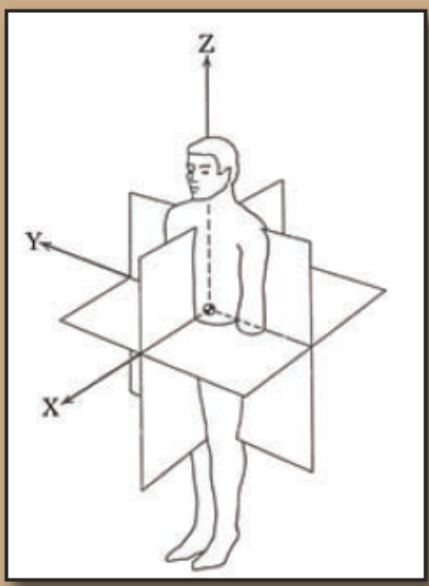
Humans And Acceleration

The NATO study referenced in this article's main text, *Injuries in Fatal Aircraft Accidents*, notes, "The human body is able to withstand remarkable crash forces if provided with appropriate restraint and if protected from collapsing structure and injurious interior objects." Just how much acceleration—positive or negative (deceleration)—can the human body withstand?

It depends—on gender, age, physical conditioning and a host of other factors. The direction of the acceleration also is a factor, since humans can withstand some 45G in some directions but only 15G in others.

The image at right, and the table below it, describe a common way to measure acceleration rates to which humans may be subjected. The three axes defined translate directly to the ways in which pilots think about an aircraft's movement about its center of gravity. The table at bottom lists the various human tolerance levels research has demonstrated, as well as the inertial response experienced.



Aircraft	Human
Roll	X
Pitch	Y
Yaw	Z

Perhaps the most successful and dramatic research into human acceleration tolerance was performed in the 1940s and 1950s by USAF Col. John P. Stapp at what is now Edwards Air Force Base. Stapp devised a rocket-powered sled mounted on rails and incorporated a braking system allowing significant G forces to be applied. We recognized Stapp and his contributions to crash-survivability research in our January 2006 issue. As we wrote at the time, "By riding the decelerator sled himself, Dr. Stapp demonstrated that a human can withstand at least 45G in the forward position, with an adequate harness. This is the highest known G force voluntarily encountered by a human."

But that's not all there is to a general aviation aircraft's crashworthiness. When considering a human seated in an airframe and being subjected to these acceleration, factors like restraints and the aircraft structure itself play huge roles, as does the aircraft's velocity. The sidebar on page 19 details the results of NTSB research into crash survivability.

Direction of Acceleration	Occupant's Inertial Response	Tolerance Level
Headward (+Gz)	Eyeballs Down	20-25G
Tailward (-Gz)	Eyeballs Up	15G
Lateral Right (+Gy)	Eyeballs Left	20 G
Lateral Left (-Gy)	Eyeballs Right	20G
Back to Chest (+Gx)	Eyeballs Out	45G
Chest to Back (-Gx)	Eyeballs In	45G