

# Shoulder Sprain/Strain Cliff

## Branch Baseline

An shoulder sprain is an injury to the ligaments around that joint. While an shoulder strain is an injury to the muscles around that joint. Sprains and strains involve the stretching or tearing of tissue of the ligaments or the muscle-tendon unit, respectively.

Both sprains strains are classified according to three degrees of injury. Sprains break down as follows: first-degree sprain is one in which the ligament fibers are over-stretched but intact, second-degree sprain is one in which some fibers are actually torn and third degree sprain is one in which the ligament is completely torn and nonfunctioning. Strains with first-degree indicate over-stretching, second-degree indicating partial tear, and third-degree indicating complete tear (rupture) (Reed, 1994).

### Incidence Data Included in the Model

The model imports the following incidence information from the IMM database: incidence data category, space adaption status, incidence data, incidence and occurrence distribution data and incidence data characteristics. Data category defines the type of data available for incidence calculations (i.e. raw data vs. fixed data). Space adaptation identifies medical events that onset occurs in the first 5 days of flight and does not reoccur. Incidence values vary by data category and define the number of medical events per person-year or medical events per person-at-risk for each medical condition. Incidence values can be modified by crew characteristics such as gender. Modifying characteristics are noted below and incidence values are listed individually for each characteristic. Distributions are assigned to medical events incidence values and occurrences in the model. For each crew member in a given trial, the incidence and number of occurrences of each medical condition are randomly selected from these probability distributions. Detailed descriptions of the distributions are included in the IMM Technical Description Document.

#### Incidence

|                   |          |
|-------------------|----------|
| Data Category:    | Raw Data |
| Space Adaptation: | No       |
| Incidence Type:   | Rate     |

#### Distribution Data

|             |         |
|-------------|---------|
| Incidence:  | Gamma   |
| Occurrence: | Poisson |

#### Data Characteristics

|                                                      |                                  |
|------------------------------------------------------|----------------------------------|
| Events:                                              | 35                               |
| Person Years:                                        | 44.58                            |
| Space Flight Incidence Rate (Events / Person Years): | $35 / 44.58 = 0.785105428443248$ |

### Incidence Comments

Injuries to the astronauts can be caused by impacting structures or objects inside the space craft cabin, injuring them. Upper extremity injuries may occur more frequently as the crew does use the arms to transverse throughout the cabin. We know these and other soft tissue injuries occur. Scheuring study's objective was to construct a database of in-flight musculoskeletal injuries including incidence, types, mechanism of injury and relevance to post-flight health outcomes (Scheuring, 2009).

Added 13 new events and 18.17 person years based on the real world system's incidence information (Saile, 2017).

Updated the Person-Years based on the revised real world system integrated incidence data. The integrated person years changed from 18.17 to 18.13 so the conditions person years changed from 44.62 to 44.58 (Saile L., 2017)

### Information Regarding Prevention

The Astronaut Strength, Conditioning and Rehabilitation (ASCR) program and Astronaut gym at Johnson Space Center are strategic to providing not post flight rehabilitation as well as strengthening preflight in attempts to prevent or mitigate injuries. The Strength Coach's primary role is to provide an exercise plan designed to achieve flight physical readiness and prevent musculoskeletal injuries during spaceflight training.

### Incidence Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

| Citation        | LOE Value | LOE Category |
|-----------------|-----------|--------------|
| Scheuring, 2009 | 1         | Incidence    |
| Saile L., 2017  | 1         | Incidence    |

### Alternative Incidence Data

Descatha's studied the outcomes of workers with upper extremity musculoskeletal symptoms or disorders over a three year period in a population exposed to repetitive work. The 3 year recovery rate differed based on the location of the injury in the upper extremity. The shoulder injuries showed a moderate for neck or shoulder disorders (17 of 74) (Descatha, 2009).

## Treatment and Outcomes

Based on the best evidence available best and worst case percentage ranges are assigned. The medical condition is divided into three clinical phases in all three clinical phases a functional impairment is assigned. The clinical phase I and II's functional impairments remain for the duration for that respective clinical phase. The function impairment in clinical phase III represents final impairment for this medical condition and remains for the rest of the mission. Other mission end states include evacuation and loss of crew life.

The IMM checks medical resource availability once the number of medical events and scenarios has been established. If there is not sufficient essential resources called out in the ClIFF, then the medical condition will go down an untreated best or worst case scenario pathway.

The table below summarizes the treated and untreated best and worst case scenarios.

|                                                            | Clinical Phase I<br>Diagnosis & Initial<br>Treatment <sup>1</sup> |                   | Clinical Phase II<br>On-going Treatment /<br>Convalescence <sup>2</sup> |                                    | Clinical Phase III<br>Recovered / Mission End<br>State <sup>3</sup> |               |               |
|------------------------------------------------------------|-------------------------------------------------------------------|-------------------|-------------------------------------------------------------------------|------------------------------------|---------------------------------------------------------------------|---------------|---------------|
|                                                            | FI*<br>(%)                                                        | Duration<br>(hrs) | FI*<br>(%)                                                              | Duration (hrs)<br>(Min - ML - Max) | FI*<br>(%)                                                          | EVAC**<br>(%) | LOCL**<br>(%) |
| ISS-based Treatment<br>(best case scenario %: 97.22 - 100) | 100                                                               | 0.25              | 0 - 8                                                                   | 24 - 48 - 72                       | 0                                                                   | 0             | 0             |
| ISS-based Treatment<br>(worst case scenario %: 0 - 2.78)   | 100                                                               | 0.75 - 1          | 1 - 15                                                                  | 72 - 216 - 360                     | 0 - 8                                                               | 0             | 0             |
| Untreated Best Case                                        | 0                                                                 | 0                 | 1 - 15                                                                  | 24 - 48 - 72                       | 0 - 8                                                               | 0             | 0             |
| Untreated Worst Case                                       | 0                                                                 | 0                 | 8 - 29                                                                  | 72 - 216 - 360                     | 1 - 29                                                              | 0 - 1         | 0             |

<sup>1</sup>Clinical Phase I: Clinical phase I covers only the initial assessment of the affected crew member to define his or her medical condition, and completion of appropriate initial treatment to stabilize the crew member. While the affected crew member is being assessed, he or she is not able to perform any assigned tasks, thus Functional Impairment during this phase is considered 100%. In the untreated case, there is no diagnosis performed or treatment given, therefore Functional Impairment and Duration will always be "not applicable".

<sup>2</sup>Clinical Phase II: On-going Treatment and Convalescence- During clinical phase II, the affected crew member is receiving any appropriate follow-on treatment for his or her medical condition to allow the crew member to recover as much as he or she is able to recover in the ISS environment. Clinical phase II also encompasses relapses or reoccurrences of the same original medical condition in clinical phase I necessitating additional treatment or recovery time due to unsuccessful primary treatment response. The duration in Clinical Phase II is expressed in minimum, most likely (ML) and maximum hours. This was updated for future capabilities in IMM but is currently not being used by the model.

<sup>3</sup>Clinical Phase III: Recovered/Mission End State- Clinical phase III is reached once the affected crew member has recovered from the medical condition as much as he or she is able to recover in the ISS environment. This may or may not be recovery from the given medical condition to the full extent possible. If this "recovered" state results in an evacuation or loss of the crew member, this will be noted in the mission end state results.

\*Functional Impairment (FI) is a measure of the affected crew member's health and performance ability.

\*\*Two mission end state results are addressed in the ClIFF: 1) Evacuation (EVAC) - crew and patient are evacuated from the spacecraft due to the medical condition, and 2) Loss of crew (LOCL) - death of affected crew member due to medical condition. EVAC is considered as an end state result if any of the following criteria are met: 1) potential LOCL, 2) potential significant permanent impairment, or 3) potential intractable pain. Probability distributions are assigned for each range of values within the Table of Treatments and Outcomes.

Refer to the Integrated Medical Model Technical Document for more information on how risk is reported by the IMM, Crew Health Index (CHI) and Quality Adjusted Mission Time calculations.

Definition and Probability of Best and Worst Case Scenario: (includes definitions of best and worst case scenarios and identifies the probability of those scenarios.)

### Scenario Comments

#### Best and Worst Case Scenario Percentages:

Based on the Real World Systems data there were no worst cases so to integrate this data into the BC/WC percentage the algorithm developed with the original data set was used for all the medical events in both data sets. Therefore, if the next case is a worst case we would 1/35 or 3% of cases as worst cases. If the next case is best case, we would have 35/35 or 100%. Thus the percentage for worst case is 0-3% (Saille L., 2017).

**Best case scenario** is defined as a mild sprain/strain that will resolve with minimal or no treatment.

**Worst case scenario** involves a moderate or severe sprain/strain that could result in a ligament, tendon or muscle tear.

### Best Case Comments

The functional impairments (FI) calculation for this condition follows the IMM Mild Non-Space Adaptation Medical Conditions template (Kerstman, 2010). According to the template in Clinical Phase II the FI follows Class 0-1 in the Guide to the Evaluation of Permanent Impairment, which translates to a 0-8% Whole Person (WP) impairment for duration of 24-72 hours. While in Clinical Phase III the FI follows Class 0 for 0% WP impairment (American Medical Association, 2008). Consequently, the outcomes in Clinical Phase III are 0% chance of EVAC or LOCL, which is supported by the actual flight experience of no evacuations to date in the U.S. Space Program

### Worst Case Comments

In the worst case scenario, the initial duration in Clinical Phase I is estimated to be 45 minutes because the care giver will need to complete additional diagnostic tasks and equipment set up. In Clinical Phase II the FI follows Classes 1-2 (Kerstman, 2010), which derives 1-15% WP impairment. The duration based on terrestrial guidelines needed to be modified because in microgravity the crew translates in the vehicle primarily using their upper extremities. While in Clinical Phase III the FI assigned to Class 0-1, which translates to 0-8% WP impairment (American Medical Association, 2008).

There has been no EVAC of any musculoskeletal injuries in US spaceflight to date so the percentage of EVAC is 0% (Saile L., 2017). There is no probability of LOCL (Kerstman, 2011).

### Untreated Best Case Comments

In the best case when it goes untreated the FI is derived by Classes 1-2 in Clinical Phase II and Classes 0-1 in Clinical Phase III (Kerstman, 2010). The respective FI are 1-15% WP impairment, and 0-8% WP impairment (American Medical Association, 2008). The duration continues to be 24-72 hours for the best case in Clinical Phase II. As in a best case, whether treated or untreated, there is no chance of EVAC or LOCL resulting as seen by the US space program (In-flight Compilation Lockdown revised, 2010).

### Untreated Worst Case Comments

In this scenario the crew member has suffered at least a grade II sprain or strain. As a result, the acuity in Clinical Phase II the FI is assigned to Classes 2-3, which derives a 8-29% WP impairment lasting 72-360 hours (3-15 days). While in Clinical Phase III, the assigned FI classes are 1-3 [ Kerstman, 2010 ]. These classes could translate that the crew could be 1-29% WP impaired (American Medical Association, 2008).

The likelihood of an EVAC was derived from a study of ankle injuries by Mawanga, which out of 175 non-fractures injuries only 1 required surgery. Should that happen during a mission, evacuation would be required. So that translates to 0-1% (1/175 or 0.57%) requiring evacuation (Mawanga, 1986).

There would be no chance of LOCL (Kerstman, 2011). An EVAC probability results from the possible inability to treat on orbit and severity of condition. To date, there has not been any report of crew members suffering from an ankle sprain in flight (Scheuring, 2009).

### Treatment and Options Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

| Citation                           | LOE Value | LOE Category |
|------------------------------------|-----------|--------------|
| American Medical Association, 2008 | 3         | FI           |
| Muwanga, 1986                      | 4         | EVAC         |
| Saile L., 2017                     | 1         | BCWC         |
|                                    | 1         | EVAC         |

**Additional Comments**

Pubmed search keywords included shoulder injury, soft tissue injury, musculoskeletal injury, sprain and strain, and orthopedic.

## The Resource Table (RT)

| Resource                                                      | Units<br>Required<br>Best<br>Case | Units<br>Required<br>Worst<br>Case | Units<br>Available<br>At Start<br>Of<br>Mission | Consumable | Essential | Rationale                                                                                                                                       |
|---------------------------------------------------------------|-----------------------------------|------------------------------------|-------------------------------------------------|------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Ace bandage 2 inches                                          | 0                                 | 1                                  | 1                                               | No         | Yes       | For immobilization                                                                                                                              |
| Ace bandage 3 inches                                          | 0                                 | 1                                  | 1                                               | No         | Yes       | elastic bandage (also known as an ACE bandage, elastic wrap or compression bandage) is a "stretchable bandage used to create localized pressure |
| Ace bandage 4 inches                                          | 0                                 | 1                                  | 1                                               | No         | Yes       | For immobilization                                                                                                                              |
| Hot and Cold Pad                                              | 1                                 | 1                                  | 1                                               | No         | No        | For pain & swelling                                                                                                                             |
| Motrin (Ibuprofen) 400mg                                      | 6                                 | 14                                 | 500                                             | Yes        | Yes       | Pain relief                                                                                                                                     |
| SAM splint - Leg/Arm Splint                                   | 0                                 | 1                                  | 1                                               | No         | Yes       | Immobilization                                                                                                                                  |
| Vicodin HP (Hydrocodone/<br>Acetaminophen HP) 10 mg/660<br>mg | 0                                 | 3                                  | 30                                              | Yes        | Yes       | Pain relief                                                                                                                                     |

### Resource Comments

According to most commercial guidelines basic recover includes P.R.I.C.E. (Protect, Rest, Ice, Compression, and Elevation) and simple analgesics (acetaminophen) or analgesic doses of nonsteroidal anti-inflammatory drugs (NSAIDs) (Agency for Healthcare Research and Quality, 2011). All can be accomplished with the exception of elevation. The source of the resource table data was derived from the ISS Medical Check List (MOD, 2011).

### Required Resources Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

| Citation                                        | LOE Value | LOE Category |
|-------------------------------------------------|-----------|--------------|
| NASA Mission Operations Directorate (MOD), 2011 | 2         | Resources    |

### Level Of Evidence

| Input Data                 | LOE Average | Description | Range |
|----------------------------|-------------|-------------|-------|
| Incidence                  | 1           | Excellent   | 1-2   |
| Functional Impairment      | 3           | Good        | 2.1-3 |
| Best Case / Worst Case     | 1           | Fair        | 3.1-4 |
| EVAC / LOCL                | 2.5         | Poor        | 4.1-5 |
| Resources                  | 2           |             |       |
| <b>QUALITY OF EVIDENCE</b> | <b>1.9</b>  |             |       |

## Reference List

### Reference

---

Agency for Healthcare Research and Quality. National Guideline Clearinghouse. U.S.Department of Health & Human Services, editor. 2011. USA gov: The U.S. Governments Official Web Portal.

---

American Medical Association. Upper Extremities. In: Rondinelli R, editor. Guides to the Evaluation of Permanent Impairment. 6th ed. Chicago: American Medical Association Press; 2008. p. 383-492.

---

Descatha A, Roquelaure Y, Chastang JF, Evanoff B, Cyr D, Leclerc A. Description of outcomes of upper-extremity musculoskeletal disorders in workers highly exposed to repetitive work. J Hand Surg Am 2009 May;34(5):890-5.

---

IMM FI Guidelines. IMM Functional Impairment Guidelines for the Clinical Findings Form (ClIFFs). 12-31-2010.

---

Kerstman EL. Conversation with Dr. Kerstman. Saile L, editor. 2011.

---

Lopez V. In-flight medical events revised\_Functional Impairment. 2010. Houston, Texas, NASA, Johnson Space Center.

---

Muwanga CL, Hellier M, Quinton DN, Sloan JP, Dove AF. Grade III injuries of the lateral ligaments of the ankle: the incidence and a simple stress test. Arch Emerg Med 1986 Dec;3(4):247-51.

---

NASA Mission Operations Directorate (MOD). International Space Station Integrated Medical Group Medical Checklist. Mission Operations Directorate (MOD), Systems Operations Data File (SODF) . 6-24-2011. Houston, TX, National Aeronautics and Space Administration (NASA).

---

Reed P. The Medical Disability Advisor. 2nd ed. Horsham, PA: 1994.

---

Saile L., Boley L, Kerstman E. Integration RWS ISS STS Observed Incidence V2. 2017.

---

Saile L., Boley L, Arellano J, Kerstman E. iMED Best and Worst Case Percentage Update. 2017.

---

Saile L, Boley L, Kerstman E. Integration RWS ISS STS Observed Incidence. 2017.

---

Scheuring RA, Mathers CH, Jones JA, Wear ML. Musculoskeletal injuries and minor trauma in space: incidence and injury mechanisms in U.S. astronauts. Aviat Space Environ Med 2009 Feb;80(2):117-24.