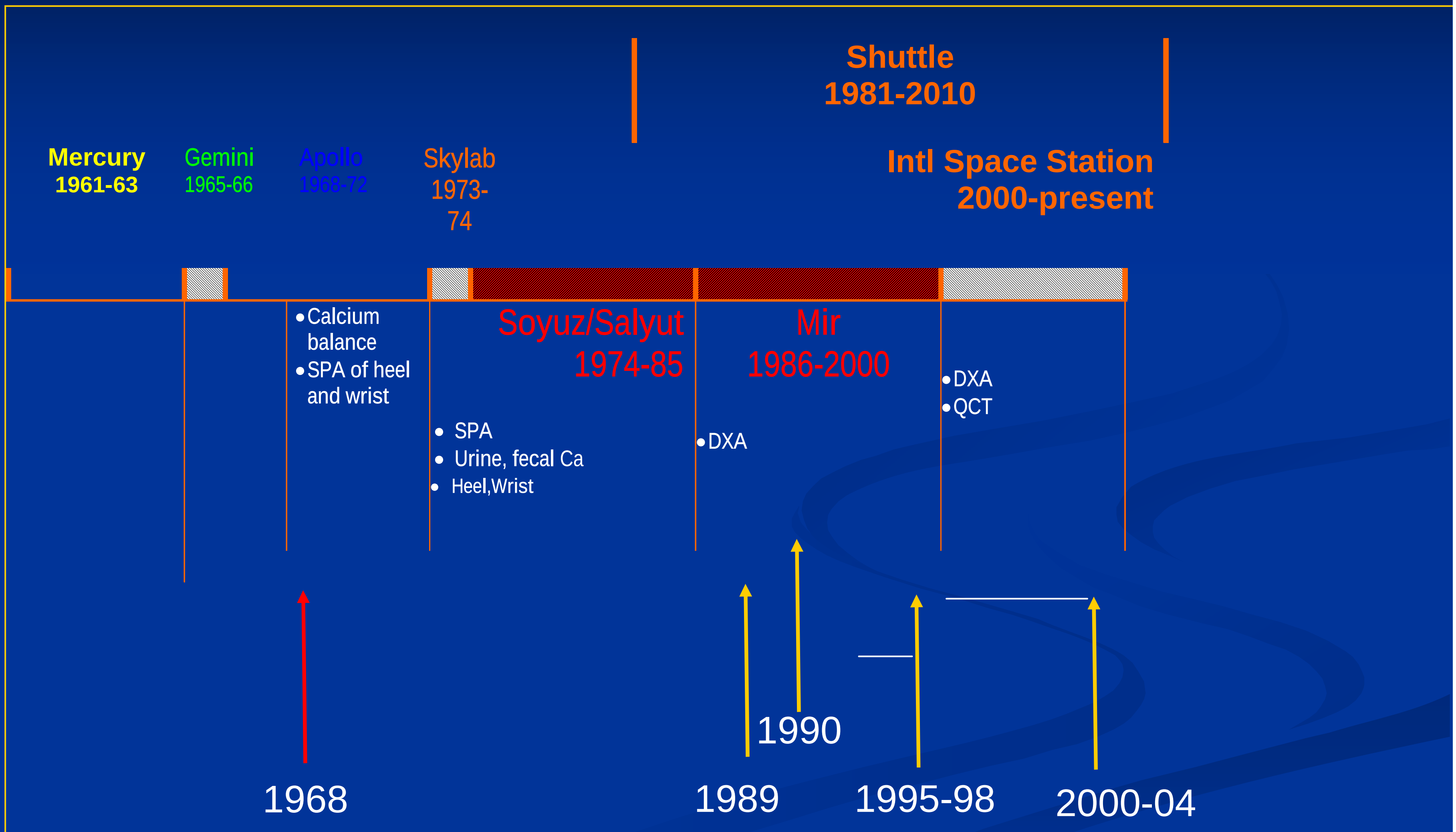
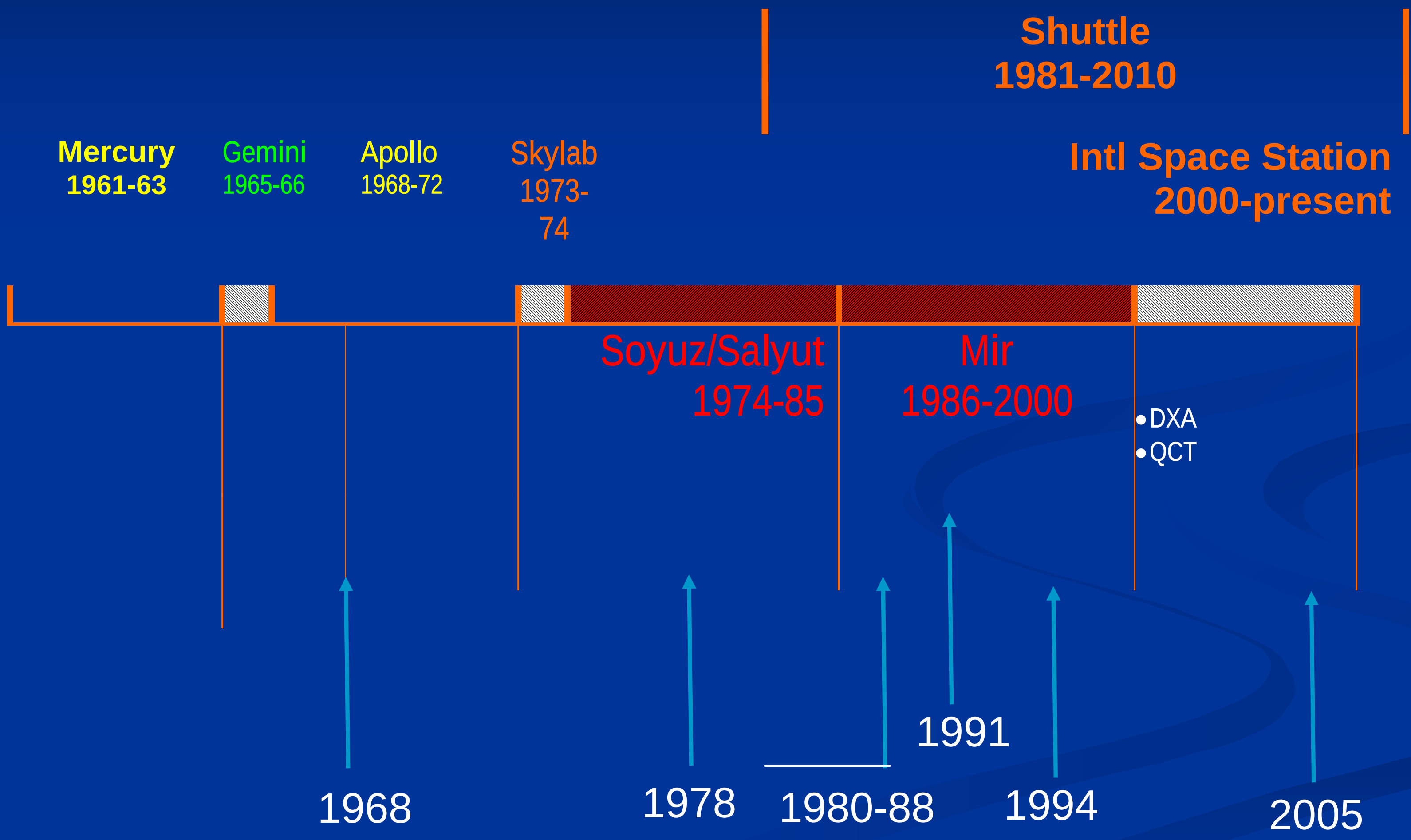
Bone Research at NASA:
Career pathway to the space program

Jean D. Sibonga, Ph.D.
Universities Space Research Association [USRA]
Science Lead, Bone and Mineral Lab
Discipline Lead Bone Team, Human Research Program
NASA Johnson Space Center

Characterizing Bone-Loss in Space



Career Transitions

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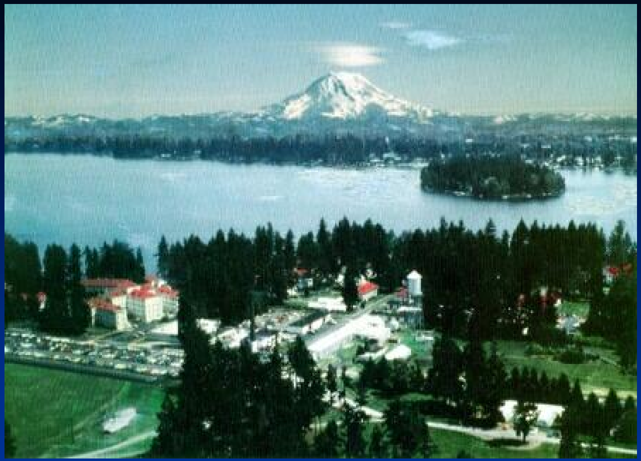
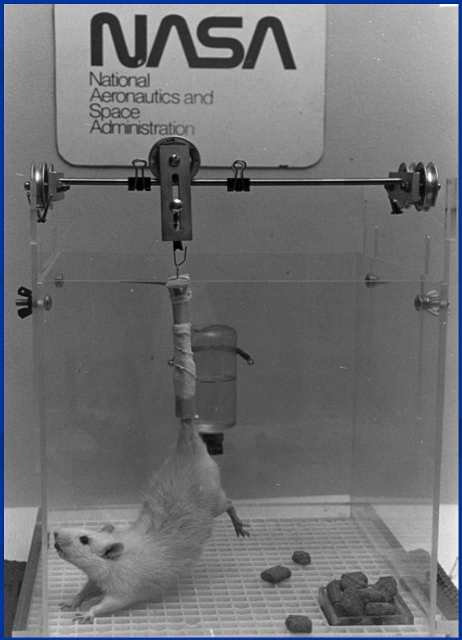
SCIENCE
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

1978




Red
Lob

1980's


NASA
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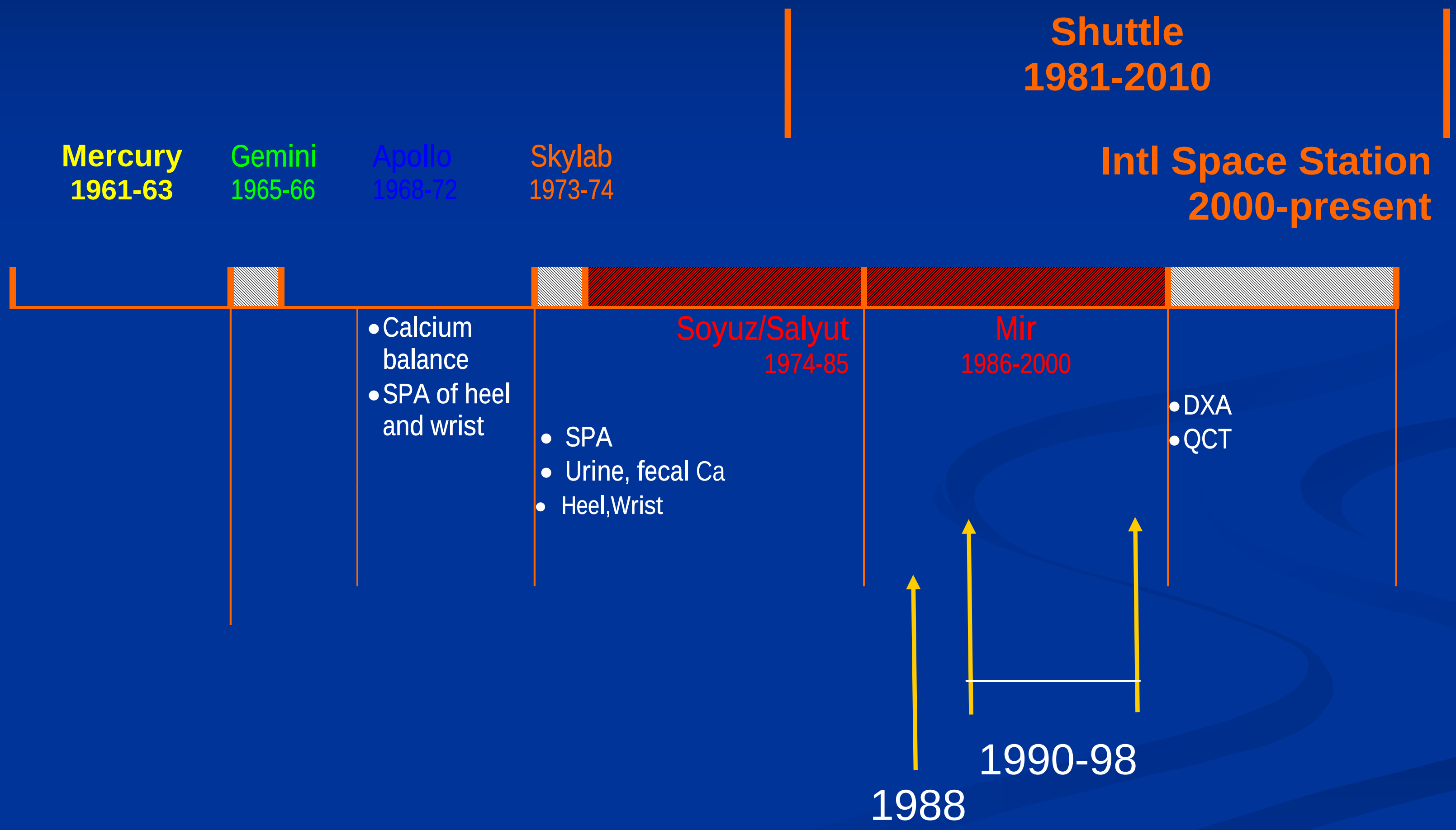
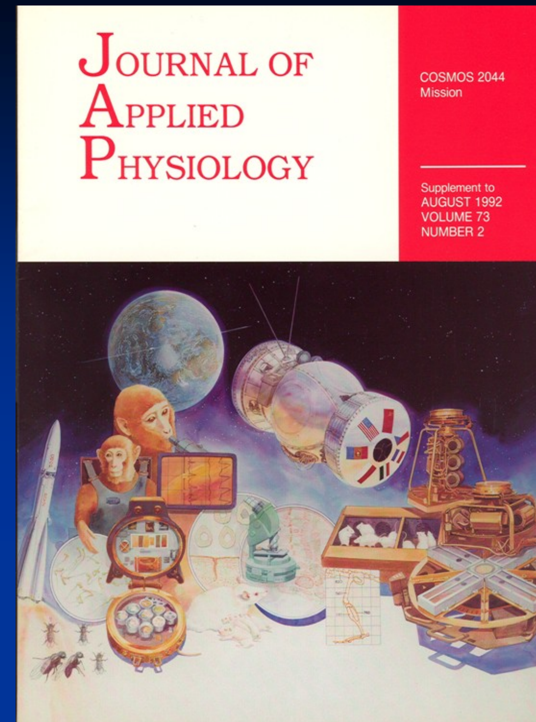
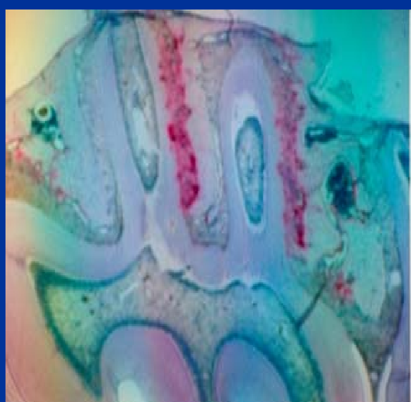
Administration

DXA Evaluations in Space Program

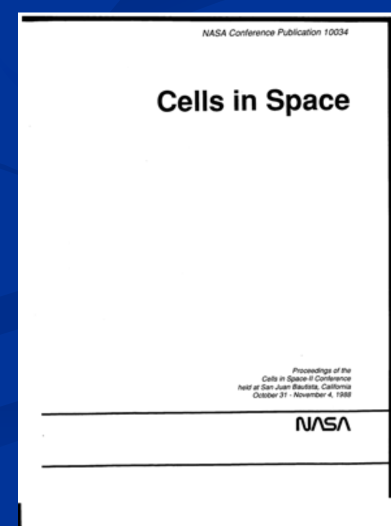






1990's

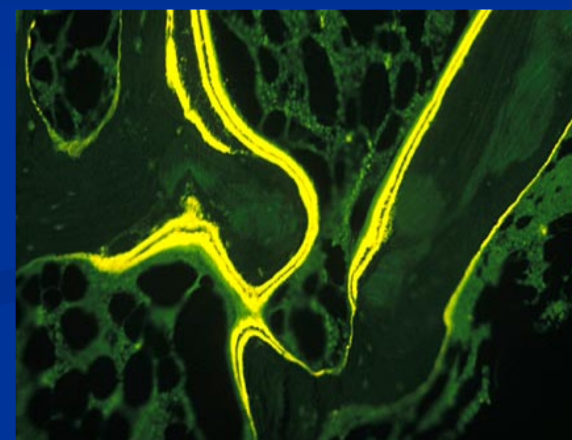
VERITAS

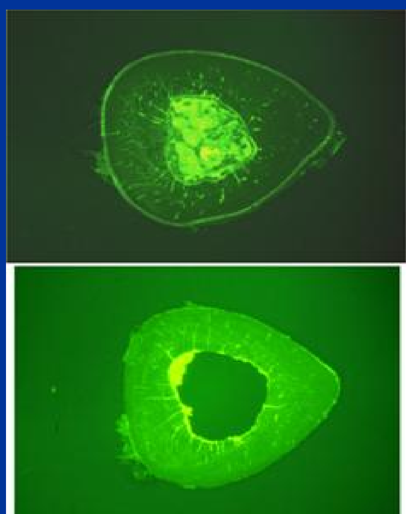

NASA Conference Publication 10034

Cells in Space

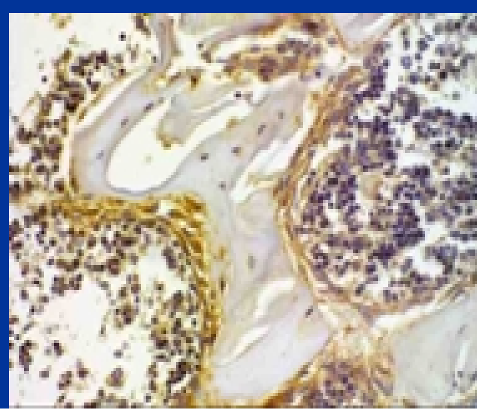
Proceedings of the
Cells in Space-II Conference
held at San Juan Bautista, California
October 31 - November 4, 1988

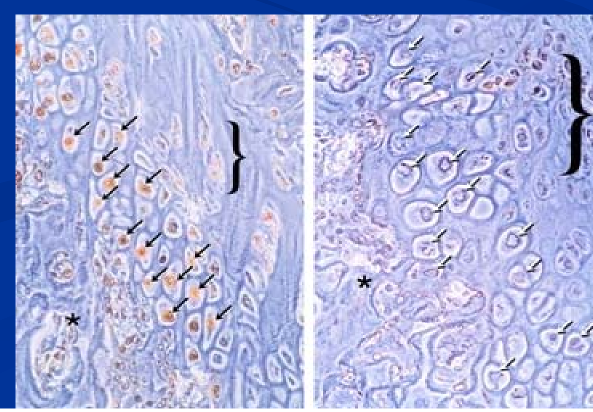
NASA





1994-
2004



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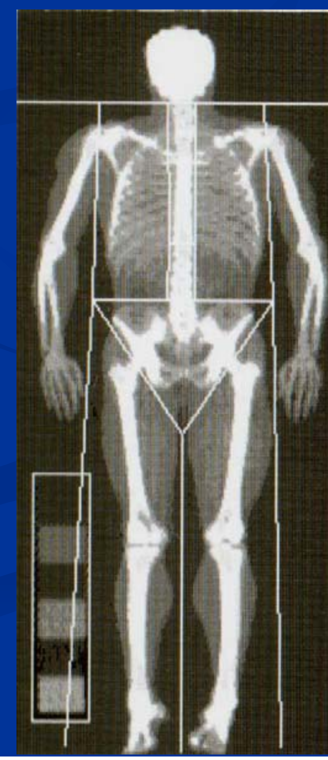
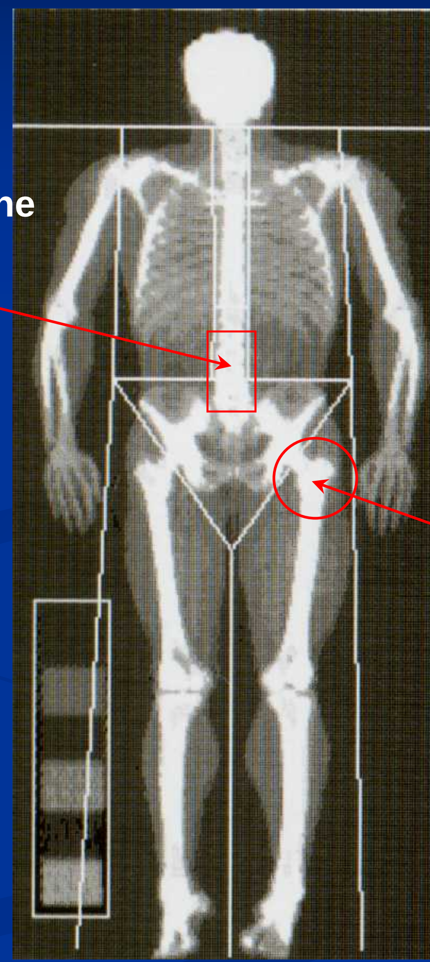
XCT 2000
STRATEC

2005-
Today



Regional BMD losses Mir

Index DXA aBMD g/cm2	%/Month Change ± SD
Lumbar Spine	-1.06±0.63*
Femoral Neck	-1.15±0.84*
Trochanter	-1.56±0.99*
Total Body	-0.35±0.25*
Pelvis	-1.35±0.54*
Arm	-0.04±0.88
Leg	-0.34±0.33*
*p<0.01, n=16-18	LeBlanc et al, 2000



Medical Requirement: Skeletal Integrity by DXA BMD

- Required medical evaluation triennial basis
- Identify rehabilitation targets
- Verify restored health status

- Characterize the skeletal effects of spaceflight
- Evaluate efficacy of bone countermeasures

Retrospective Review of BMD Data

Spacecraft	Cosmonauts	Astronauts	Males	Females
Mir	Cooperative Agreement 22 (1990-98)	Research 7 (1995-98)	28	1
ISS	Research 5 (2000-04)	MR035L 12 (2000-04)	15	2

Required preflight and postflight BMD measurements for long duration flights (MR035L)

- L-(360-180) days
- L-(45-30) days
- R+5 days
- R+6 months
- R+12 months
- R+24 months
- R+36 months

“Recovery of Spaceflight-induced Bone Loss: Bone Mineral Density after Long-duration Missions as Fitted with an Exponential Function”

by JD Sibonga, HJ Evans, HG Sung, ER Spector, TF Lang, VS Oganov, AV Bakulin, LC Shackelford, AD LeBlanc.

Crewmembers

- 56 manned-missions (duration 181±47 d)
- 1990-2004
- 45 crewmembers (27 cosmonauts, 18 astronauts)
- 9 repeat flyers
- 3 females, 42 males
- Average age 43.2±5.2 years

Data Analysis

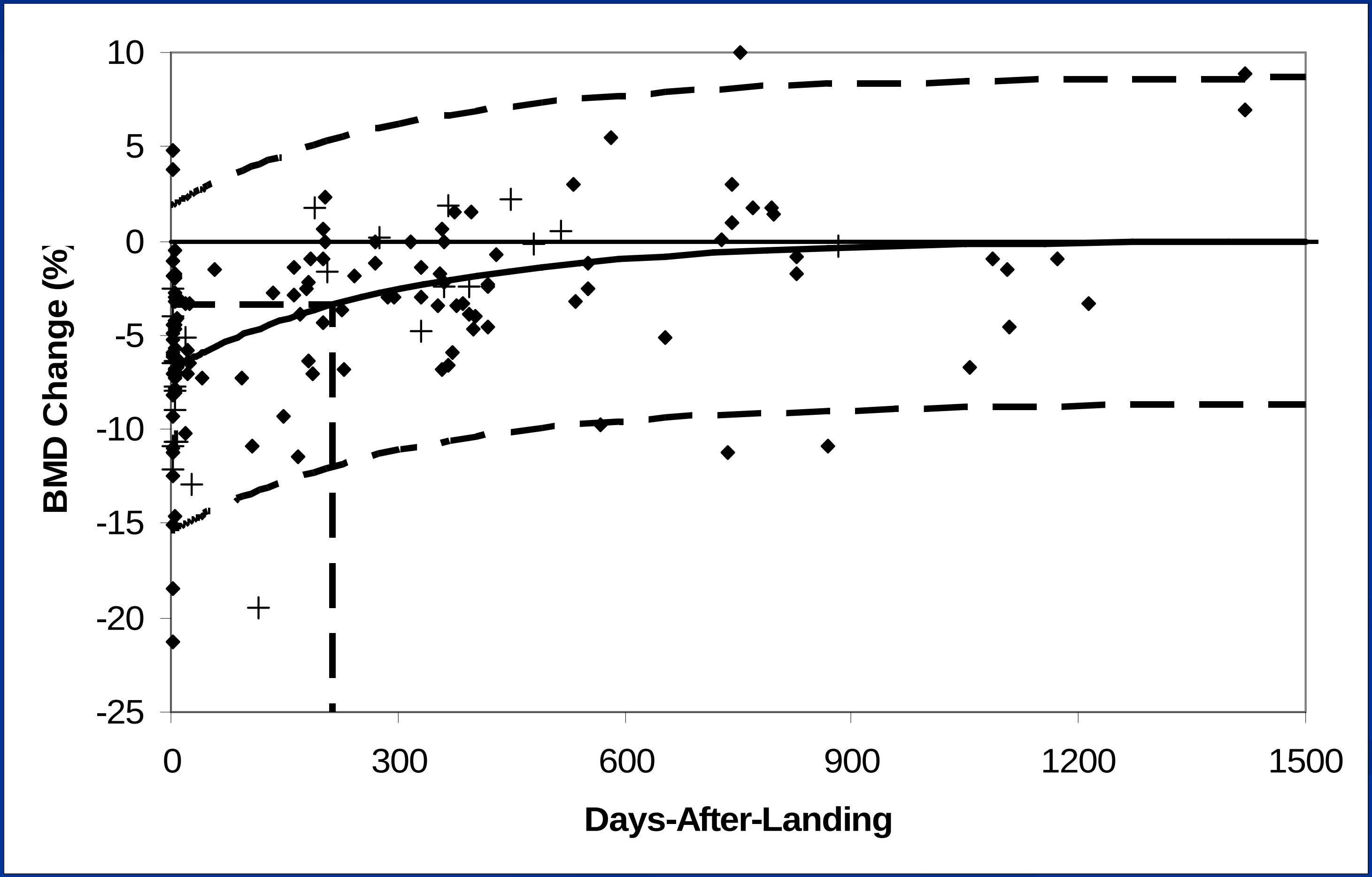
- Changes in BMD calculated for each postflight scan performed
- BMD changes plotted against # days after landing
- Plots generated for lumbar spine, femoral neck, trochanter, pelvis and calcaneus

Data Analysis (cont.)

- Apparent exponential relationship
- $L_t = L_0 * \exp^{\ln(0.5)*t/HL}$
- "Recovery Half-life" = time at 50% restoration of lost bone

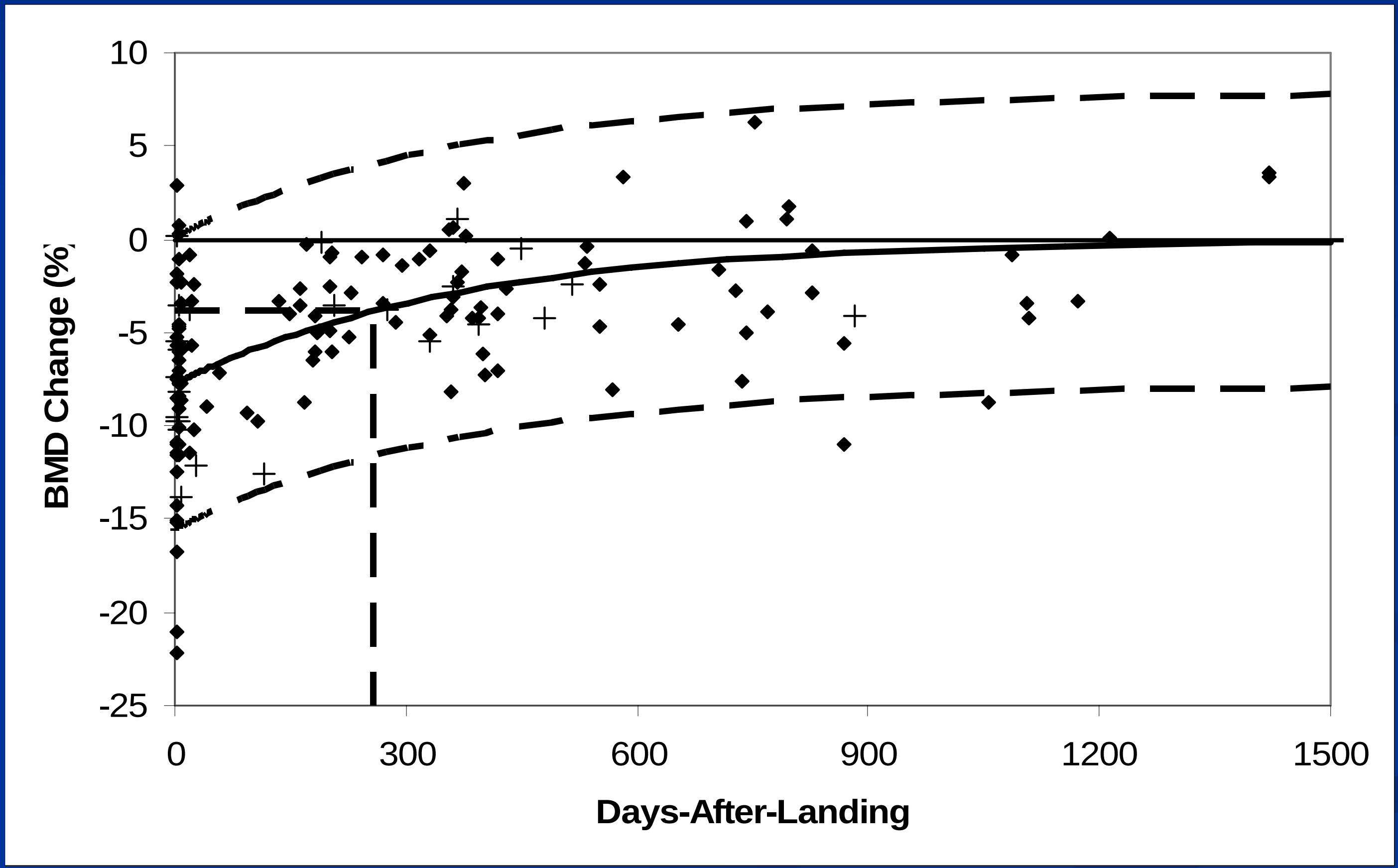
Femoral Neck

$Loss_0$= 6.8 % **Recovery Half-life=211 d**



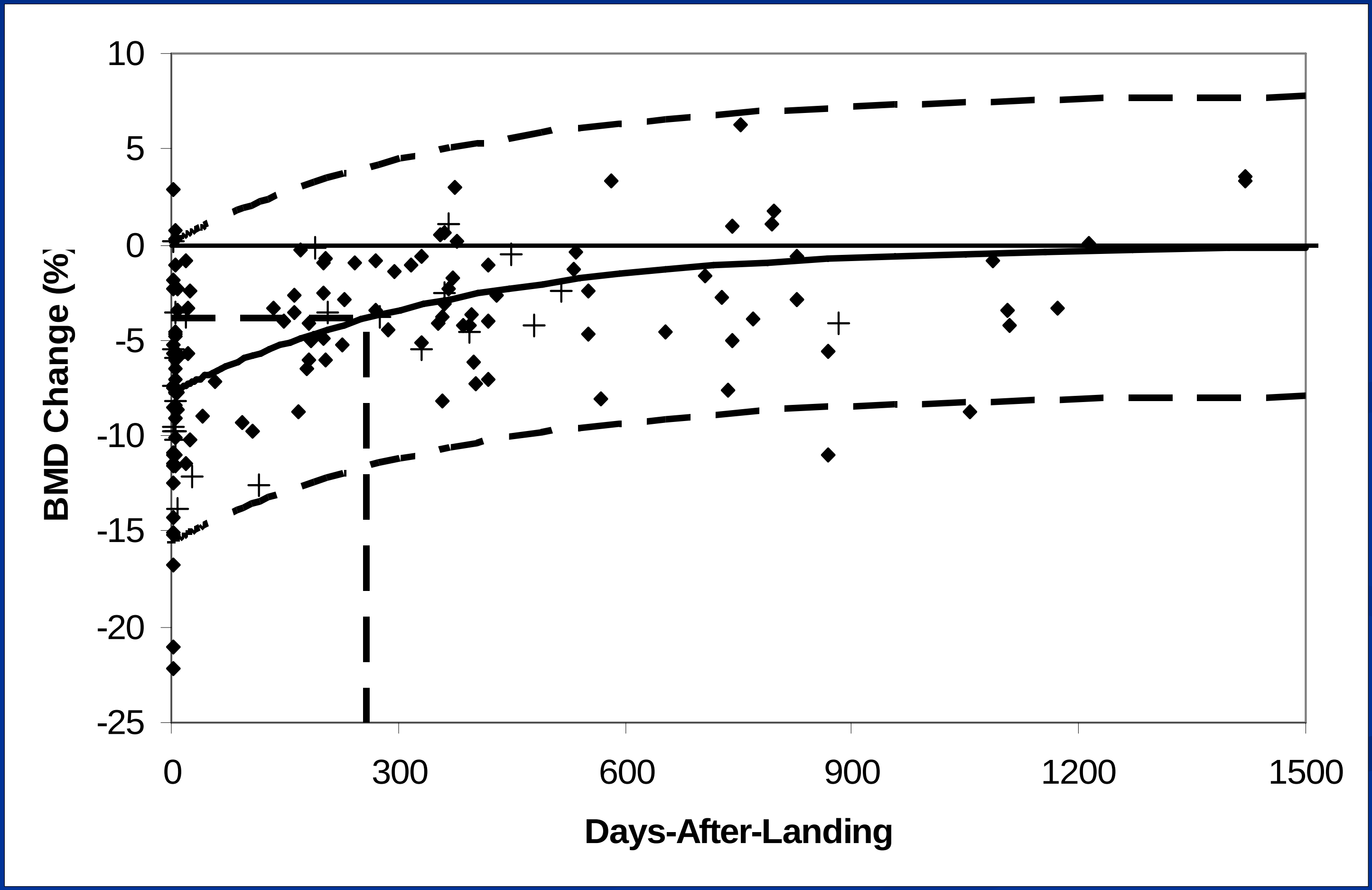
Trochanter

Loss$_0$= 7.8 %   Recovery Half-life=255d



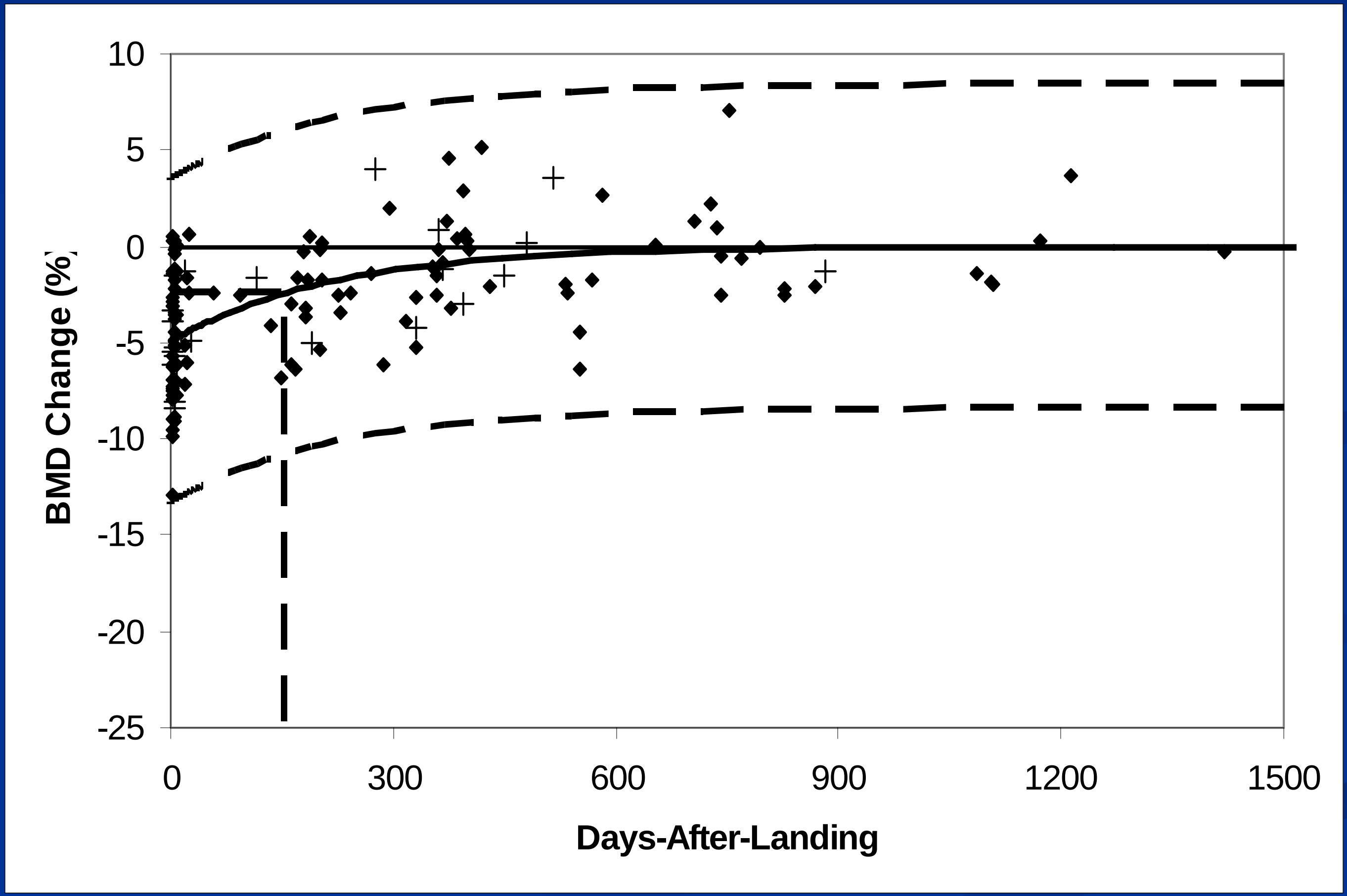
Pelvis

$Loss_0$= 7.7 % **Recovery Half-life=97d**



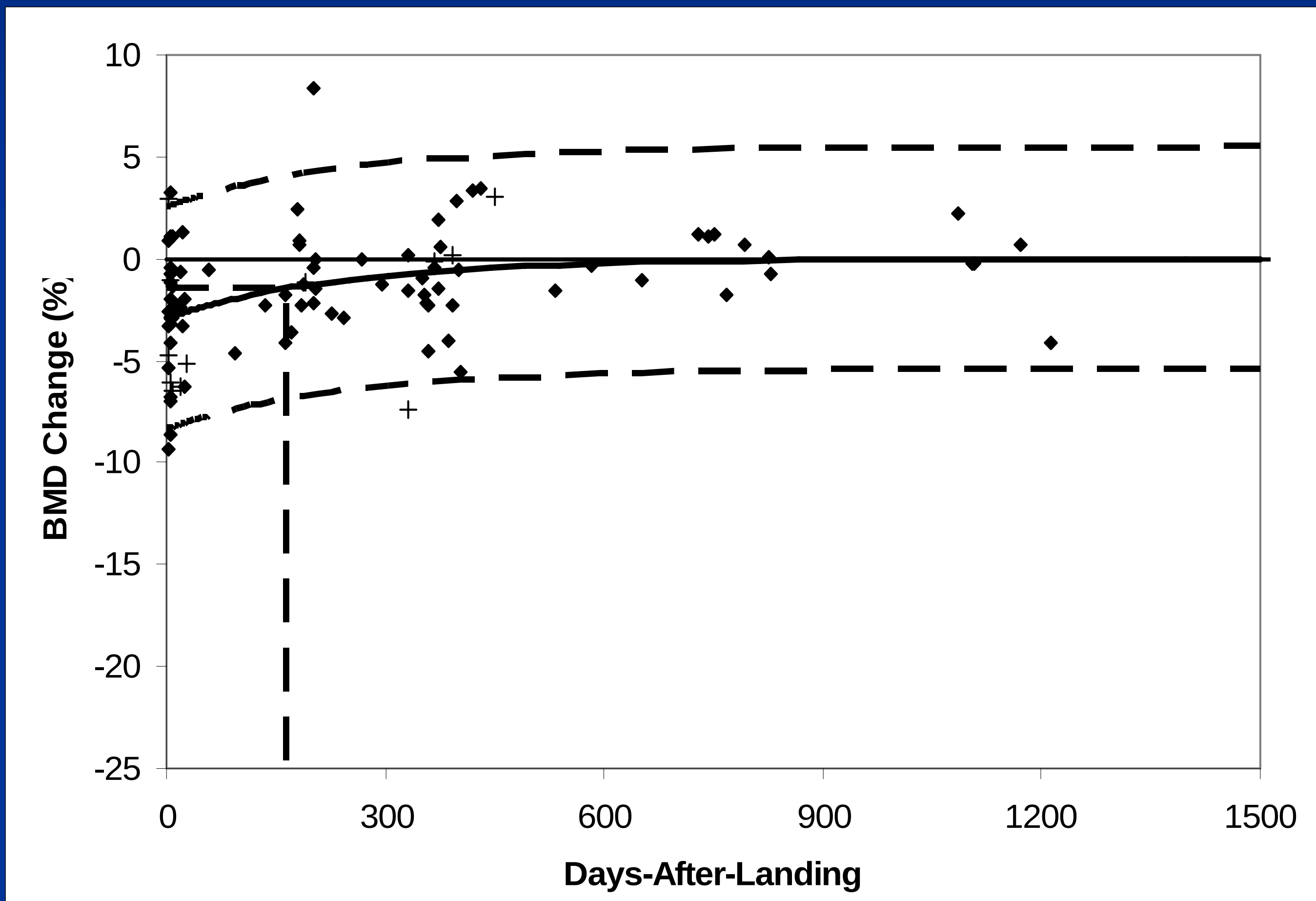
Lumbar Spine

$Loss_0$= 4.9% Recovery Half-life=151d



Calcaneus

Loss$_0$= 2.9%   Recovery Half-life=163d



Data Summary

Skeletal Site	Loss (L_0) at landing %	Recovery half-lives (days)
Femoral Neck	6.8 *(5.7, 7.9)*	211 *(129, 346)*
Trochanter	7.8 *(6.8, 8.8)*	255 *(173, 377)*
Pelvis	7.7 *(6.5, 8.9)*	97 *(56, 168)*
Lumbar Spine	4.9 *(3.8, 6.0)*	151 *(72, 315)*
Calcaneus	2.9 *(2.0, 3.8)*	163 *(67, 395)*

Limitations & Constraints

Inability to evaluate confounding or influencing factors

- Limited information on cosmonaut
- Limited # of multiple fliers, female fliers
- Minimal variability of flight durations

Privacy issues with medical data

Constraints with mission operations

- Time
- Access
- Use of same densitometers for pre- and postflight scans

Study Conclusions

Crew members after long-duration spaceflight recover bone lost during spaceflight.

Based upon our model, restoration to preflight BMD would occur within 3 years of return – period of recovery > mission duration.

Knowledge Gaps*

- Do we have a restoration of bone strength ?
- Will a compromised musculoskeletal system hold up to the loads/activities associated with critical mission tasks?
- What is the time course of bone loss in space?
- A preventative countermeasure validated in space (e.g., exercise, pharmacological agents)
- What skeletal change accounts for any deficit in function?

*partial list

Research Priorities*

- What additional evaluations need to be performed to establish a skeletal health risk during space missions (weightlessness and hypogravity)? E.g., *Need to fully characterize structural changes.*

- What are the factors accounting for those crew members who do not lose bone and those who lose a greater amount of bone while in space?

- What technologies can be used in space to assess musculoskeletal changes?

- What are the long-term health risks associated with spaceflight exposure?

*__partial list__

In closing,

- My expertise as *in vivo* investigator and histomorphometrist in the Human Research Program at Johnson Space Center – not likely
- My 20+ years in the bone and mineral field, the multiple collaborative projects and the value of service at the Mayo Clinic
- Making a contribution to the NASA as a bone biologist and providing a critical bridge to the expertise in the external science community

Thank you

Acknowledgments

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- Mayo Clinic (Rochester, MN)
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