force movements. This over-reliance on the quadriceps muscles leads to imbalances in strength and coordination between the quadriceps and the knee flexor musculature. Female athletes reacted to a forward translation of the tibia primarily with a muscular activation of the quadriceps muscles, whereas male athletes relied on their hamstring muscles to counteract the anterior tibial displacement. At last, female athletes have been reported to generate lower hamstrings torques on the non-dominant than in the dominant leg. Side-to-side imbalances in neuromuscular strength, flexibility, and coordination have been shown to be important predictors of increased injury risk. [13]

It has also been suggested that there may be sex differences in ligamentous laxity [8, 9], possibly related to cyclic hormonal effects, but there are no studies supporting this hypothesis. [9]

It is seen that in the case of ACL injuries, the presence of both estrogen and progesterone receptors in synoviocytes in the synovial lining and in fibroblasts in the stroma in human ACL specimens, suggesting that female sex hormones may have an effect on the structure and composition of the ligament. [9]

Fine structure and low physical power in women are the factors of more damages among them. It is believed that female players have fine structure and lack of muscle strength, less experience and skills than men who cannot control the ball correctly. [2]

More injuries prior to menstruation are thought to be caused due to premenstrual problems, such as irritability or swelling/discomfort of the breasts.

It has also been observed that women using oral contraceptives had a lower injury rate than those who did not. [2, 9]

Increased joint laxity has also been suggested as a possible factor for the increased injury incidence among women, but the effects of female sex hormones on the material properties of ligaments have not yet been examined. [9]

It is assumed that backs have less body contact than the other out- field players (wings and line players), but when they do have contact they make contact with a higher force that might result in a higher number of injuries, although this alone cannot explain the difference. It is probably one of many factors having an influence on the number of injuries. We also found that a significantly higher number of injuries occurred in the offence compared to the defence and the middle of the field. The higher speed and many cutting moves made during offensive play could explain this. An alternative explanation could be lack of proprioception and kinematic sense. [4]

Higher prevalence of non-contact injuries was also observed in some papers. [4, 8, 9]

Injuries were seen more during competition. [3, 4, 9]

Male players presented with more self-inflicted injuries. [10]

Fatigue was not seen as a major factor. [2, 8]

## MANAGEMENT

"Disabling the opponent at any cost" has led to numerous registrations of injuries [13]. Hence development of strong prevention strategies is a need of the day for handball athletes. Each sport has its own framework of injuries which can be more or less specially designed. The knowledge behind this framework is very important for designing preventive measures for handball athletes. On this view of preventive strategies Martin 2 enlighten us with developing the strategies before the age of 15. Their findings focus on implication of clinical monitoring routine sections and improving medical support for athletes. [14]

"A goal of the WHO is a substantial reduction of sports injuries, in extent as well as in severity, before the year 2000. Realization of this goal calls for a structured plan of preventive measures. This plan consists of four steps. The first step is to acquire data concerning the nature, extent and severity of sports injuries. The second step is to identify the etiological factors involved in sports injuries. The third step is to apply one or more preventive measures to prevent injuries or reduce their severity, based on the results of steps one and two. The fourth step is to evaluate the effectiveness of the applied preventive measures" [5]. Similar prevention strategies have been designed in a stepwise manner by Kamran Shadanfar, 2011.[13]

Handball players used both conservative and surgical approaches for preventing and treating the injuries, both during competition and training. 15.8% male players used more surgical approaches in comparison to 37.5% of female players, who used training programs with no modification [13]. 40% players needed medical assistance, 0.5% surgery and 18% of occupational change [4]. 70 % of shoulder Injuries reported in the study were treated non-operatively and 68.3% of handball players modified their training habits due to onset of pain [22]. However, 17 findings reported that not warming up before the game could have been the cause of many injuries. [3]

Various studies reported that prevention measures vary drastically in their focus and implementation. While some programs focused on neuromuscular and balance training, others used conservative methods or biomechanical advent support (for example, change in footwear). Thanos Badekas et al, 2009 mentioned the use of acute and ortho-mechanical approaches. [10]

To reduce the risk of shoulder injury and substantial shoulder injury, OSTRC (Oslo Sports Trauma Research Centre) proposed a shoulder injury prevention program which consisted of 5 exercises. This program was suggested as a part of the

10 minute warm up routine in the daily athletic schedule 3 times per week. Shoulder injury prevention programs help improves kinetic chain and thoracic mobility, the chain of exercises prescribed increase glenohumeral rotational strengths and scapular muscle strengths. Implication of same prevention programs resulted in a 69% decrease in substantial shoulder problems and 28% of shoulder problems with no compliance. However, introduction of strengthening and stabilizing exercises for rotator cuff and securing the scapular stability in the early age group might lower the load on shoulder and pain aspects [22].

Reduction in LBP can be achieved when physiological training concentrates on strength, coordination and condition. Increased training volume including preventive core exercises and measures might induce further lowering down of risk. [4]

**Table 1: Musculoskeletal Injuries**

| Musculoskeletal injuries / Location | No. Of injuries | Percentage Of Injuries | Reference | Level / comment |
|---|---|---|---|---|
| Head/Face | 2 | 3.3% | Shadanfar , 2011 | Female handball players |
| Head and neck<br>Face<br>Neck<br>Jaw<br>Skull<br>Ear<br>Nose<br>Eye<br>teeth | 23- average 0.25 injury per 1000 hours play<br>23-average 0.24 injury per 1000 hours play | 3.25%<br>4.62%<br>45%<br>2%<br>5%<br>5%<br>7%<br>14%<br>17% | Rasuli et al ,2012<br><br><br><br><br><br><br><br>Rasuli et al ,2012 | Injury during the event injury<br>Injury during the practice |
| Clavicle | 0.02 damages in 1000 hours play | 1.15% | Rasuli et al ,2012 | Female athlete |
| Shoulder / clavicle | 4 | 6.6% | Shadanfar , 2011 | Professional handball players |
| Upper limb injuries | 207 - average 2.13 injury per 1000 hours play<br>146-1.50 average injury for 1000 hours play | 42.52%<br><br>20.28% | Rasuli et al ,2012 | During practice injury occurred<br>During Event Injury Occurred |
| Arm | Mean 0.13 damage to 1000 h play<br>24 | 4.92%<br>11% | Rasuli et al ,2012<br>Salman , 2014 | |
| Upper arm | 1 | 1.6% | Shadanfar , 2011 | 16 professional handball players |
| Current Shoulder pain<br><br>4-6 weeks<br>5-26 weeks<br>27-52 weeks<br>>1 year | 34 players<br>10<br>11<br>6<br>7<br>12 | 52.3%<br>15.4%<br>30.1%<br>16.7%<br>19.4%<br>33.3% | Myklebust et al , 2011 | During playing<br>After handball exposure<br>Adolescent elite handball players<br>Norwegian elite female handball players |
| Intermittent shoulder pain | 16 players | 24.6% | Myklebust et al , 2011 | Regardless of exposure |
| Constant shoulder pain | 1 player | 1.5% | Myklebust et al , 2011 | Norwegian elite handball players |
| Onset of shoulder pain:<br>Sudden<br>Gradual | <br>15<br>45 | <br>25.0%<br>75.0% | Myklebust et al , 2011 | Currently having pain |
| Shoulder problems | 0.99 damage to 1000 hours play | 59.53% | Rasuli et al ,2012 | At some point during preceding season |
| Due to shoulder problems affected ADLS | 27 | 42.2% | Myklebust et al , 2011 | Currently having pain |
| Shoulder sprain | 2 | | Wedderkopp et al , 1997 | Goalkeepers |
| Elbow<br><br>Elbow sprain | 3<br><br>10 | 4.9% | Shadanfar , 2011<br><br>Wedderkopp et al , 1997 | 16 professional handball players<br>European team handball players |
| Forearm<br><br> | <br>1 | 5%<br>1.6% | Rasuli et al ,2012<br>Shadanfar , 2011 | <br>Professional handball players |
| Wrist | | 26% | Rasuli et al ,2012 | |
| Hand / finger / thumb/palm<br>Hand/Fingers/Thumb<br>Finger sprain<br>Hand sprain | 1.77 damage to 1000 hours play<br>6<br>28<br>2 | 64.43%<br>9.8% | Rasuli et al ,2012<br>Shadanfar , 2011<br>Wedderkopp et al , 1997 | 97 female athletes<br>Iranian professional<br>Mostly female european team handball players |

| ***Table 1 Continued…*** | | | | |
|---|---|---|---|---|
| Abdomen | 1 | 1.6% | Shadanfar , 2011 | Professional handball players |
| Trunk | 93-average 0.95 injury per 1000 hours play<br>118-average 1.22 injury per 1000 hours play | 13.01%<br>24.13% | Rasuli et al ,2012<br>Rasuli et al ,2012 | Injury during the event injury<br>Injury during the practice |
| Joint damage in the trunk | | 41.4% | Rasuli et al ,2012 | 97 female athlete were taken |
| Joint damage in trunk muscles | | 39.8% | Rasuli et al ,2012 | 97 female athlete were taken |
| Back / pelvic /ribs area | 9 | 14.8% | Shadanfar , 2011 | Professional handball players |
| Pelvic | | 1% | Rasuli et al ,2012 | Female athlete |
| Sacrum | | 2% | Rasuli et al ,2012 | |
| Vertebra back | | 7% | Rasuli et al ,2012 | Female athlete |
| Radiating LBP:<br>Gluteal region<br>Thigh<br>Knee<br>Lower leg / foot | | <br>18.2 %<br>8.6 %<br>1.1%<br>3.2% | Tunas et al,2004 | 277 Female handball players |
| Hip / thigh / groin | 5 | 8.2% | Shadanfar , 2011 | Professional handball players |
| Thigh | | 12% | Rasuli et al ,2012 | Six undergone surgery |
| Lower limb injuries | 457- average 4.71 injury per 1000 hours play<br>140-average 1.44 injury per1000 hours play | 63.44%<br>28.73% | Rasuli et al ,2012<br>Rasuli et al ,2012 | Injury during the event injury<br>Injury during the practice |
| Knee injury | 2.96 damage to 1000 h play)<br>0.93 knee injuries per 1000 player hours<br>12 | 40%<br>19.7% | Rasuli et al ,2012<br>Shadanfar, 2011<br>Shadanfar, 2011 | 97 female athletes taken for study<br>Professional handball players |
| Knee sprain | 31 | | Wedderkopp et al , 1997 | 4 ruptured the same knee and 8 suffered an B/L ACL injury |
| Cruciate ligament injuries | 59 | 63%<br>4.5%; 2.0%; 1.3% | Myklebust et al , 1997 | Division 1;2;3 players |
| ACL rupture<br>ACL injuries | 4<br>54<br>23 | | Wedderkopp et al , 1997<br>Myklebust et al , 1997<br>Myklebust et al,1998 | European team handball players<br>Norwegian top level handball<br>High level team handball players |
| PCL injuries | 5 | | Myklebust et al , 1997 | Norwegian top level team |
| Arthritis | Average 0.61 injury per 1000 hours play | 12.10%<br>31.8% | Rasuli et al ,2012 | 97 female athletes taken for the study |
| Knee and ankle sprain | 87;31(Knee); 56 (Ankle) | 67% | Wedderkopp et al , 1997 | European team handball players |
| Lower leg/ Achilles | 9 | 14.9% | Shadanfar , 2011 | Professional handball players |
| Peroneal tendinitis | 2 | | Badekas et al , 2009 | Athens 2004 Olympic games |
| Achilles tendon | 5 | | Badekas et al , 2009 | Athens Olympic games , 2004 |
| Ankle injury | 7 | 11.5% | Shadanfar , 2011 | Professional handball players |
| Ankle sprain | 7<br>56 | | Badekas et al , 2009<br>Wedderkopp et al , 1997 | Athens Olympic games<br>European team handball players |
| Toes | | 2% | Rasuli et al ,2012 | 97 female athletes |
| Lesser toes sprains | 3 | | Badekas et al , 2009 | Athens 2004 Olympic games |
| Hallux valgus | 5 | | Badekas et al , 2009 | Olympic games |
| Foot /toe | 3 | 1.6% | Shadanfar , 2011 | Professional handball players |

**Table 2: Types of Sports Injuries**

| Type of injuries | Prevalence and Incidence of injuries | References |
|---|---|---|
| Traumatic injuries | 196 (93%) | Wedderkopp et al , 1997 |
| Traumatic lower limb injuries<br>Without contact with an opponent | 124<br>63(51%) | Wedderkopp et al , 1997 |
| Non- contact injuries of lower extremities | (13)62% (goal keeper)<br>(13)48% (wings) | Wedderkopp et al , 1997 |
| Overuse injury | 16 (7%)<br>16 (1.07 injuries per 1000 player)<br>43.8%(Female); 42.9%(women); 44.4% (Senior girls) | Wedderkopp et al , 1997<br>Shadanfar , 2011 |
| Acute injuries | 1.81 injuries /1000 player hours | Shadanfar , 2011 |
| Soft tissue injuries (Ankle and Foot) | 19 | Badekas et al , 2009 |
| Bony Injuries (Ankle and Foot) | 11 | Badekas et al , 2009 |

| ***Table 2 Continued…*** | | |
|---|---|---|
| Fracture and other bone injuries | 3.06% (average 0.23 injury per 1000 hours play) | Rasuli etal ,2012(during competition) |
| Stress fracture | 7.99% (average 0.40 injury per 1000 hours play) | Rasuliet al ,2012 (during training) |
| fracture | 2(3.3%) | Shadanfar, 2011 |
| Finger fracture | 2 | Badekas et al , 2009 |
| Metacarpal fracture | 9 | Wedderkopp et al , 1997 |
| Lateral malleolus # | 6 | Wedderkopp et al , 1997 |
| $5^{th}$ metatarsal tubercle fractures | 1 | Wedderkopp et al , 1997 |
| Lateral malleolus fracture | 2 | Badekas et al , 2009 |
| Open fracture | 1 | Badekas et al , 2009 |
| Close fracture | 2 | Badekas et al , 2009 |
| | 4%(0.22 damage per 1000 hours play) | Rasuli et al ,2012 |
| | 25% | Rasuli et al ,2012 |
| Carpometacarpal Dislocation | 1 | Wedderkopp et al , 1997 |
| Concussion | 4 | Wedderkopp et al , 1997 |
| Contusion | 30 (49.2%) | Shadanfar , 2011 |
| | 18 | Wedderkopp et al , 1997 |
| Bone | 50 (23%) | Salman , 2014 |
| Bone injuries in form of spilt | 71% (0.44 damage per 1000 hours play) | Rasuli et al ,2012 |
| Accessory bone injuries | 1 | Badekas et al , 2009 |
| Axels | 27% | Rasuli et al ,2012 |
| Other injuries | 1(1.6%) | Shadanfar , 2011 |
| Body | 16 (7%) | Salman , 2014 |
| Joint and ligament injuries | 30(49.2) | Shadanfar , 2011 |
| Muscle and tendon injuries | 58% (average 4.29 injury per 1000 hours play) | Rasuli et al ,2012(during event) |
| | 4.464% (average 2.24 injury per 1000 hours play) | Rasuli et al ,2012 |
| | 20 (32.8%) | (during training) |
| | | Shadanfar , 2011 |
| Muscle soreness | 42% (2.83 injury per 1000 hours play) | Rasuli et al ,2012 |
| Muscle stretch | 33% (2.17 injury per 1000 hours play) | Rasuliet al ,2012 |
| Tendon rupture | 1% (0.11 injury per 1000 hours play) | Rasuliet al ,2012 |
| Joint sprain | 55% (1.67 injuries per 1000 hours play) | Rasuliet al ,2012 |
| Joint erosion | 2% (0.06 injury per 1000 hours play) | Rasuliet al ,2012 |
| shin | 24% | Rasuliet al ,2012 |
| Tearing of muscle | 10% | Rasuliet al ,2012 |
| Tendon stretch | 14% | Rasuliet al ,2012 |
| Menisci injuries | 3% | Rasuliet al ,2012 |
| Laceration | 20% | Rasuli et al ,2012 |
| Joint pain | 20% | Rasuliet al ,2012 |
| Morton neuroma | 1 | Badekas et al , 2009 |
| Disc herniation | 1 | Wedderkopp et al , 1997 |
| Dislocation | 1 | Wedderkopp et al , 1997 |
| Sprain | 129 | Wedderkopp et al , 1997 |
| | 53.3%;(Female) ;50% (women); 57.1%(Senior Girls) | Hatzimanouil et al , 2015 |
| Strain | 25 | Wedderkopp et al , 1997 |
| Tendinitis | 16 | Wedderkopp et al , 1997 |

**Table 3: Prevalence and Incidence of Injuries in Male and Female**

| Parameter | References | Factor | Male | Female |
|---|---|---|---|---|
| Prevalence and Incidence of injuries | Asker et al , 2018 And Females (n=256), Males (n=215) | Any shoulder problems, n(%) PR(95%CI) (preceding season) | 50(23) 1.0 | 83(32) 1.36(1.02-1.83) |
| | | Substantial shoulder problems, n(%) PR(95%CI) (preceding season) | 22(10) 1.0 | 38(15) 1.36(0.84-2.19) |
| | | Any shoulder problems, n(%) PR(95%CI) (follow -up season) | 83(39) 1.0 | 124(48) 1.25(1.02-1.54) |
| | | Substantial shoulder problems, n(%) PR(95%CI) (follow- up season) | 40(19) 1.0 | 70(27) 1.46(1.04-2.06) |
| | Hatzimanouil et al , 2015 And Women (n=15), Men (n=16) | During games- Incidence rate | 8.3/ (1000h) | 6.79/ (1000h) |
| | | During training- Incidence rates | 0.69/ (1000h) 69.6 (male) 58.3(men) 81.8 (juniors) | 0.47/ (1000h) 68.8 (female) 85.7 (women) 55.6 (senior girls) |
| | | Severity (Incidence rate) | Serious (40.9%), moderate (36.4%), very serious (13.6%) and small (9.1%) | Serious (40%), very serious (33.3%), moderate (13.3%) and small (13.3%) |
| | | Upper Extremities injuries | 8.7% | 29.4% |

| | | | | |
|---|---|---|---|---|
| | | Incidence of injuries | 40.6 %(male)<br>37.5(men)<br>43.8(juniors) | 37.9 %(female)<br>50(women)<br>26.7(senior girls) |
| | | Incidence of one injury | 73.3(male)<br>75(men)<br>71.4(juniors) | 54.5(female)<br>42.9(women)<br>75(senior girls) |
| | | Players with past injuries | 20(male)<br>20(men)<br>20(juniors) | 15(female)<br>12.5(women)<br>16.7(senior girls) |
| | | Ligament injuries(male)<br>Sprains (female) | 31.8(male)<br>33.3(men)<br>30(juniors) | 53.3(female)<br>50(women)<br>57.1(senior girls) |
| | | Overuse injuries (player's opinion) | 69.6(male)<br>66.7(men)<br>72.7(juniors) | 43.8(female)<br>42.9(women)<br>44.4(senior girls) |
| | Myklebust et al , 1997<br>and men & women (212 teams, 16 players each squad consists ) | During matches-Cruciate Ligament injury | 0.31% | 0.77% |
| | | Division 1 - Injury risk in matches<br>Cruciate Ligament injury | 0.54<br>2.2% | 1.62<br>4.5% |
| | | Division 2 - Injury risk in matches<br>Cruciate Ligament injury | 0.84<br>2.0% | 1.82<br>2.0% |
| | | Division 3 - Injury risk in matches<br>Cruciate Ligament injury | 0.27<br>0.6% | 0.72<br>1.3% |
| | Shadanfar ,2011<br>And Women (n=125), Men (n=154) | 43712 hours training exposure risk (men)<br>14492 hours training exposure risk (women) | 1.18 injuries per 1000 hours – (43712 hours training exposure to risk 52 injuries were Recorded) | 1.86 injuries per 1000 hours – (14492 hours training exposure to risk, 27 injuries were recorded) |
| | | During 88 matches (men)<br>During 30 matches (women) | 29 injuries recorded (1008 player hours during matches)- 28.76 injuries per 1000 match hours player match exposure to risk | 18 injuries recorded (420 player match hours) - 0.6 injuries per match or 42.85 injuries per 1000 hour player match exposure to risk |
| | Salman , 2014<br>And Females (n=5318), Men (n=6231) | Injured players | 36%(82) | 28%(63) |
| | | Total injuries | 59%(130) | 41%(90) |
| | | Non – injured | 19%(44) | 16%(37) |
| | Shadanfar ,2011<br>And Women (n=125), Men (n=154) | Time loss injuries.<br>(In women 1.66 times higher) | 47 injuries (56.5%)<br>(1.05 time-loss injuries per 1000 player hour) | 27 injuries (55.7%) (3.02 time-loss injuries per 1000 player hours). |
| | | Non- time loss injuries | 61(56.5%) | 34(55.7%) |
| | | Time loss injuries | 47(43.5%) | 27(44.3%) |
| | | Acute injuries<br>(1.66 acute injuries in Female were more than men) | 3.01 injuries /1000 player hours | 1.81 injuries /1000 player hours |
| Types of injuries (presented more injuries in particular gender are bademention ed) | Shadanfar ,2011<br>And Women (n=125), Men (n=154) | Concussion | 3(2.8%) | 0% |
| | | Fracture and other bone injuries | 4(3.7%) | 2(3.3%) |
| | | Skin damage | 5(4.6%) | 3(4.9%) |
| | | Joint and ligament injuries | 45(41.7%) | 30(49.2%) |
| | | Contusion | 15(13.9%) | 30(49.2%) |
| | | Other injuries | 6(5.6%) | 1(1.6%) |
| | | Muscle and tendon injuries | 30(27.8%) | 20(32.8%) |
| | | Overuse injuries<br>Ratio was 1.77 between two | 0.60 injuries per 1000 player hours (27 injuries) | 1.07injuries per 1000 player hours (16 injuries) |
| | Badekas et al | Tibialis anterior tendinitis | 3 | 0 |
| | | Shin splints | 1 | 0 |
| | | Skin infection | 2 | 0 |
| | | Hallux rigidus | 2 | 0 |
| | Salman , 2014<br>And Females (n=5318), Men (n=6231) | Acute injury<br>Overload injury | 36% (79)<br>23%(51) | 24% (53)<br>17%(37) |
| Localization of injuries | Hatzimanouil et al , 2015<br>And Women (n=15), Men (n=16) | Lower limbs | 78.3(male)<br>83.3(men)<br>72.7(juniors) | 58.8(female)<br>42.9(women)<br>70(senior girls) |

| | | | | |
|---|---|---|---|---|
| | Myklebust et al , 1997 and men & women (212 teams, 16 players each squad consists ) | ACL injuries | 33 | 54 |
| | | PCL injuries | 1 | 5 |
| | Myklebust et al , 1998 And Women teams (n=12), Men teams (n=12) | ACL injuries | 5 injuries 0.06+/-0.03 injuries/1000 players hours | 23 injuries - 0.31 +/-0.06 injuries /1000 player hours |
| | Salman , 2014 And Females (n=5318), Men (n=6231) | Arm | 23%(50) | 11%(24) |
| | | Bone | 29%(64) | 23%(50) |
| | | Body | 7%(16) | 7%(16) |
| | | Null | 54%(44) | 46%(37) |
| | Shadanfar,2011 And Women (n=125), Men (n=154) | Knee injuries | 0.38 knee injuries per 1000 player hours | 0.93 knee injuries per 1000 player hours |
| | | Head/face | 7(6.5%) | 2(3.3%) |
| | | Abdomen | 6(5.6%) | 1(1.6%) |
| | | Back/pelvic/ribs area | 16(14.8%) | 9(14.8%) |
| | | Shoulder/clavicle | 6(5.6%) | 4(6.6%) |
| | | Upper arm | 4(3.7%) | 1(1.6%) |
| | | Elbow | 4(3.7%) | 3(4.9%) |
| | | Forearm | 2(1.9%) | 1(1.6%) |
| | | Hand/finger/thumb | 11(10.2%) | 6(9.8%) |
| | | Thigh/hip/groin | 12(11.1%) | 5(8.2%) |
| | | Concussion | 3 (2.8%) | 0(0.0%) |
| | | Neck/cervical spine | 2(1.9%) | 0(0.0%) |
| | | Wrist | 1(0,9%) | 0(0.0%) |
| | | Knee | 10(9.3%) | 12(19.7%) |
| | | Lower leg/ Achilles tendon | 8(7.4%) | 9(14.9%) |
| | | Ankle | 10(9.3%) | 7(11.5%) |
| | | Foot/Toe | 2(1.9%) | 1(1.6%) |
| | | Foul of opponent | 14 injuries (48.2%) | 11 injuries (61%) |
| Cause of injuries | Shadanfar,2011 And Women (n=125), Men (n=154) | Foul actions lead to injury Sanctions by reference | 57.1% (14 Foul actions lead to injury, 8 cases sanctioned by referee) | 54.5% (11 Foul actions lead to injury, 6 cases sanctioned by referee) |
| | | Action leading to injury was not a violation of handball laws | 2 (12.5%) | 1(8.3%) |
| | | Action leading to injury was a violation of laws, without sanction | 5(31.3%) | 5(41.7%) |
| | | Action leading to injury was a violation of laws, with yellow cart to opponent | 8(50%) | 4(33.3%) |
| | | Action leading to injury was a violation of laws ,with red card to opponent | 0(0) | 1(8.3%) |
| | | Action leading to injury was a | 0% | 1(8.3%) |

**Table 4 : Miscellaneous Facts and Other Injuries Reported**

| References | Reported Facts Considered | Prevalence and Incidence |
|---|---|---|
| Dimitris hatzimanouil et al (2015) | Use of Prophylactic Equiment | 66.7% (Female)<br>60% (Women)<br>73.3% (Senior Girls) |
| | Contact with opponent player | 35.7% (Female)<br>42.9%(Women)<br>28.6%(Senior girls) |
| Myklebust G.,et al(1998) | ACL injuries Without contact of players | 89% |
| | ACL injuries occurred During plant-and-cut manoeuvres | 19 |
| | Non-contact attack injuries ( ACL) | 23 |
| Rasuli S.,et al S. (2012), | During practice session | 7.41 injury per 1000 play |
| | During competition | 5.03 injury per 1000 play |
| | Non sports specific fitness | 11.68% |
| | Lack of protective equipment | 13.08% |
| | Poor healing(Incident of injuries in head and neck) | 18% |
| | Opponent kicks and hitting to equipment and Falling on ground | 21.2% |
| | Non-compliance with safety issues | 12% |
| | Lack of fitness (Incident of injuries in head and neck) | 11% |
| | At rest (Incident of injuries in head and neck) | 2% |
| | Lack of skills (Incident of injuries in head and neck) | 4% |
| | ***Table 4 Continued…*** | |

| | | |
|---|---|---|
| | Lack of knowledge of performance (Incident of injuries in head and neck) | 3% |
| | Illness (Incident of injuries in head and neck) | 4% |
| Wedderkopp N.,et al. (1997) | During games (104 players) | 40.7 injuries/ 1000 hours of game<br>115 injuries occurred |
| | During practice (104 players) | 3.4/1000 hours of practice<br>96 injuries occurred |
| | Back players | 54.8/1000 hours of game |
| | Goal keeper | 30.6/1000 hours of game |
| | Wings | 23.6/1000 hours of game |
| | Line | 54.3/1000 hours of game |
| | Playing in the defence | 32% |
| | In middle of the field | 12% |
| | In offence | 56% |
| | Major injuries | 26(12.3%) |
| | Moderate injuries | 64(30.3%) |
| | Minor injuries | 121(57.4%) |

In 1998, a neuromuscular prevention training program was introduced in team handball due to a remarkable increase of sport injuries both on and off field [7]. A sagacious progression in proprioception training following a neuromuscular training program hypothesized that increased proprioceptive training cues by the brain, first at the conscious level early in training, then later at the autonomous level in the brain.

Neuromuscular Training programs aim to elevate neuromuscular stabilizing forces required to be generated to resist the destabilizing load applied prior to any ligament damage in the knee. Strength and technique parameters are used in designed programs to decrease the landing forces and abducting movements in the knee. Further, introducing jump training in the program lowers the risk of knee injuries in females. Prevention programs included mainly three types of exercises: floor exercises, wobble board exercises, and balance mat exercises. Exercises are planned in such a manner where players get promoted from easy to more advance. The programs come with the disadvantages of no noticeable balance index changes in handball players especially in non- dominant regions [7]

The aim of balance exercises contributes to limit mediolateral knee displacement and limit loading during dynamic activities [17]. These exercises seem to be more efficient when done using wobble boards to enhance static and dynamic balance. He proposed Multicomponent exercises programs for ACL rehabilitation which consists of various neuromuscular and balance exercises. This type of exercise protocol when applied among handball players resulted in increased muscular activation especially in medial hamstring muscles prior to landing and collectively helped in postural control. Introducing balance board training with warm- up significantly lowered the risk of both traumatic and overuse injuries [7]. Implementation of strengthening exercises in training programs can lower risk of injuries [3]. Specific training in proprioception, motor control and kinetic sense might minimize the body contact injuries [5]. Limited article studies support proprioceptive training helps in preventing ankle discs and postural sways.

Evidence based practices also concluded that Knowledge regarding handball injury characteristics has been improving; however, there is still a long way to go to improve athletic healthcare in handball team sports in terms of rehabilitation and preventive strategies.

Prophylactic equipment

Prophylactic equipment is a medication used in preventive strategies to avoid prevalence and incidence of both traumatic and overuse injuries in handball. Variety of equipment such as knee pads, elbow pads, secure spectacles and ankle supports are used in such indoor and outdoor sports. Lack of usage of equipment might cause 13.08% of injuries [3] (Table 5). Use of prophylactic equipment provides

external joint support, majorly preferred by 68.2%, 63.6% and 72.7% of females, women and senior girls respectively in comparison to 43.8%, 56.3% and 31.3% of male, men and juniors respectively. Hence mostly females use prophylactic support than male players [13]. In handball players had to attack with greater speed and intensity in the aim for goal which led to high friction development between floor and shoes [5, 10]. Thus, choosing lightweight, breathable shoes which provide better grip for playing handball [5] Moreover, choosing Parquet and Plastic floor materials are more preferred for prevention [10].

## CONCLUSION

This systematic review scrutinized that female handball athletes are more vulnerable to injuries over their male counterparts due to various anatomical and athletic elicitations in practice sessions as well as during competition. The prevalence and incidence of MSD injuries is extremely high due to frequent and tactical movements of the sport. Our review indicated that athletes who use prophylactic equipment are far less prone to musculoskeletal injuries. Further, Evidence supporting sport injury rehabilitation programmes along with use of prophylactic equipment during match with their optimal dose are the key areas from future research.

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