

Long pass: Pigskin in wobbly flight

It's the last minute of the game. Quarterback John Elway of the Denver Broncos fires the football down the field. Wobbling slightly as it soars through the air, the spinning pigskin travels in a long arc into the outstretched arms of a receiver. Touchdown!

To an aerodynamics expert watching the play, the real surprise is that, unlike a bullet, artillery shell, or unguided missile, a football doesn't naturally drift to one side when it flies a long distance. This puzzle so intrigued engineer William J. Rae that he has spent the last few years investigating the motion of a football, particularly during a long pass.

"It turns out that the flight of a football is almost as complicated as the flight of an airplane," says Rae of the mechanical and aerospace engineering department at the State University of New York at Buffalo. He uses his football studies as a way to involve students in his flight dynamics class.

Anyone who has thrown a football successfully knows from experience that one must give it a substantial spin about its long axis. Otherwise, it tumbles end over end instead of following the tight spiral of a well-thrown pass.

Ballistics engineers apply the same principle to stabilize the flight of artillery shells and missiles. However, when a shell and most other elongated, rapidly spinning objects travel in an arc through the air, they experience an aerodynamic twisting force, or torque, that causes them to drift to one side of their initial path.

That doesn't happen to a thrown football.

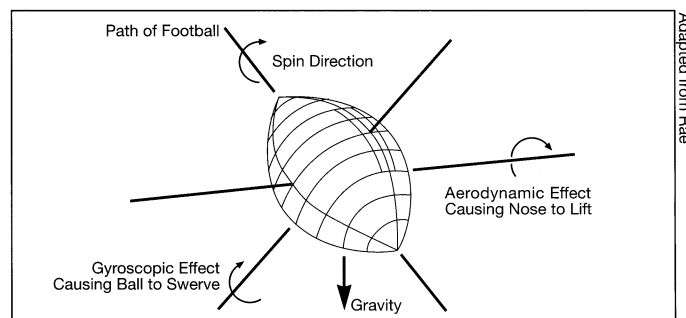
One clue to its apparently aberrant behavior may lie in the observation that a football thrown long distances not only spins but also usually wobbles. The football's nose doesn't point directly along the ball's path. Instead, as it moves forward, the ball's angled nose also precesses, tracing out a circle

centered on the flight path. Studies show that a football typically spins about five times for every three times its nose circles.

Rae's computer simulations suggest that this motion introduces an additional aerodynamic force, known as the Magnus effect, that essentially cancels out a football's tendency to drift to one side during its flight. It isn't completely clear why this effect would be important for a football but not for a missile or bullet.

"This is work very much in progress," Rae says. "My period of doing computer simulations and twiddling knobs is over now. It's time to get into the wind tunnel and make some measurements."

These studies also make it easier to appreciate the tremendous skill of professional quarterbacks. "It's a credit to these fellows that they are able to throw tight passes over such long distances," Rae comments.



Adapted from Rae

Twisting forces, or torques, acting on a thrown football include a gyroscopic component due to the ball's spin and an aerodynamic component that tends to push the football's nose up while causing a sideways drift.

SCIENCE NEWS INDEX

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A	Allan, Jonathan S.299	<i>Arabidopsis</i>399	Baby Fae298	Bertschinger, Edmund212
Abdullah, K.38	Allard, Frances389	Archives, preservation.....58	Bach, Fritz H.298	Beschorner, William E.300
Abortion165	Allergies172	Archuleta, Ralph J.404	Bacteria20, 117, 167	Beta amyloid23
Abstracting services55	Alligators44	Arendt, Detlev218	Bailey, J. Michael295	Beta-blockers327
Acetaldehyde200	Alstad, Donald N.21	Argon199	Baker, Ralph S.39	Beta carotene244
Acetylsalicylic acid.....102, 165	Altruism328	Aronowitz, Bonnie41	Balandrin, Manuel F.392	Beta Lyrae9
Acoustic pingers423	Alzheimer's disease62, 84, 89,	Arthritis, rheumatoid158,	Baldwin, Brian S.376	Beta Pictoris37
Acoustic thermometry415	139, 311, 394	171, 263	Baliunas, Sallie238	Betulinic acid231
Activin223	Alzheimer's disease,	Arthropods216	Balogh, André278	Betz, Hans-Dieter.....91
ADA deficiency284	early-onset23, 118	Artificial life280	Baltimore, David388	Bhardwaj, Harbans L.377
Addiction406	Alzheimer's disease, S182 gene ..23	Asai, Rihito150	Banks, Sir Joseph249	Bidleman, Terry F.39
Adenoviruses149	American Association for the	Ash, Richard A.199	Barnham, Michael261	Bier, Ethan218
Adler, John137	Advancement of Science204	Ashburner, Michael423	Bar-Yosef, Ofer261	Bimber, Bruce286
Adolescents277	Americas, early civilization250	Ashkenazi Jews215	Baranyai, Peter S.378	Biological clock108, 111, 334
Aerodynamics442	Americas, human occupation ...250	Asteroids248, 283	Bard, Allen338	Biological diversity326
Agate180	Amos, Bill7	Asthma279	Barnham, Michael235	Bioluminescence.....108
Aging15, 36, 84, 86, 283, 363	Amyloid precursor protein89	Astro 2 Observatory9, 76	Bartel, David P.53	Biomimetics309
Agriculture376, 423	Anderson, Dana Z.292	Astrometry332	Baski, Alison A.223	Biomimetics309
Aguillon Martinez, Martha C. ...314	Anderson, David J.284	Asymmetry223	Basri, Gibor S.200	Biomolecules70
A'Hearn, Michael428	Anderson, James W.127	Atala, Anthony25	Bass, Andrew H.267	Bioremediation39, 85, 359
AIDS198, 299, 388	Anderson, Roy382	Atom manipulation175, 292	Bates, John K.374	Biosensors157
AIDS, long-term survivors71, 308	Andes Mountains124	Atoms252	Batten disease223	Biot, Jean-Baptiste249
AIDS drugs116, 172,	Andow, David A.21	Atrial fibrillation182	Bauman, Margaret116	Birds231, 277, 378, 388
324, 388, 409	Andrews, Peter119	Attention deficit disorder360	Baumgardner, Jeffrey397	Birds, songbird dialects236
AIDS vaccines276, 308	Angel, J. Roger260, 333	Auchincloss, Hugh, Jr.300	Bazzaz, Fakhri101	Birkhead, Timothy R.231
Air pollution117, 232, 431	Angelfish150	Auroras334	Beachey, Philip A.246	Birnbaum, Linda45
Air pollution, health effects ..5, 247	Angioplasty214	<i>Australopithecus</i>71, 119, 155	Beal, M. Flint84	Birth defects127, 244, 314
Air pressure207	Antarctica87	Autism116	Beard, K. Christopher309	Bishop, Colin E.132
Aircraft206, 229	Antibodies230	Automobiles232	Bedwetting111	Bjorker, Gordon L.420
Akazawa, Takeru261	Anticoagulants175, 182	Autonomic nervous system276	Beeman, Richard W.247	Bjorgo, Einar123
Alaska359	Antimatter38, 268	Avorn, Jerry86	Beer375, 380	Black, David C.332
Albritton, Daniel L. ...238, 262, 405	Antioxidants399	Axons356	Bees212, 329	Black holes140, 407
Alcohol135, 375, 380	Ants280, 311	Ayala, Francisco J.200	Belitsos, Peter C.311	Blackburn, Elizabeth.....362
Alcohol abuse200	Anxiety191, 277	Ayres, Matthew P.119	Bell, Roger A.151	Bladder disease25
Alcoholism20, 79, 135	Apfel, Robert E.325	Babbitt, Bruce43	Berg, Howard C.167	Blaese, R. Michael284
Algae294	Apolipoproteins23, 394	Babergeron, Ann172	Berthoz, Alain105	Blake, Donald R.117
Algorithms150	Apoptosis263, 421	Baboons298		Blankschtein, Daniel.....100
	Aquarius laboratory185			
		B		