Knee Sprain/Strain Cliff

Branch Baseline

A knee sprain refers to the damage or tearing of ligaments or the joint capsule. Ligaments are the main structures that bind the knee together as the ligaments connect bone to bone, while the tendons attach muscles to bone. A knee strain refers to a tearing of a muscle tendon associated with the knee joint. Both sprains and strains are evaluated based on the stability and loss of function of the knee. (Reed, 1994)

On orbit knee sprain or strain can occur due to mechanical loading such as with exercise, during EVA or during high mass object transfer operations. (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:	27
Person Years:	44.58
Space Flight Incidence Rate (Events / Person Years):	27 / 44.58 = 0.605652759084791

Incidence Comments

The effects of microgravity result in progressive muscle atrophy and loss of bone mass. This puts the astronauts at risk of sustaining musculoskeletal injuries during a mission (Scheuring, 2009).

Integrated 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 for providing post-flight rehabilitation, as well as strengthening preflight, in order 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 exercise.

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

Knee pain is a complaint in as many as 20% of the general adult population. Soft tissue injuries of the knee are some of the most common and clinically challenging musculoskeletal disorders in patients presenting to the ED. Annually, more than 1 million emergency department (ED) visits and 1.9 million primary care outpatient visits are for acute knee pain.

In Jennings and Bagian’s study of astronauts, found 28 orthopedic surgical procedures resulting from fractures, serious ligament, cartilage or other soft tissues injuries. Of the 28 injuries 19 involved knee injuries.

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 %: 96.43 - 100)	100	0.25	0 - 5	24 - 48 - 72	0	0	0
ISS-based Treatment (worst case scenario %: 0 - 3.57)	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 - 19	72 - 216 - 360	1 - 19	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

Based on Real World System data set and previous data set, there were 27 events and all were best case. Since there were no worst cases, 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 1/28 or 4% of cases as worst cases. If the next case is best case, we would have 28/28 or 100%. Thus the worst case percentage would be 0-4% (Saile L., 2017)

Best case scenario would involve minor knee pain with minimal analgesic needed for discomfort.

Worst case scenario is an injury that does not resolve with conservative treatment and/or may involve significant tearing of the ligament, tendon or cartilage. The crew member would likely require considerable pain management.

Best Case Comments

The best case scenario is a very mild sprain/strain that results in some discomfort for a few days without instability. This scenario's Clinical Phase (CP) II, the functional impairment (FI) will be derived by Classes 0-1 (Kerstman, 2011 1356 /id. This will translate to a 0-5% Whole Person (WP) impairment which will last from 24 to 72 hours {American Medical Association, 2008). During CP III, the FI Class is 0 so there is no FI or no chance of evacuation (EVAC) or loss of crew life (LOCL) (Reed, 1994).

Worst Case Comments

In the worst case the sprain/strain does involve a serious tear and could be a complete tear if instability is elicited. The FI Classes 1-2 are assigned even though this is a lower extremity in CP II because of the pain management and possible instability. This translates to 1-10% WP impairment, which can last 72 to 360 hours (3-15 days) to resolve. Though in CP III, the FI Classes are decreased to 0-1 (Kerstman, 2011) so WP impairment is 0-5% (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 not likelihood of loss of crew life (Reed, 1994).

Untreated Best Case Comments

In CP II, the FI class assigned is 1-2 resulting from no treatment available. The WP impairment is 1-10%. As a best case, it is estimated to last 24 to 72 hours. While in CP III, the FI Classes are decreased to 0-1 (Kerstman, 2011) so WP impairment is 0-5% (American Medical Association, 2008) again as a best case there is no chance of EVAC or LOCL (Reed, 1994).

Untreated Worst Case Comments

The scenario is the most challenging because of the inability to treat the tear and instability including pain management for the crew member. So the FI Class in CP II is 2-3 (Kerstman, 2011) giving 6-20% WP impairment. In CP III, the range widens for FI impairments to 1-20 WP impairment (American Medical Association, 2008),

The likelihood of an EVAC was derived from a study of ankle injuries by Mawanga. The ankle injury was used as substitute for knee, 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). There is not likelihood of loss of crew life (Reed, 1994).

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

Key words used in PubMed searches include knee, soft tissue injury, muscloskeletal, sprain, strain, ligament, tendon, and knee joint.

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
CMRS	0	1	1	No	No	Restrain crew member to ensure safety
Hot and Cold Pad	1	1	1	No	No	For pain and swelling.
Motrin (Ibuprofen) 400mg	9	33	500	Yes	Yes	Pain relief (Second line)
SAM splint - Leg/Arm Splint	0	1	1	No	Yes	Immobilize joint
Vicodin HP (Hydrocodone/ Acetaminophen HP) 10 mg/660 mg	0	16	30	Yes	Yes	Pain relief (Third line)

Resource Comments

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

National Guideline Clearinghouse recommends initial conservative treatment of sprains start with an inspection and assessment. The purpose of the initial treatment is to reduce symptoms, optimize healing/function, and increase work, with appropriate modifications to minimize the risk factors that contributed to the injury (ECRI Institute, 2009).

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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