# Back Sprain/Strain Cliff

### Branch Baseline

Back injury usually involves a strain or sprain in the supporting muscles of the vertebral spine, especially common in the lumbar region, and usually involves pain and functional impairment. The most common mechanism of injury terrestrially is lifting. The dynamics of this injury is different in microgravity but may occur when a crewmember is translating a high mass object or during regular exercise. (Scheuring, 2009) A pre-existing history of a significant back injury increases the risk of occurrence on orbit. Treatment is tailored to the specific condition and often includes the alleviation of pain with analgesics. (National Institutes of Health, 2011). For the purpose of this CliFF, back injuries are limited to soft tissue

### 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: | In-flight |
| Space Adaptation: | No |
| Incidence Type: | Rate |

| **Distribution Data** | |
|---|---|
| Incidence: | Gamma |
| Occurrence: | Poisson |

| **Data Characteristics** | |
|---|---|
| Events: | 61 |
| Person Years: | 44.58 |
| Space Flight Incidence Rate (Events / Person Years): | 61 / 44.58 = 1.36832660385823 |

**Incidence Comments**

In Scheuring 2009 study, the object was to construct a database of in-flight musculoskeletal injuries including incidence, types, mechanism of injury and relevance to post-flight health outcomes. Hand injuries dominate throughout the space program, with shoulder and back injuries also notable in the data. One of the finding was that overall incidence of in-flight musculoskeletal injuries related to exercise was low, though high number of minor back injuries did occur while using exercise equipment. This may account to the larger number of back injuries on ISS to other NASA programs (Scheuring, 2009).

The incidence data was updated to integrate the Real World System observed events including the person at risk from our validation data set. There were 30 new events (27 ISS and 3 STS) added. Also there was 18.17 person years added. This data set included the remaining Shuttle missions and ISS Expedition 31/32 through Expedition 39/40 (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 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

Wing's study of Shuttle astronauts reported incidence of in-flight back pain of 68% and 74% (Wing, 1991).

In a study of farmers and farm workers reviewed the potential risk of musculoskeletal disorders including low back pain. There was suggestive evidence that this population often had more low back pain than workers in few physical demands. The tractor drivers seemed to have lower back pain. The links with occupation risk factors such as heavy loading on joints and whole-body vibration is sufficient to suggest the course that future prevention should be taken but for several outcomes more research is still needed (Walker-Bone, 2002). The astronauts' occupational task and environment lends itself to many similiar in this study.

## 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 Diagnosis & Initial Treatment[1]** | | **Clinical Phase II On-going Treatment / Convalescence[2]** | | **Clinical Phase III Recovered / Mission End State[3]** | | |
|---|---|---|---|---|---|---|---|
| | **FI[*] (%)** | **Duration (hrs)** | **FI[*] (%)** | **Duration (hrs) (Min - ML - Max)** | **FI[*] (%)** | **EVAC[**] (%)** | **LOCL[**] (%)** |
| ISS-based Treatment (best case scenario %: 96.77 - 98.39) | 100 | 0.25 | 1 - 14 | 0 - 36 - 72 | 0 | 0 | 0 |
| ISS-based Treatment (worst case scenario %: 1.61 - 3.23) | 100 | 0.75 - 1 | 10 - 24 | 72 - 216 - 360 | 0 - 24 | 0 | 0 |
| Untreated Best Case | 0 | 0 | 10 - 24 | 0 - 36 - 72 | 0 - 14 | 0 | 0 |
| Untreated Worst Case | 0 | 0 | 15 - 33 | 72 - 216 - 360 | 15 - 33 | 0 - 3 | 0 |

[1]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".

[2]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.

[3]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**

Since the incidence of significant soft tissue injuries including back injuries have been uncommon according to Scheuring in his 2009 study the percentage for best case scenarios was assigned 97-99 percent leaving worst case scenarios at 1-3 percent (Scheuring, 2009).

Integrated the real world systems data into the best case and worst case. Based on this data and previous events 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. Therefore, if the next case is a worst case we would 2/61 or 3% of cases as worst cases. If the next case is best case, we would have 60/61 or 98%. Thus the percentage for worst case scenario would 2-3% (Saile L., 2017)

**Best case scenario** is defined a mild or moderate back injury which resolves by itself or causes minimal disturbance requiring only symptomatic treatment.

**Worst case scenario** is defined as having a severe back injury accompanied by severe pain.

**Best Case Comments**

The functional impairments (FI) calculation for this condition follows the IMM Severe Non-Space Adaptation Medical Conditions template (Kerstman, 2010). According to the template in Clinical Phase II the FI follows Class 1-2 in the Guide to the Evaluation of Permanent Impairment, which translates to a 1-14% Whole Person (WP) impairment for a duration of 0-72 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**

The functional impairments (FI) calculation for this condition follows the IMM Severe Non-Space Adaptation Medical Conditions template (Kerstman, 2010). According to the template in Clinical Phase II the FI follows Class 2-3 in the Guide to the Evaluation of Permanent Impairment, which translates to a 10-24% Whole Person (WP) impairment for a duration of 72-360 hours. While in Clinical Phase III the FI follows Class 0-3 for 0-24% WP impairment (American Medical Association, 2008). Though no in-flight musculoskeletal injury to date that has caused a failure of mission objectives, the reports of the Apollo EVA crewmembers and other astronauts listed in our investigation suggest their injuries could impact the mission given the right circumstances such as extended duration operation. The actual flight experience of no evacuations or 0% to date in the U.S. Space Program (In-flight Compilation Lockdown revised, 2010)(Saile L., 2017).There is no probability of LOCL (Kerstman, 2011).

**Untreated Best Case Comments**

The functional impairments (FI) calculation for this condition follows the IMM Severe Non-Space Adaptation Medical Conditions template (Kerstman, 2010). According to the template in Clinical Phase II the FI follows Class 2-3 in the Guide to the Evaluation of Permanent Impairment, which translates to a 10-24% Whole Person (WP) impairment for a duration of 0-72 hours . While in Clinical Phase III the FI follows Class 0-2 for 0-14 % 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 (In-flight Compilation Lockdown revised, 2010) (Saile L., 2017).

**Untreated Worst Case Comments**

The functional impairments (FI) calculation for this condition follows the IMM Severe Non-Space Adaptation Medical Conditions template (Kerstman, 2010). According to the template in Clinical Phase II the FI follows Class 3-4 in the Guide to the Evaluation of Permanent Impairment, which translates to a 15-33% Whole Person (WP) impairment for a duration of 72-360 hours . While in Clinical Phase III the FI remains Class 3-4 for 15-33 % WP impairment (American Medical Association, 2008). Consequently, the outcomes in Clinical Phase III is 0-3% chance of EVAC. Incidence of total terrestrial back injuries 9.1/100. The incidence of non-surgical hospital admissions for back injuries was 150/100,000 person years. The incidence of surgical hospital admissions was 158/100,000 person years. Dividing the total hospital admissions by the total back injuries equals 0.033. Therefore it is estimated 0-3 percent of worst case back injuries would require EVAC (Andersson, 1999). The outcomes in Clinical Phase III are 0% chance LOCL, which is supported by the actual flight experience of no evacuations to date in the U.S. Space Program (In-flight Compilation Lockdown revised, 2010)(Saile L., 2017). The LOCL remains at 0% which is supported by the actual flight experience of no evacuations to date in the U.S. Space Program (Inflight Compilation Lockdown, 2008).

**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 |
|---|---|---|
| Scheuring, 2009 | 1 | BCWC |
| American Medical Association, 2008 | 3 | FI |
| Inflight Compilation Lockdown, 2008 | 1 | EVAC |
| Saile L., 2017 | 1 | EVAC |

### Additional Comments

PubMed search keywords included back pain, acute musculoskeletal pain, soft tissue injuries.

## The Resource Table (RT)

| Resource | Units Required Best Case | Units Required Worst Case | Units Available At Start Of Mission | Consumable | Essential | Rationale |
|---|---|---|---|---|---|---|
| Hot and Cold Pad | 1 | 1 | 1 | No | No | pain relief |
| Motrin (Ibuprofen) 400mg | 4 | 15 | 500 | Yes | Yes | Pain relief |
| Tylenol (Acetaminophen) 325 mg | 8 | 45 | 250 | Yes | Yes | pain relief |
| Vicodin HP (Hydrocodone/ Acetaminophen HP) 10 mg/660 mg | 0 | 30 | 30 | Yes | Yes | Pain relief |

**Resource Comments**

The source of the resource table data was derived from the ISS Medical Check List (MOD, 2011).

According to the Merck Manual, the underlying disorders should be treated along with treatment for pain. Acute musculoskeletal pain (with or without radiculopathy) is treated with analgesics, heat, and rest with passive/active exercises (Merck, 2009).

**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 |
|---|---|
| Incidence | 1 |
| Functional Impairment | 3 |
| Best Case / Worst Case | 1 |
| EVAC / LOCL | 1 |
| Resources | 2 |
| **QUALITY OF EVIDENCE** | **1.6** |

| Description | Range |
|---|---|
| Excellent | 1-2 |
| Good | 2.1-3 |
| Fair | 3.1-4 |
| Poor | 4.1-5 |

## Reference List


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