

Strain Sprain Upper Extremity CLiFF Peer Review

1. *Strength of evidence presented in CLiFF in modeling the characteristics and mission impact of this medical condition within the spaceflight environment?*

Score: 2

Grading Scale:

4 - Confident

3 - Somewhat confident

2 – Neutral

1 – Somewhat unconfident

0 – Not confident

2. How confident are you that these data accurately represent the spaceflight environment?	Tables 1, 2 Composite Incidence and Level of Confidence	Table 3, 4 BC/WC Loss of Crew and probability	Table 4 - Clinical Phase 1, 2 durations Table 5 – CP 2 Loss of Crew	Table 4 – RTDC % Table 6 – RTDC Loss of Crew	Table 4 – Loss of Crew Life % Table 7 – Loss of Crew Life, Loss of Crew	Table 8 – TI
Score	3	2	2	1	3	3

Comments and limitations:

1. General comments. Sprains and strains arising from injury to the supporting muscles, ligaments or tendons of the upper extremity are common musculoskeletal complaints. As defined in this CLiFF these injuries include strain/sprain to the wrist, elbow, and shoulder. Sports injuries, overuse, trauma, and falls are common mechanisms on earth. In microgravity, however, the incidence of trauma, sports injuries, and falls would be expected to be lower. In partial G, that would be encountered during surface lunar or Martian operations, the incidence may be slightly higher. The best case is considered to be a Grade I or II strain/sprain in which there is minimal or partial muscle or ligamentous tearing while the worst case is a Grade III strain/sprain in which there is full thickness muscle or ligamentous tearing, and/or instability.

2. Incidence. As in similar CLiFFs involving strains/sprain at other anatomical locations, the incidence is informed by spaceflight data from Johnston III et al, 2020 and previous IMM CLiFFs. This includes data from the US Space Program from Mercury – ISS Expedition 40. There have been a total of 9 wrist strain/sprains, 23 elbow sprain/strains, and 35 shoulder sprain/strain events over 44.58 person-years yielding a mean incidence of 1.502 events per person/year. It is possible that this is an

Strain Sprain Upper Extremity CLiFF Peer Review

under-estimate of the true incidence because of under-reporting of subtle strain/sprains. The best case/worst case probabilities used a range of data from terrestrial data utilizing the need for surgery as a surrogate for worst case. The clinical phase durations, RTDC and LOCL probabilities are supported by terrestrial evidence, and I am in agreement with their calculation although there is little available data for the untreated scenarios that could be used to calculate clinical phase durations. LOCL probability was considered to be zero given the medical condition definition. The probability density curve that was derived appears to be a reasonable representation of the data presented.

3. Clinical phase data. I am in agreement with the clinical phase 1 duration entered in this CLiFF. This data was compiled by a team of expert clinicians, and I was involved in the discussions leading to the calculation of the clinical phase duration. CP2 was supported by terrestrial evidence.

4. Task impairment. The analysis was performed and reviewed by a separate team of expert clinicians. I am aware of the methods that were used but did not directly participate in the discussions.

5. Dependence on mission phase or duration of mission. This medical condition may have a higher incidence during phases of high physical activity such as EVA's or during surface operations where falls may occur in a partial g environment.

6. Limitations

- Under-reporting for this condition could have occurred during past space missions due to subtle sprains/strains that were not of clinical consequence. This may result in underestimation of the incidence.
- The incidence for this condition is based on LSAH/IMM data regarding wrist, elbow, and shoulder injuries. This may be an underestimate of upper extremity sprains/strains overall given the limitation to these three anatomic locations but was felt to be the best approximation for spaceflight incidence of upper extremity sprains/strains available.
- There is a paucity of data related to the duration of "upper extremity sprains/strains" as defined in this CLiFF. The literature focuses on individual tendons or ligaments, which have varying recovery times. For many of the scenarios, data is based on rotator cuff tears which may not be an appropriate surrogate for strains/sprains.
- There is a paucity of data related to "Upper Extremity Sprains/Strains" the way they are defined in this CLiFF. The literature focuses on individual tendons/ligaments, which makes it difficult to source data for duration, RTDC, or LOCL for all-comer upper extremity sprains/strains.
- There is a paucity of data related to the best-case scenario durations for "Upper Extremity Sprains/Strains" as defined in this CLiFF. Two sources were used to inform these durations that are not peer reviewed.
- Much of this CLiFF is informed by rotator cuff tears, and in some cases atraumatic rotator cuff tears, which are a degenerative process seen with advancing age. This is not an accurate surrogate for the traumatic injury that would be anticipated to cause an upper extremity sprain/strain in spaceflight.
- This medical condition may have a higher incidence during phases of high physical activity such as EVA's or during surface operations where falls may occur in a partial g environment.

Strain Sprain Upper Extremity CliFF Peer Review

Reviewed by:

David C. Hilmers