Hip Sprain/Strain Cliff

Branch Baseline

The hip has three functional muscle groups: abductors, flexors and adductors. It is a stable joint, less likely to be strained than the knee or ankle. Hip sprain or strain on orbit can occur due to mechanical loading such as with exercise, during EVA or during high mass object transfer operations. (Marshburn, 2008)

Hip sprain results from damage to the ligaments to the hip that binds the bones together. While hip strain is damage to the hip muscles due to over-stretching of the muscle tissue, which may involves tearing of the muscle tissue. (wrongdiagnosis.com, 2005)

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:	17
Person Years:	44.58
Space Flight Incidence Rate (Events / Person Years):	17 / 44.58 = 0.381336922386721

Incidence Comments

Injuries to the astronauts can be caused by strain, overuse and impacting structures or objects inside the spacecraft cabin. These and other soft tissue injuries have occured on orbit. Due to the effects of microgravity on muscle and bone mass loss, astronauts are at risk of sustaining musculoskeletal injuries during a mission. 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).

Integrated 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 strengthening pre-flight in attempts to prevent or mitigate injuries as well as post-flight rehabilitation. The Strength Coach's primary role is to provide an exercise plan designed to achieve flight physical readiness and prevent musculoskeletal injuries during spaceflight conditioning exercises.

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 literature did not provide suitable studies to compare the general population because in microgravity the majority of injuries impact the upper extremities, which is the opposite in ground base studies. 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.

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. (Hedge, 2007)

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 %: 94.44 - 100)	100	0.25	0 - 5	24 - 48 - 72	0	0	0
ISS-based Treatment (worst case scenario %: 0 - 5.56)	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

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. So WC would be 6% (1/18) and best would be 100% (18/18). Therefore the range for WC will be 0-6%. (Saile L., 2017)

The best case scenario is defined as a mild hip sprain or strain that involves minimal or no treatment.

The worst case scenerio involves a moderate or severe sprain or 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 0-5% 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 complete additional diagnostics tasks and equipment is set up depending on the estimated severity. In Clinical Phase II the FI follows Classes 1-2 which derives 1-10% WP impairment (Kerstman, 2010). The duration is based on terrestrial guidelines and thus needs to be modified for microgravity since the crew primarilty translates 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 continues to be 24 -72 hours as it is for the best case in Clinical Phase II. As in the treated best case there is no chance of EVAC or LOCL, reflected in historical data from 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 6-19% 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 1-19% 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). To date there has not been a report of a crew member suffering from a hip 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 key words include soft tissue injury, NASA, muscloskeletal, pain

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Motrin (Ibuprofen) 400mg	4	0	500	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 commercial guidelines, initial treatment includes P.R.I.C.E. (Protect, Rest, Ice, Compression, and Elevation) and analgesics including analgesic doses of nonsteroidal anti-inflammatory drugs (NSAIDs) (Agency for Healthcare Research and Quality, 2011). On orbit all can be accomplished with the exception of elevation. The source of the resource table data was derived from the ISS Medical Check List (Mission Operations Directorate (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
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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