Ankle Sprain/Strain Cliff

Branch Baseline

An ankle **sprain** is an injury to the ligaments supporting the ankle. While an ankle **strain** is an injury to the tendons or muscles supporting the ankle. Ankle sprains and strains involve the stretching or tearing of tissue of the ligaments or the muscle-tendon unit, respectively.

Both Sprains and Strains are classified according to three degrees of injury.

Sprains break down as follows: a 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 non-functioning.

First-degree strains indicate over-stretching, second-degree indicating partial tear, and third-degree indicating complete tear (rupture) (Reed, 1994).

In-flight sprains have generally been mild and self-limited. Several mechanisms of injury can occur during nominal flight operations. Ankle inversion injuries have been reported during daily treadmill exercise, or when using other exercise equipment used to mitigate muscle atrophy and the loss of bone mineral density. Another is during EVA when the crewmember ingresses and egresses from a Portable Foot Restraint requiring the use of forceful ankle inversion and eversion. The risk of injuries on orbit is increased if there is a history or recent ankle injury pre-flight. Due to the microgravity cephalad fluid shift, the presentation of an ankle injury in-flight would likely appear less severe than the actual degree of injury due to less swelling. (Marshburn, 2008)

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:	11
Person Years:	44.58
Space Flight Incidence Rate (Events / Person Years):	11 / 44.58 = 0.246747420367878

Incidence Comments

Injuries to the astronauts can be caused by impacting structures or objects inside the space craft cabin, injuring them. Foot and ankle injuries can also occur for the EVA astronauts probably more related to fitting of the boot, and the use of fott restraints. Exercise is another factor impacting musculoskeletal injuries of the foot and ankle. These and other soft tissue injuries have been reported. 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).

Updated incidence data by increasing person years by 18.17 based on the real world system incidence data (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

The Bureau of Labor Statistics in 1998 reports that sprains and strains are by far the leading occupation injuries between 34-51% for any industry. Of those the lower back and upper extremities are the most common. The available literature for terrestrial studies was not suitable because in microgravity the majority of injuries impact the upper extremities, which is the opposite in ground base studies as demonstrated by the Bureau of Labor statistics. There also appears to be a causal relationship between the muscle atrophy and upper extremities sprains/strains, which increases the likelihood of this happening in microgravity (Hedge, 2007).

Ankle sprains are common problem and occur at a rate of 1 injury per 10,000 population a day. A quarter of all sports injuries involve the lateral ligament complex of the ankle (Struijs, 2001).

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 %: 97 - 99)	100	0.25	0 - 5	24 - 48 - 72	0	0	0
ISS-based Treatment (worst case scenario %: 1 - 3)	100	0.75 - 1	1 - 10	72 - 216 - 360	0 - 5	0	0
Untreated Best Case	0	0	1 - 10	24 - 48 - 72	0 - 5	0	0
Untreated Worst Case	0	0	6 - 20	72 - 216 - 360	1 - 20	0 - 1	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 sprains and dislocation have been uncommon according to Scheuring in his 2009 study the percentage for best case scenerios was assigned 97-99 percent leaving worst case scenerios at 1-3 percent (Scheuring, 2009).

The **best case scenerio** is defined as a mild sprain/strain that will resolve in 2-4 weeks with minimal or no treatment.

The **worst case scenerio** involves a moderate or severe sprain/strain that does not resolve in 2-4 weeks.

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 0-5% 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 45 minutes to one hour as the care giver will additional diagnostics tasks and equipment set up related to the increase in severity. In Clinical Phase II the FI follows Classes 1-2 (Kerstman, 2010), which derives 1-10% WP impairment. The duration based on terrestrial guidelines need to be modified as in microgravity the crew transverse in the vehicle with their upper extremities. While in Clinical Phase III the FI assigned to Class 0-1, which translates to 0-5% WP impairment (American Medical Association, 2008). There has been no EVAC of any muscule skeletal injuries in US spaceflight to date so the precentage 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 1-10% WP impairment and 0-5% WP impairment (American Medical Association, 2008). The duration because 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 of the acuity in Clinical Phase II the FI is assigned to Classes 2-3, which derives a 6-20% WP impairment lasting 72-360 hours. While in Clinical Phase III, the assigned FI classes are 1-3 (Kerstman, 2010). These classes could translate that the crew could be 1-20% 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 (Muwanga, 1986).

Though there would be no chance of LOCL (Kerstman, 2011). The EVAC probability is resulting from the inability to treat and severity of condition. We do know that to date there has not been crew members suffer such 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
Scheuring, 2009	1	BCWC
Saile L., 2017	1	EVAC

Additional Comments

Pubmed search keywords included ankle, ankle injury, soft tissue injury, muscleskeletal injuries, sprain and strains.

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Ace bandage 3 inches	1	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
Hot and Cold Pad	1	1	1	No	No	To provide cold for decreasing pain and edema
Motrin (Ibuprofen) 400mg	4	16	500	Yes	Yes	Pain relief
SAM splint - Leg/Arm Splint	0	1	1	No	Yes	Immobilization
Tylenol (Acetaminophen) 325 mg	2	8	250	Yes	Yes	pain relief
Vicodin HP (Hydrocodone/ Acetaminophen HP) 10 mg/660 mg	0	24	30	Yes	Yes	Pain relief

Resource Comments

According to most terrestrial guidelines, basic initial treatment includes P.R.I.C.E. (Protect, Rest, Ice, Compression, and Elevation) and OTC analgesics (acetaminophen) or prescription doses of non-steroidal anti-inflammatory drugs (NSAIDs) (Agency for Healthcare Research and Quality, 2011). All can be accomplished on orbit 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)

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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	2.5
Resources	2
QUALITY OF EVIDENCE	**1.9**

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

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