Skydive Parachute Opening Shock

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Parachute Opening Shock
BAM!
Decelerations and Muscle Responses During Parachute Opening Shock

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Introduction: Pain in the neck region among skydivers can be related to repeated parachute opening shocks (POS), but empirical data on ram-air POS biomechanics is lacking in the literature. The aim of this study was to develop and evaluate a methodology for assessment of multidirectional accelerations and neck muscle activity during parachuting, and to describe preliminary data. Methods: In an experimental design, four experienced skydivers made two consecutive skydives. Deceleration was recorded with two triaxial accelerometers, one placed on the skydiver’s cervicothoracic junction (acc-neck) and the other on the harness (acc-rig). Surface electromyography (EMG) was sampled from four sites bilaterally: anterior-neck, posterior upper and lower neck, and upper shoulder muscles. EMG activity was normalized against a premeasured maximum voluntarily produced electrical signal (MVE). Results: The measuring equipment did not interfere with the parachute jumps. High-quality signals were recorded. The median peak POS deceleration for the acc-neck vs. acc-rig indicated differences (4.0 G vs. 5.1 G), in addition to significant differences emerging for medians of average and maximum onset rates of deceleration (avg: 1.2 G · s⁻¹ vs. 19.5 G · s⁻¹; max: 23.0 G · s⁻¹ vs. 80.0 G · s⁻¹). The median of overall muscle activity was as high as 87% MVE, but no differences in peak activity were found between muscles. Temporal activations of the posterior upper neck occurred less than 50 ms after deceleration initiation, indicating feedforward control of the neck. Conclusion: All instruments recorded data of good quality without impeding the skydiving activity. Triaxial accelerometry on the neck vs. the harness yielded dissimilar results, underlining the importance of correct accelerometer placement. Muscle activity was high during POS and neck muscles showed anticipatory tendencies. Keywords: neck muscles, skydiving, sport parachuting, surface electromyography.

n = 4 skydivers, 8 skydives
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Acceleration was expressed as multiples of Earth’s gravitational acceleration \( g \) using the dimensionless ratio \( G \).
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## Table 1. Parameters of G Development During Parachute Opening Shock (POS) Presented as Mean Values Between Two Skydives From Each Subject.

| Subject | \(|a|_{\text{max}} (\text{G})\) | \(\%a_{\text{z}}\) | \(\tau (\text{s})\) | \(\tau_{2G} (\text{s})\) | \(\tau_{3G} (\text{s})\) | \(d|a|/dt_{\text{avg}} (\text{G} \cdot \text{s}^{-1})\) | \(d|a|/dt_{\text{max}} (\text{G} \cdot \text{s}^{-1})\) |
|---------|-------------------------------|----------------|----------------|----------------|----------------|---------------------------------|---------------------------------|
| 1       | 4.3 / 4.0                     | 81.4 / 78.6    | 12.9 / 11.8    | 4.9 / 4.4      | 0.7 / 1.0      | 1.0 / 15.1                       | 32.7 / 64.7                     |
| 2       | 4.0 / 5.3                     | 83.8 / 75.5    | 8.3 / 7.4      | 2.3 / 2.6      | 0.7 / 2.1      | 1.1 / 22.0                       | 19.3 / 91.9                     |
| 3       | 3.6 / 5.4                     | 82.3 / 69.2    | 9.9 / 11.8     | 2.6 / 3.2      | 0.4 / 1.3      | 1.9 / 19.1                       | 26.0 / 75.7                     |
| 4       | 3.8 / 4.7                     | 87.6 / 82.6    | 6.3 / 6.0      | 2.5 / 2.9      | 0.4 / 1.1      | 1.2 / 20.1                       | 21.7 / 91.8                     |
| Median  | 4.0 / 5.1                     | 82.8 / 77.8    | 9.3 / 8.7      | 2.5 / 3.0      | 0.5 / 1.1      | 1.2 / 19.6                       | 23.0 / 80.0                     |
| \(P\)-value* | 0.057                      | 0.114          | 0.886          | 0.486          | 0.029          | 0.029                            | 0.029                           |

Peak deceleration: \(|a|_{\text{max}}\); cranial proportion of deceleration during \(\tau\): \(\%a_{\text{z}}\); duration of POS: \(\tau\); total duration of deceleration exceeding 2 G: \(\tau_{2G}\); total duration of deceleration exceeding 3 G: \(\tau_{3G}\); average onset rate: \(d|a|/dt_{\text{avg}}\); maximum onset rate: \(d|a|/dt_{\text{max}}\).

* \(P\)-value concerns statistical testing between acc-neck vs. acc-rig.
Space Shuttle – 3G

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Results: There seems to be two temporal accelerometric phases.

Early X (20%) – Cervical Flexion

Avg Max G
4G @ Neck
5.1G @ Rig

Late Z (80%) – Axial Compression

How does the neck respond?

G-Onset
1.2 G/s @ Neck
19.2 G/s @ Rig

>1G/s = “Fast” by DoD
Neck muscle activity in skydivers during parachute opening shock

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This observational study investigated skydiver neck muscle activity during parachute opening shock (POS), as epidemiological data recently suggested neck pain in skydivers to be related to POS. Twenty experienced skydivers performed two terminal velocity skydives each. Surface electromyography quantified muscle activity bilaterally from the anterior neck, the upper and lower posterior neck, and the upper shoulders; and two triaxial accelerometers sampled deceleration. Muscle activity was normalized as the percentage of reference maximum voluntary electrical activity (% MVE); and temporal muscle activity onset was related to POS onset. Our results showed that neck muscle activity during POS reached mean magnitudes of 53–104% MVE, often exceeding reference activity in the lower posterior neck and upper shoulders. All investigated muscle areas’ mean temporal onsets occurred <50 ms after POS onset (9–34 ms latencies), which is consistent with anticipatory motor control. The high muscle activity observed supports that the neck is under substantial strain during POS, while temporal muscle activation suggests anticipatory motor control to be a strategy used by skydivers to protect the cervical spine from POS. This study’s findings contribute to understanding the high rates of POS-related neck pain, and further support the need for evaluation of neck pain preventative strategies.

20 experienced skydivers were recruited and scheduled for two consecutive belly-down terminal velocity skydives each.
Neck muscle activity in skydivers during parachute opening shock

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Highest force absorption = Max eccentric contraction
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Normalized Mean Max Muscle Activity

Forward Flexion

Max Eccentric Contraction: Lower Extensors + Upper Shoulders
Motor Plan <50ms
Co-activation
Extensors
Flexors
Protect + Stabilize
Reflexive >50ms
Neck muscle activity in skydivers during parachute opening shock

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Co-activation
Extensors
Flexors
<50ms
Anticipatory
Motor Plan

sEMG Onset Normalized to POS onset

Protect + Stabilize

Muscle activity onset [ms]
Cervical muscle training for students?

Protect + Stabilize

11% of jumps completed by students
44% of POS injury occurred to students
Protect + Stabilize
Thanks!

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