

# Human Packing:

An Exploration of Density Bounds for Coffins, Cars, and Chambers

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Human

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## Abstract

The problem of packing identical objects into bounded containers has been studied for squares [69], circles, and spheres [420], but not humans. We approximate the human body as a rigid shape and investigate how many fit inside everyday human enclosures via face-centered cubic lattice optimization with exact geometric containment. Principal findings include that a standard coffin cannot, despite advertising a capacity of one, hold a single human, and that the Boeing 747 is underutilized by a factor of 13.6 (though we expect this margin to narrow as legroom continues to shrink).

## 1 Introduction

Readers may be familiar with spherical cows of uniform density. We take the logical next step: approximating the human body as a rigid sphere and investigating how many fit inside everyday enclosures. The problem turns out to be choosing *which* sphere: a volume-equivalent sphere has a radius of 25 cm (a beach ball); a height-bounding sphere has a radius of 85 cm (a hamster ball). That is a 240% difference in radius and a 3,800% difference in volume.

Fortunately, sphere packing is well-studied. Kepler conjectured in 1611 [1] that the face-centered cubic (FCC) arrangement achieves maximum density at  $\pi/(3\sqrt{2}) \approx 74.05\%$ , proved by Hales in 2005 [420] and formally verified in 2017 [2]. The analogous problem of packing into finite containers, where wall effects dominate, has been studied for squares [69]. We encounter the same boundary-dominated regime in venues as small as the K6 telephone booth (0.80 m  $\times$  0.80 m  $\times$  2.30 m).

### 1.1 Contributions

1. Four spherical human models derived from anthropometric data.
2. Packing results for nine human enclosures with exact geometric containment.
3. The *Child Advantage Factor* (CAF): children pack 1.9–4.8 $\times$  more efficiently.
4. The *Overfat Paradox*: real humans outperform spheres in the K6 phone booth (5:1) and Volkswagen Beetle (1.7:1).
5. The *Coffin Curiosity*: the Meatball exceeds the casket’s depth by 119 mm.

## 2 Related Work

The packing of objects into bounded containers remains an active and challenging area of research.

Astute readers may wonder why we approximate humans as spheres when Cui et al. [3] recently demonstrated spectral packing of arbitrary 3D meshes at SIGGRAPH, achieving 670 objects in 40

seconds. In principle, one could obtain a high-resolution full-body 3D scan, segment the mesh into a watertight manifold, compute the signed distance field, voxelize the container geometry, evaluate the spectral correlation function via FFT, solve the resulting nonlinear optimization problem, and produce a physically exact packing of anatomically correct humans. However, those readers would have failed to consider that this paper was written on a literal potato that barely runs Doom and would take approximately three hundred million years per venue. Thus spheres were selected for no other arbitrary reason such as laziness.

The phone booth stuffing craze of 1959 produced a record of 25 students in a South African booth [4]. The VW Beetle record is 20 [5] humans. These serve as our primary experimental validation, and constitute useful evidence against the sphere packing methodology.

### 3 The Spherical Human: A Taxonomy

The central challenge is selecting the correct sphere to represent a human body. We develop four models, each derived from published anthropometric data.

**The Meatball (Volume-Equivalent).** The average human body has a volume of 65.22 L, as measured via underwater weighing [6].<sup>1</sup> The volume-equivalent sphere has radius  $r = (3V/4\pi)^{1/3} = 0.250$  m, producing a 50 cm sphere approximately the size of a beach ball.

**The Freedom Sphere (American Adult).** The average American adult has a mass of 83.6 kg (CDC NHANES) [8]. At tissue density  $\rho = 985$  kg/m<sup>3</sup>, this yields  $r = 0.273$  m—9% larger in radius and 30% larger in volume than the global Meatball.

**The Hamster Ball (Height-Bounding).** For applications requiring the sphere to physically enclose a standing human, we use the global average height of 1.70 m [7], giving  $r = 0.850$  m. This sphere has a volume of 2,572 L—39× the actual body. The interior is 97.5% air.<sup>2</sup> At the density required to match a 62 kg human, the effective density is 24.1 kg/m<sup>3</sup>, comparable to Styrofoam.

**The Kid (Child, Age 8).** The average 8-year-old has a mass of 25.6 kg at the 50th percentile (CDC growth charts) [9]. At child tissue density  $\rho \approx 1010$  kg/m<sup>3</sup>, this gives  $r = 0.182$  m—a sphere the size of a Pilates ball.

Table 1: Spherical human models.

Model	Basis	$r$ (m)	Vol. (L)	Vibes
The Meatball	Body volume	0.250	65.2	dense
The Freedom Sphere	American mass	0.273	84.9	patriotic
The Hamster Ball	Standing height	0.850	2572	absurd
The Kid	Child (~8) mass	0.182	25.3	invited to the island

<sup>1</sup>Underwater weighing would be easier if the subjects were spheres.

<sup>2</sup>Or hamster bedding.

## 4 The Enclosures

We select nine enclosures that collectively span three orders of magnitude in volume (0.44–968 m<sup>3</sup>) and represent the principal contexts in which humans find themselves contained: transit, recreation, shelter, and storage. All dimensions are sourced from manufacturer specifications or engineering surveys.

Table 2: Enclosures with verified dimensions, volumes, and rated capacities.

Venue	Shape	Vol. (m <sup>3</sup> )	Rated	Source
Standard Coffin	Box	0.44	1	[10]
K6 Phone Booth	Domed box	1.38	1 <sup>†</sup>	[11]
Jacuzzi J-345	Box	1.96	6	[12]
Porta-Potty	Box	2.25	1	[13]
VW Beetle (Classic)	Rounded box	2.28	4 <sup>‡</sup>	[14]
Elevator (Otis Gen2 MRL)	Box	8.31	21	[15]
ISS Destiny Lab	Cylinder	122	3	[16]
King’s Chamber	Box	319	1	[17]
Boeing 747-400	Fuselage	968	660	[18]

<sup>†</sup> World record: 25 (University of Natal, Durban, 1959) [4]. <sup>‡</sup> World record: 20 (Guinness, 2010) [5].

The **coffin** interior is 1.98 m × 0.58 m × 0.38 m (78” × 23” × 15”) [10]. The **King’s Chamber** of the Great Pyramid measures 10.47 m × 5.23 m × 5.82 m, surveyed by Petrie in 1883 [17]; it was built for one sarcophagus. The **ISS Destiny Module** is a 4.27 m-diameter cylinder, 8.53 m long [16].<sup>3</sup> In microgravity there is no floor, so the entire volume is usable. The **Boeing 747-400** main deck is modeled as a 6.13 m-diameter fuselage with a floor cut at 2.70 m above the fuselage bottom [18].

## 5 Methodology

For each (model, venue) pair, we generate FCC and simple cubic lattices, searching over a  $5^3 = 125$  grid of origin offsets and keeping the best. Each candidate sphere is tested against the venue’s exact boundary—box, dome, cylinder, fuselage, or rounded box. No partial containment is permitted.<sup>4</sup>

An interesting methodological finding: simple cubic packing *outperforms* FCC in three of nine venues (Jacuzzi, Porta-Potty, and VW Beetle—all small containers). In a hot tub, the theoretically optimal lattice is the wrong lattice. We suspect Kepler did not test his conjecture in a Jacuzzi.

<sup>3</sup>The ISS has been continuously inhabited since November 2, 2000, making it one of the longest-occupied human enclosures in history. We consider 25 years of uninterrupted residency sufficient to qualify as “everyday.”

<sup>4</sup>Partial humans are outside the scope of this paper.

## 6 Results

Table 3: Spherical humans packed per venue. Ratio = Meatball / rated capacity.

Venue	Rated	Meatball	Freedom	Hamster	Kid	Ratio
Standard Coffin	1	0	0	0	5	0×
Jacuzzi J-345	6	9	6	0	32	1.5×
Elevator	21	53	45	0	160	2.5×
VW Beetle	4	12	10	0	36	3×
K6 Phone Booth	1	5	4	0	24	5×
Boeing 747-400	660	8,966	7,072	165	24,724	13.6×
Porta-Potty	1	16	6	0	30	16×
ISS Destiny	3	1,050	774	15	2,954	350×
King's Chamber	1	3,080	2,220	54	8,512	3,080×

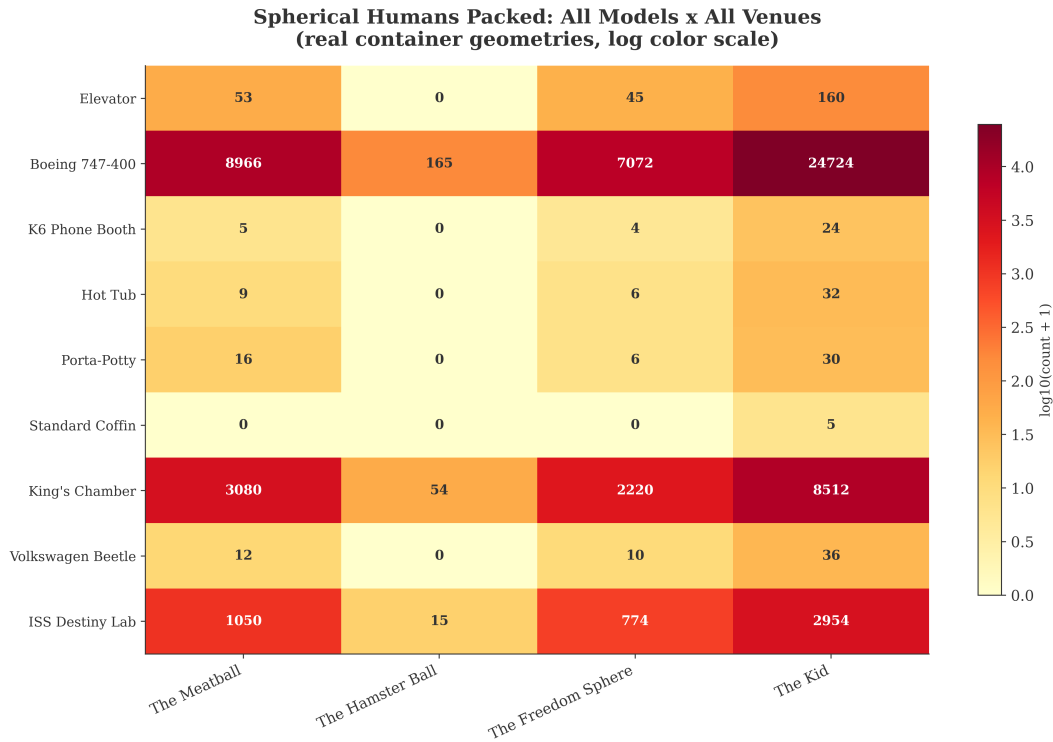


Figure 1: All models × all venues (log color scale).



Figure 2: Left: 16 Meatball spheres in a PolyJohn PJN3 porta-potty (cubic lattice). Right: 5 Meatball spheres in a K6 telephone booth (FCC). The world record for the K6 is 25 real humans.

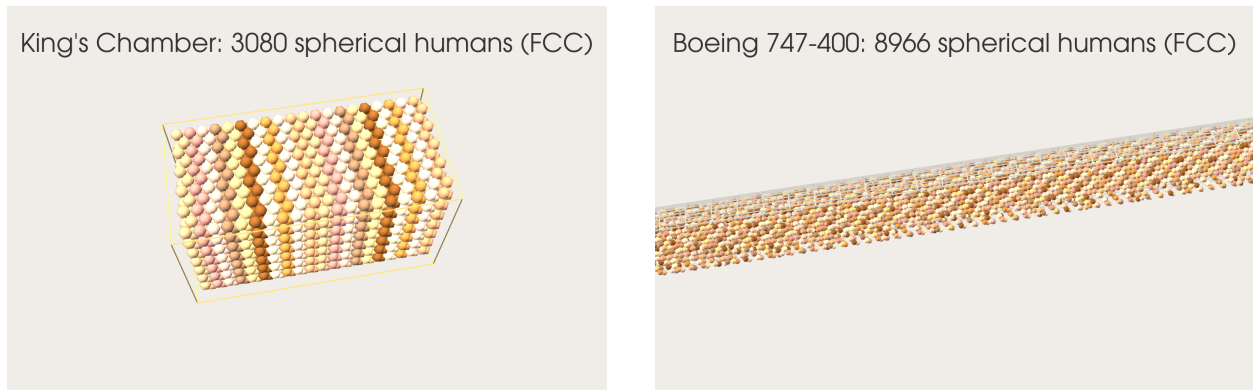


Figure 3: Left: 3,080 Meatball spheres in the King’s Chamber (FCC). The rated capacity is 1 deceased pharaoh. Right: 8,966 Meatball spheres in a Boeing 747-400 main deck (FCC). The rated capacity is 660 living passengers.

## 7 Discussion

### 7.1 The Coffin Curiosity

A coffin is designed to hold exactly one human. Yet, it cannot hold a single spherical one.

The reason is geometric: a human body is roughly 1.70 m tall but only about 0.30 m deep at the chest. A casket exploits this aspect ratio—it is long and shallow, with an interior depth of just 0.380 m (15 inches). The Meatball, by contrast, compresses all 65 L of human volume into a sphere of diameter 0.499 m, which exceeds the casket depth in every direction—the opposite of a supine body. The sphere exceeds the casket depth by 119 mm, roughly the width of a clenched fist. The one container in our study purpose-built for a human body fails to contain its spherical approximation, precisely *because* it was designed for the actual shape.

Only the Kid model succeeds: 5 spherical children in a standard casket ( $CAF = \infty$ ).

At a compressive strain of  $\varepsilon = 119/499 = 23.8\%$ , a sufficiently determined mortician could close the lid. The resulting geometry would no longer be spherical, violating our core assumption and the core composition of the subject. We consider this the mortician’s problem, not ours.

## 7.2 The Overfat Paradox

Two venues have world records, and in both cases real humans beat spheres:

Venue	World Record	Meatball	Humans / Spheres
K6 Phone Booth	25	5	5.0×
VW Beetle	20	12	1.7×

Real humans outperform spheres by factors of 1.7–5.0×. They have articulated limbs, flexible joints, and the ability to scream at each other to move over. Spheres have none of these.

The phone booth result is the most damaging: our Kid model predicts 24 spherical children, still fewer than the 25 real adults who set the record in 1959. Those students were packed more efficiently than frictionless, rigid spheres the size of Pilates balls.

## 7.3 The Porta-Potty Problem

The porta-potty achieves the highest overestimation ratio of any venue: 16:1. Sixteen spherical adults in a space rated for one. Anyone who has waited in a porta-potty line at a music festival knows that the real limiting factor is not volume but willingness. Our model does not account for willingness.

The PolyJohn PJN3 has a square interior (1.04 m × 1.04 m), which fits exactly 2 × 2 Meatball spheres per layer with 4 layers tall: 2 × 2 × 4 = 16. This is one of three venues where simple cubic outperforms FCC—the theoretical optimum is the wrong lattice when your container is the size of a bathroom stall.

## 7.4 The Child Advantage

In a spirit of purely theoretical inquiry reminiscent of Swift [19], we define the *Child Advantage Factor*:  $CAF = n_{\text{Kid}}/n_{\text{Meatball}}$ .

Table 4: Child Advantage Factor by venue.

Venue	Meatball	The Kid	CAF
Standard Coffin	0 (1*)	5	∞
K6 Phone Booth	5	24	4.8×
Jacuzzi J-345	9	32	3.6×
VW Beetle	12	36	3.0×
Elevator	53	160	3.0×
ISS Destiny	1,050	2,954	2.8×
King’s Chamber	3,080	8,512	2.8×
Boeing 747-400	8,966	24,724	2.8×
Porta-Potty	16	30	1.9×

\* 1 at 23.8% compressive strain (see Section 7.1).

Average CAF (excluding the coffin): 3.1×. A Boeing 747-400 configured for spherical children seats 24,724.

## 7.5 Ancient and Orbital Extremes

The King’s Chamber achieves a ratio of 3,080:1. Khufu’s architects allocated 319 m<sup>3</sup> of granite to one occupant. By our analysis, the pharaoh was utilizing 0.03% of his tomb’s potential.

The ISS Destiny module packs 1,050 Meatballs—350× its crew of 3. In microgravity, the entire cylinder is usable, eliminating the dead space that afflicts every terrestrial venue. If astronauts were spherical, station design would simplify dramatically.

## 8 Conclusion

The spherical human approximation produces results that are dramatic and unreliable. The Meatball overpredicts by 1.5–3,080×. The Hamster Ball predicts zero for six of nine venues. The Overfat Paradox—real humans outperforming idealized spheres—undermines our central premise.

The Jacuzzi J-345, with a ratio of only 1.5×, comes closest to its rated capacity. People in hot tubs are seated, partially submerged, and relatively still. They are, we suggest, the most spherical configuration of humans available in everyday life.

### 8.1 Future Work

1. **Ellipsoidal humans.** The NP-hard ellipsoid packing problem [20].
2. **Deformable spheres.** A pressure-dependent radius model could explain the Overfat Paradox and the coffin compression scenario.
3. **Mesh packing.** Cui et al. [3] can pack arbitrary 3D shapes. One could pack human body scans directly, removing the need for spheres.
4. **Coffin redesign.** Minimum depth for one Meatball: 499 mm. Current standard: 380 mm.

## Acknowledgments

We thank the coffin, which defeated us, and the 25 students at the University of Natal who in 1959 proved that the human body is a better packing primitive than anything in this paper. We also acknowledge the Jacuzzi J-345, whose occupants remain the most spherical humans we have encountered. No spherical humans were harmed in the production of this work, as none exist. Finally, we thank the anonymous SIGBOVIK reviewers, who we assume read this paper in its entirety while packed into a phone booth.

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