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# Stress-induced endocrine responses and anxiety: the effects of comfort food

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# Obesity

- Prevalence of overweight and obesity.
- In the USA approximately two thirds of the population is overweight, and nearly one third is obese.
- The causes of the epidemic obesity are complex, and stress has been identified as an important factor.
- Increased rates of obesity have been accompanied by a concomitant rise in perceived stress in North America.

Flegal et al., 2010

# Components of stress system

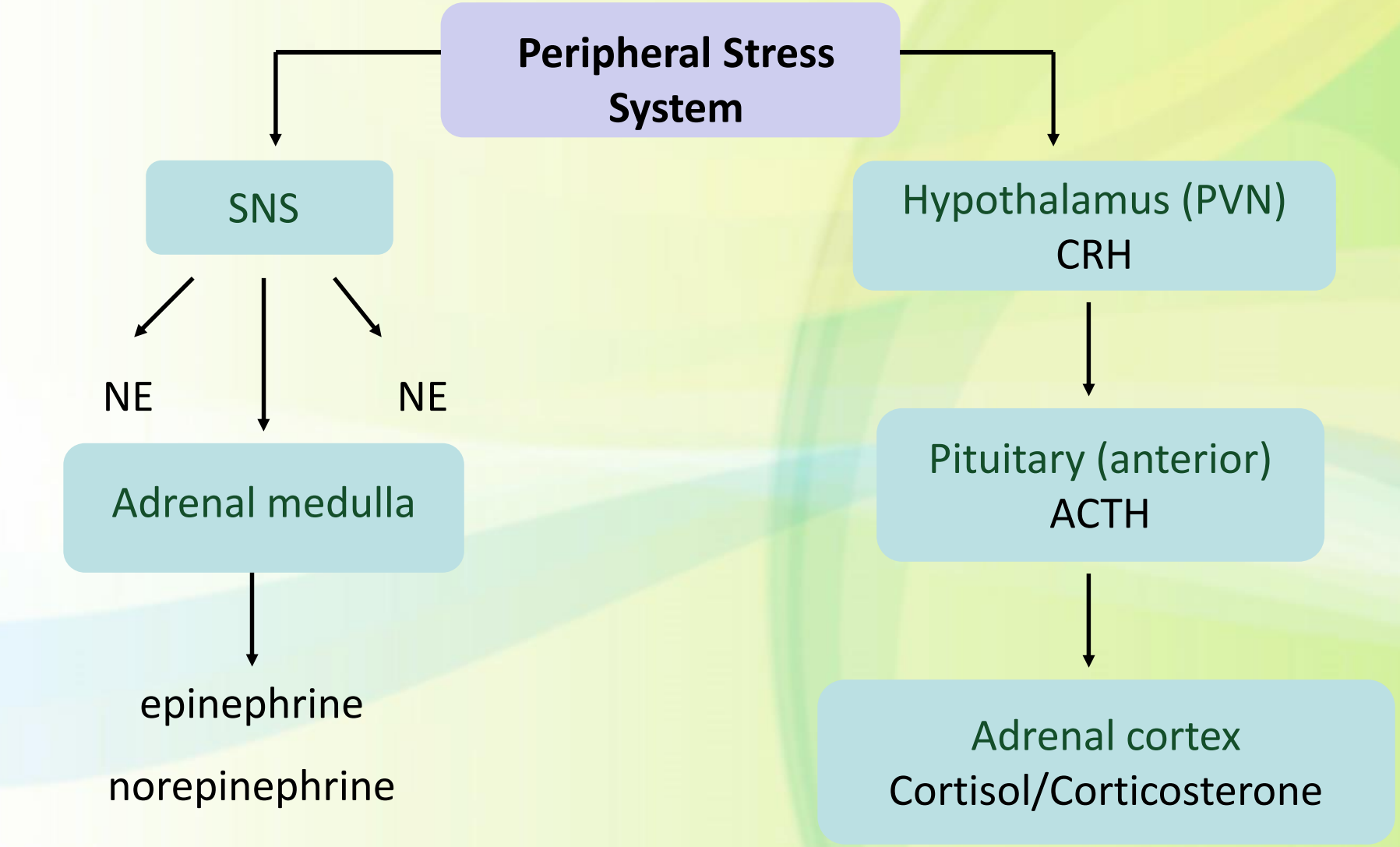
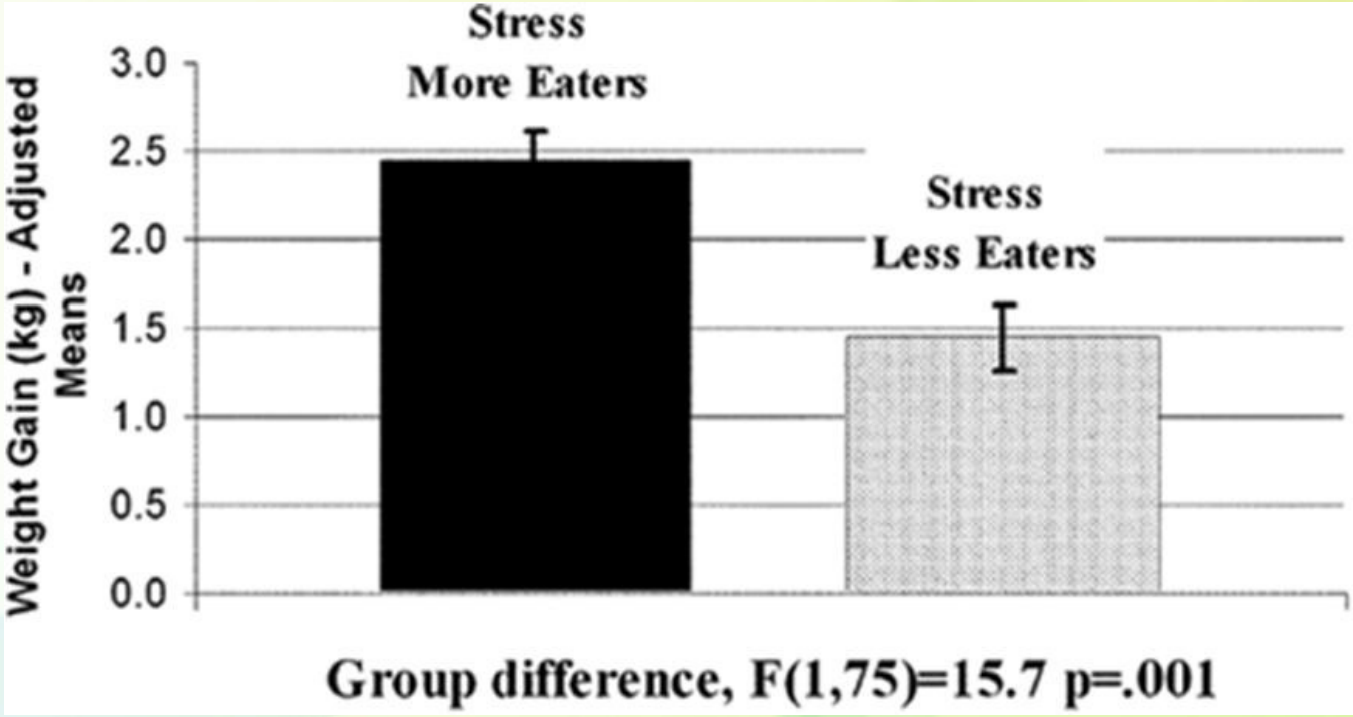


**Table 1** Main outcome measures and tests of differences between top vs. bottom stress quartiles.

| | *n* | High stress | Low stress | *p* |
|---|---|---|---|---|
| Emotional eating (1–5 scale) | 19 | 3.16 (1.39) | 2.18 (0.95) | .05 |
| Saggital diameter (cm) | 31 | 20.92 (5.30) | 18.24 (4.09) | .05 |
| BMI | 32 | 25.97 (4.26) | 23.89 (3.24) | .04 |

Tomiyama et al., 2011

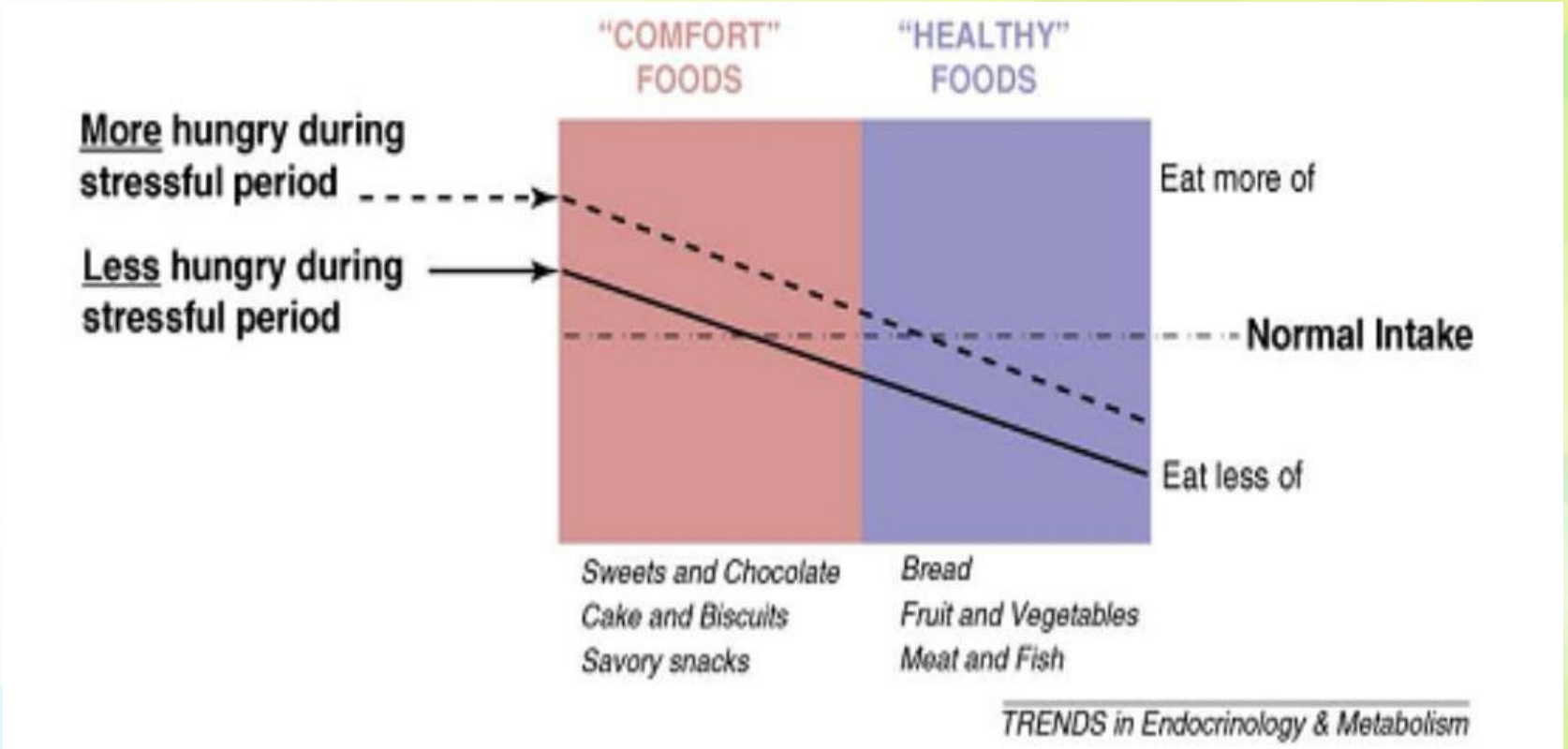



Epel et al., 2004

One subset of the population increases food intake under stress and conversely, another decreases food intake.

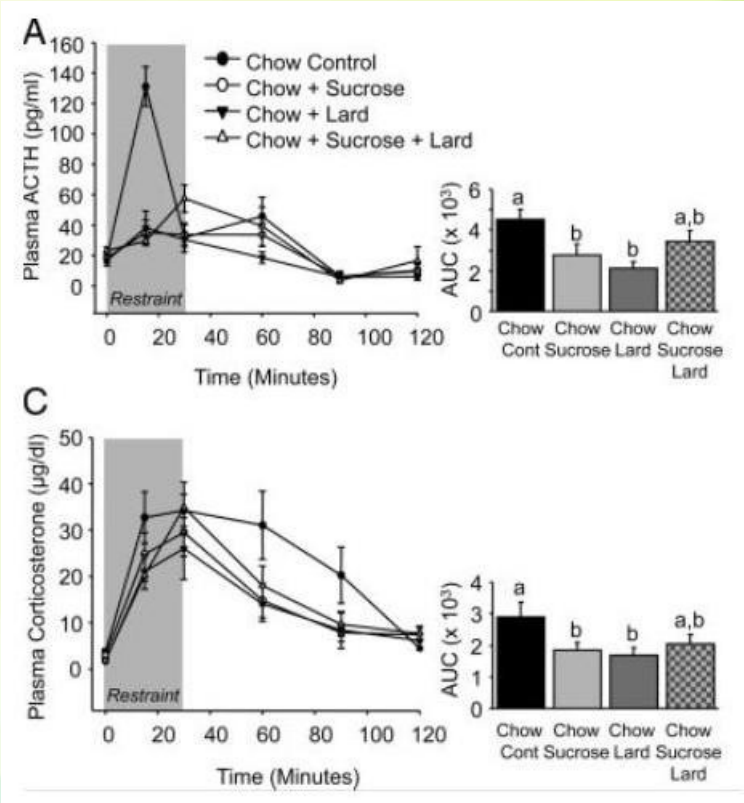
Block et al., 2009

# Stress and food preference




Foster et al., 2009; la Fleur et al., 2005

- Access to sucrose reduces the activation of the HPA axis in response to stress.




Foster et al., 2009

- Consumption of more palatable food improves emotional states, as reflected by reduced anxiety- and depressive-type behaviors.

Maniam and Morris, 2010
Ulrich-Lai et al., 2010

## Stress models used in the Laboratory of Stress Biology

- Foot shock stress – short-term stress (120 electric paw shock; 1 mA, 1 s; 30 min/day; 3 consecutive days).

- Chronic unpredictable mild stress (CUMS) – 14 days.

## Regular chow + comfort food

- Cafeteria diet
- High carbohidrate
- High lipids

Ortolani et al., 2011; 2014

# Behavioral analysis

**EPM** **EZM** **OF**

- light intensity: 60 lux, behavior was registered during 5 min.

**Analized parameters:**

- number of entries
- time spent in the open and closed arms
- number of head dipping, rearing, fecal bolus, stretched-attend posture, risk assessment and grooming.

**Analized parameters:**

- latency of first crossing,
- time spent in the periphery and in the center
- number of crossing, rearing, grooming and fecal bolus.

# Foot shock stress reduces the intake of regular chow but not that of comfort food

| | Commercial chow | | Comfort food | |
|---|---|---|---|---|
| | Control (20) | Stress (20) | Control (15) | Stress (15) |
| Commercial (g) | $24.05 \pm 0.77$ | $21.90 \pm 0.61^{a}$ | $1.43 \pm 0.30$ | $0.55 \pm 0.18^{a}$ |
| Comfort (g) | – | – | $21.77 \pm 0.59^{b}$ | $21.87 \pm 1.39^{b}$ |
| Total calories (kJ) | $409.6 \pm 13.2$ | $372.9 \pm 10.4^{c}$ | $490.2 \pm 10.9^{c}$ | $478.7 \pm 29.5^{c}$ |
| Gain body weight (g) | $10.80 \pm 1.14$ | $8.95 \pm 1.70$ | $8.43 \pm 0.83$ | $6.53 \pm 1.20$ |

Ortolani et al., 2011

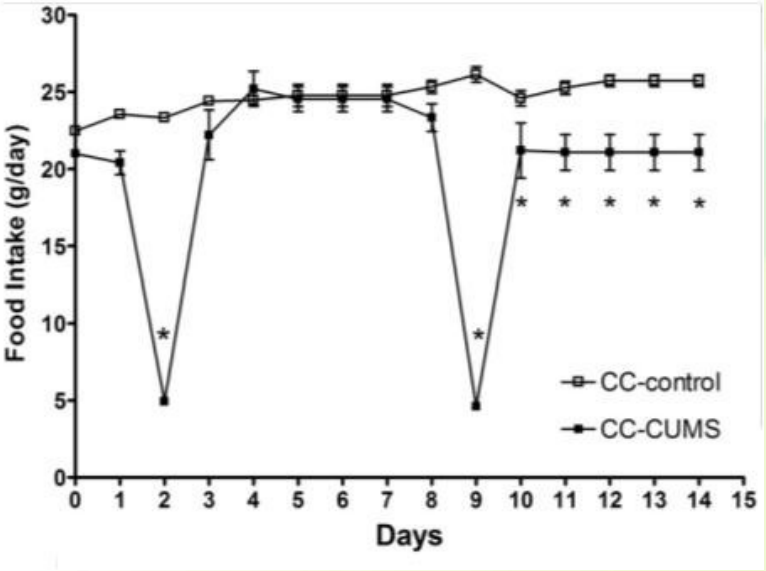
Many factors may be envolved:

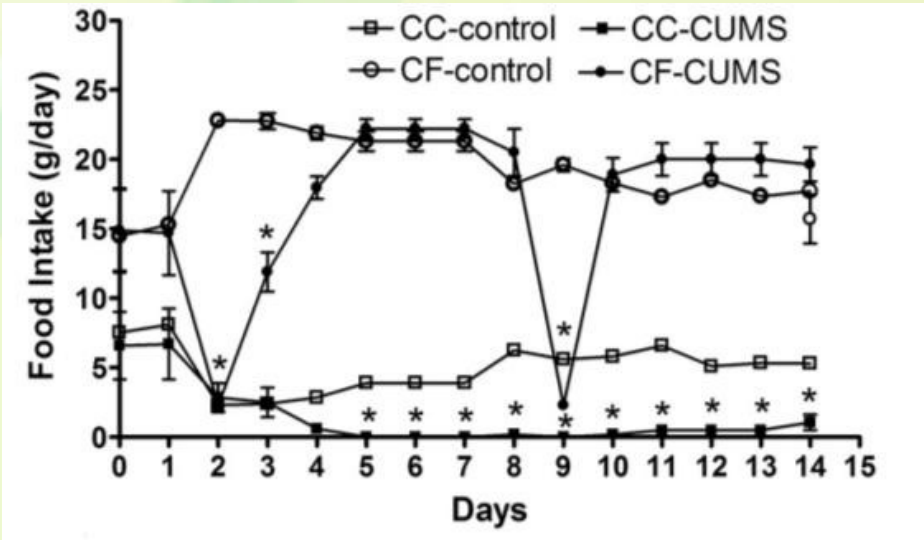
- Activation of autonomic nervous system;
- Release of CRH, ACTH, glucocorticoids, leptin and insulin.

The mechanisms have not been clarified yet

# CUMS reduces the intake of commercial chow and comfort food

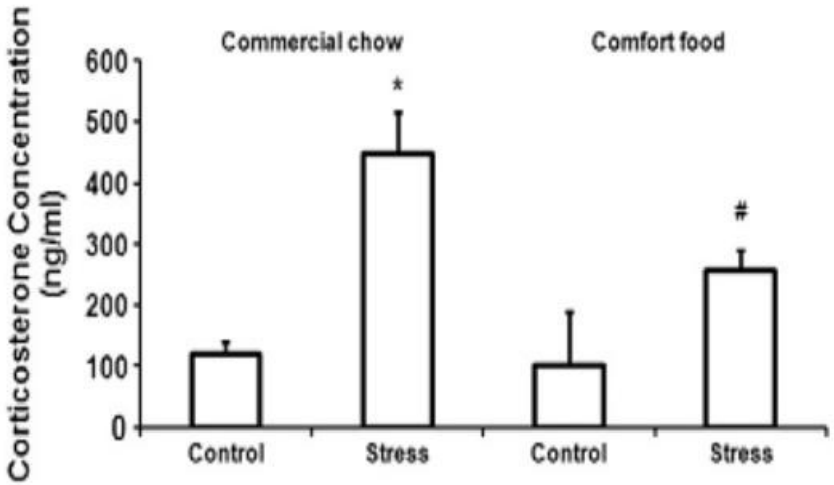
| Parameter | Group | | | |
|---|---|---|---|---|
| | CC-control | CC-CUMS | CC/CF-control | CC/CF-CUMS |
| Commercial chow intake (g/day) | 24.9 ± 0.3 | 22.9 ± 0.7[a] | 4.77 ± 0.02 | 1.06 ± 0.4[a] |
| Comfort food intake (g/day) | – | – | 19.7 ± 0.1[b] | 19.1 ± 0.5[a,b] |
| Total caloric intake (kJ/day) | 423 ± 5 | 390 ± 12[a] | 562 ± 2[b] | 428 ± 10[a,c] |
| Initial body weight (g) | 202 ± 5 | 192 ± 5 | 196 ± 4 | 191 ± 6 |
| Body weight gain (g) | 79 ± 2 | 59 ± 4[a] | 104 ± 4[b] | 74 ± 5[a] |

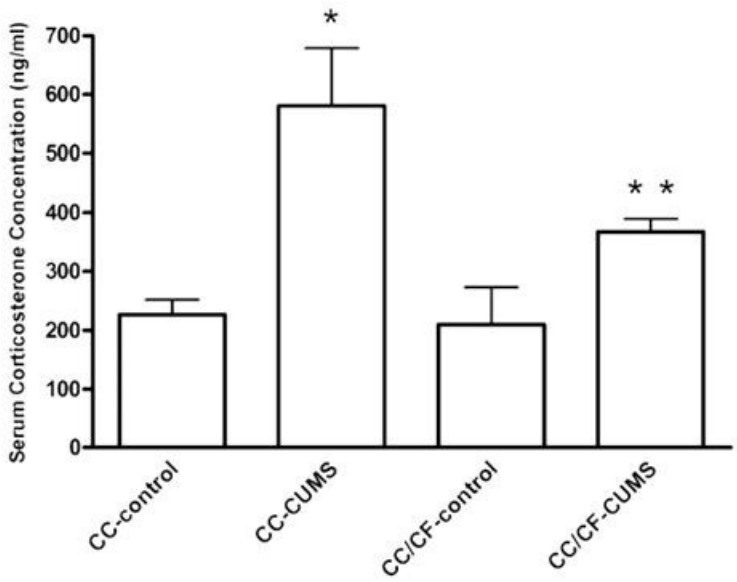



Ortolani et al., 2014

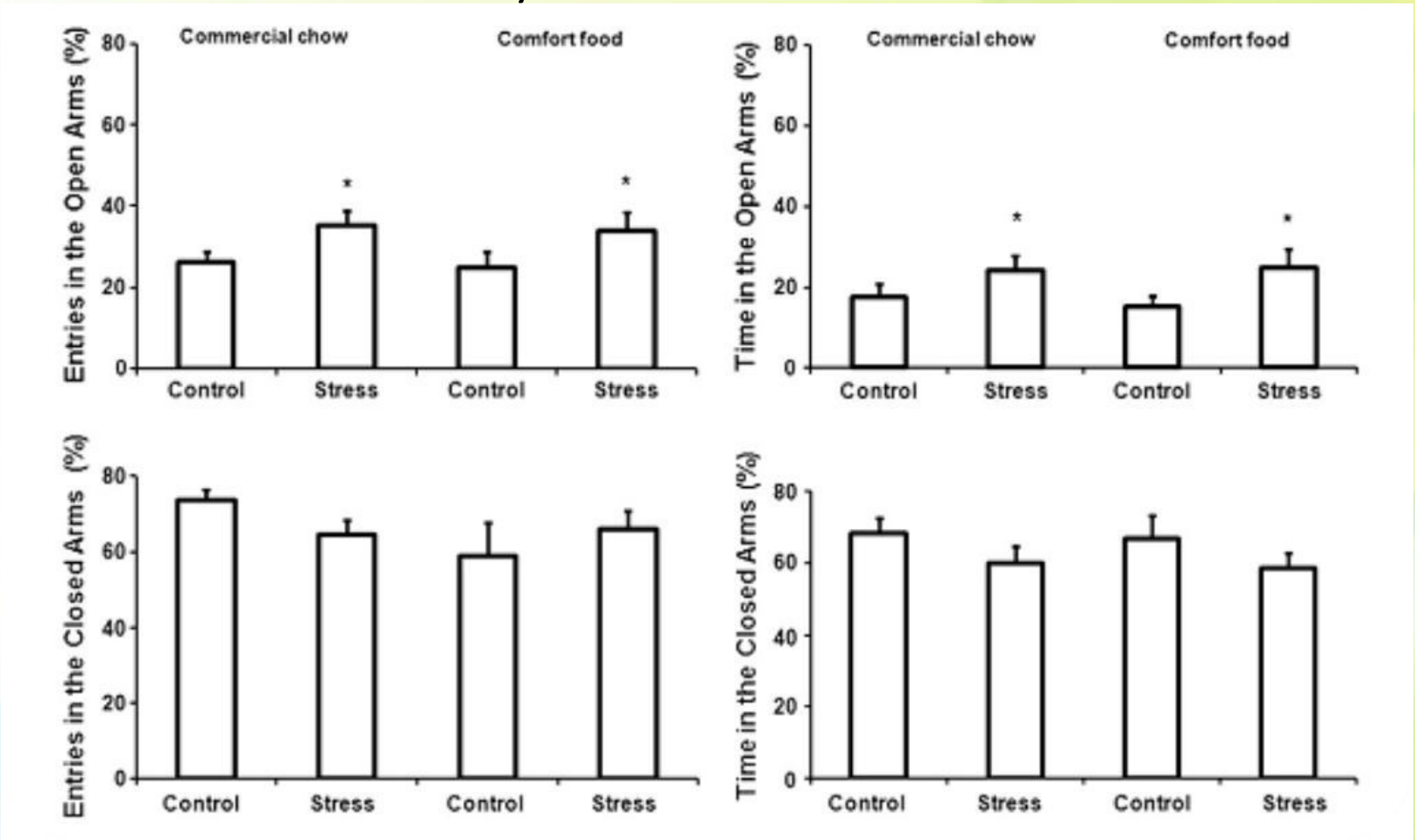
# Comfort food intake attenuates endocrine response to foot shock stress and CUMS




Ortolani et al., 2011; 2014

- Foot shock stress reduces anxiety-like behaviors – EPM.
- This effect is not altered by comfort food.




Ortolani et al., 2011

- Foot shock stress reduces anxiety-like behaviors – EPM.
- This effect is not altered by comfort food.

| | Commercial chow | | Comfort food | |
|---|---|---|---|---|
| | Control (20) | Stress (18) | Control (12) | Stress (11) |
| Head dipping | 13.85 ± 1.61 | 19.16 ± 2.85 * | 12.58 ± 2.19 | 18.45 ± 2.07 * |
| Rearing | 0 | 0 | 0 | 0 |
| Fecal bolus | 0.35 ± 0.18 | 0.61 ± 0.31 | 0.00 | 0.09 ± 0.09 |
| Stretched-attend posture | 13.05 ± 1.26 | 8.11 ± 1.19 * | 12.25 ± 1.41 | 9.54 ± 1.25 * |
| Risk assessment | 17.70 ± 0.92 | 13.44 ± 1.23 * | 11.50 ± 0.73 * | 9.63 ± 0.94 * |
| Grooming | 0 | 0 | 0 | 0 |

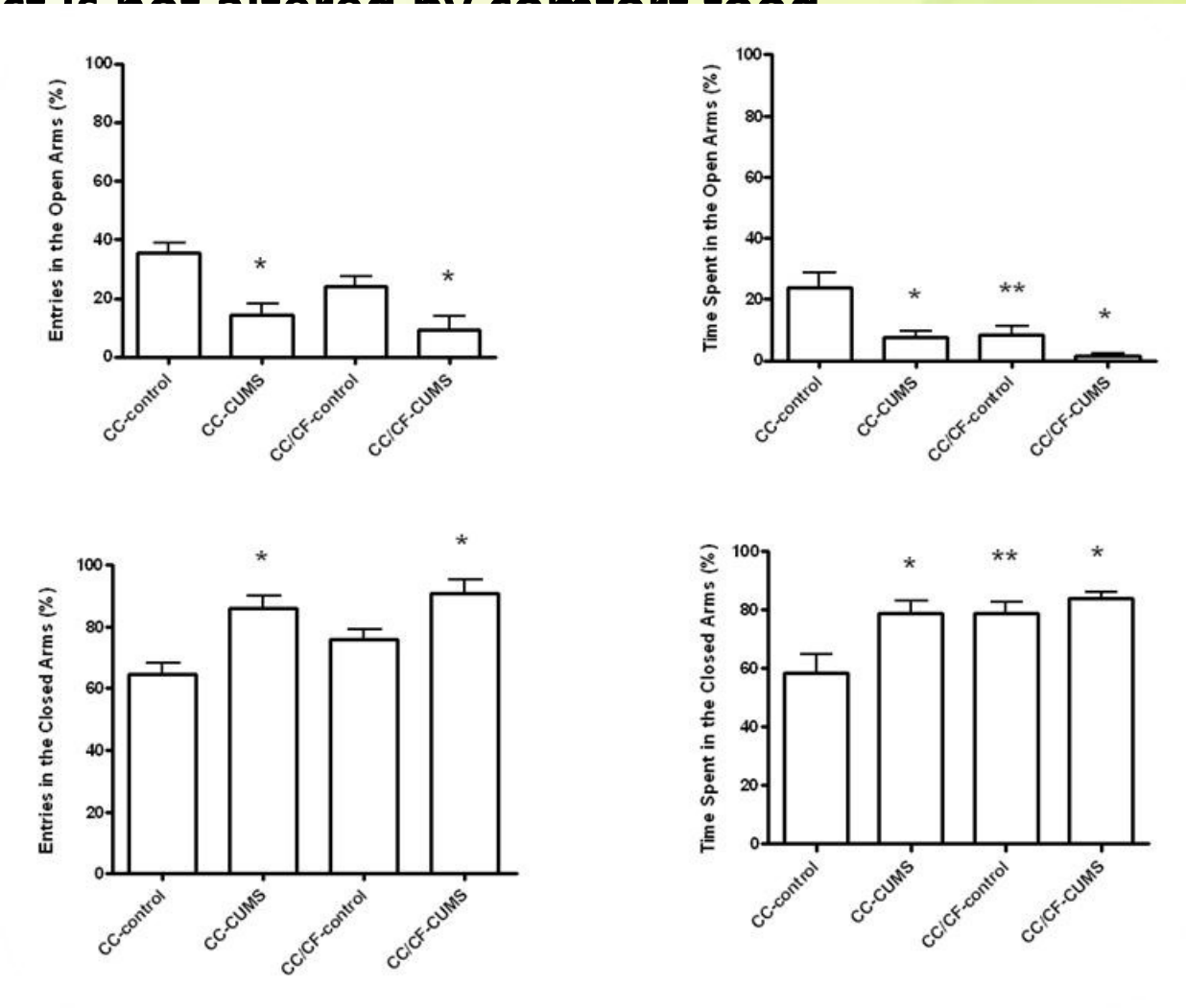
Ortolani et al., 2011

- **Foot shock stress associated to comfort** reduces anxiety-like behaviors - **open field.**

| | Commercial chow | | Comfort food | |
|---|---|---|---|---|
| | Control (20) | Stress (18) | Control (12) | Stress (11) |
| Latency to first crossing (s) | 9.05 ± 2.44 | 8.27 ± 0.99 | 5.16 ± 0.95 | 15.18 ± 4.53[a] |
| Time spent in center (s) | 48.95 ± 4.20 | 46.83 ± 6.33 | 31.33 ± 4.69 | 85.09 ± 23.37[a,b] |
| Time spent in periphery (s) | 253.75 ± 5.52 | 253.16 ± 6.33 | 265.75 ± 4.96 | 213.54 ± 23.52[a,b] |
| Crossing | 67.25 ± 4.51 | 74.11 ± 3.88 | 70.91 ± 9.35 | 59.90 ± 8.13 |
| Rearing | 39.45 ± 2.73 | 38.66 ± 2.45 | 36.75 ± 3.02 | 30.80 ± 3.79 |
| Grooming | 1.70 ± 0.23 | 2.16 ± 0.31 | 1.58 ± 0.19 | 1.54 ± 0.28 |
| Fecal bolus | 2.00 ± 0.46 | 0.55 ± 0.32 | 1.66 ± 0.68 | 1.36 ± 0.79 |

Ortolani et al., 2011

- **CUMS** (14 days) induces anxiety-like behavior - **EPM.**
- **This effect is not altered by comfort food**




Ortolani et al., 2014

- **CUMS** (14 days) induces anxiety-like behavior - **open field.**
- **This effect is not altered by comfort food**.

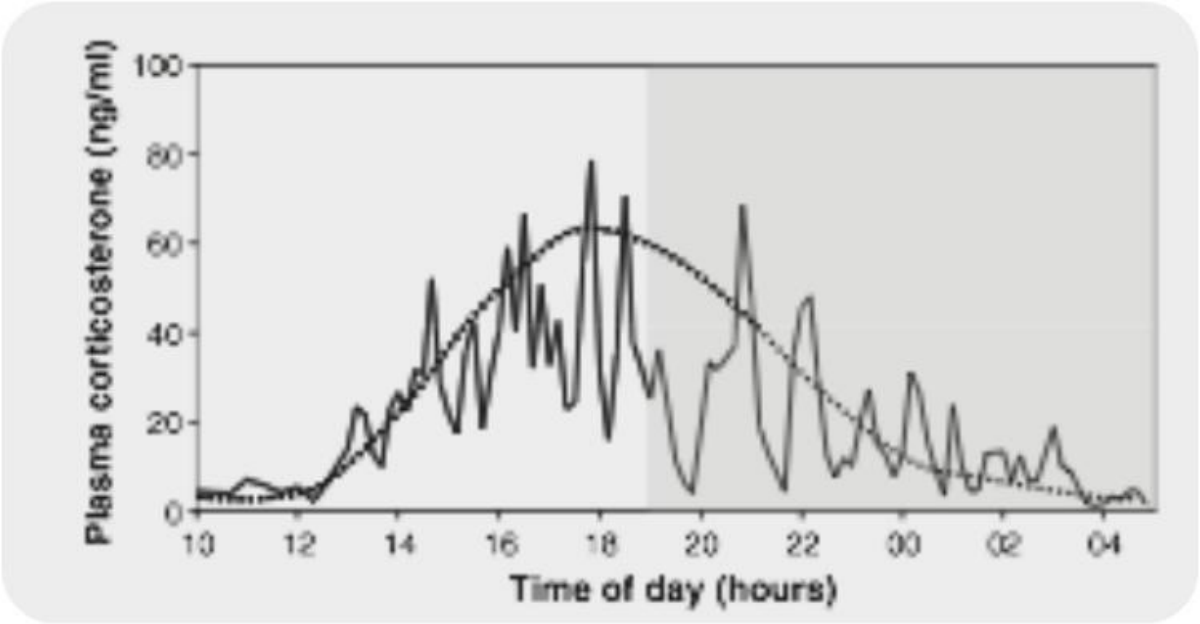
| Parameter | Group | | | |
|---|---|---|---|---|
| | CC-control | CC-CUMS | CC/CF-control | CC/CF-CUMS |
| Latency to first crossing (s) | 3.3 ± 0.7 | 3 ± 0.5 | 2.4 ± 0.4 | 3.8 ± 0.5 |
| Time spent in centre (s) | 51 ± 9.5 | 27 ± 5[a] | 42 ± 5.7 | 24 ± 3.8[a] |
| Time spent in periphery (s) | 249 ± 9.5 | 272 ± 4.5[a] | 258 ± 5.7 | 275 ± 3.8[a] |
| Crossing | 65 ± 7.4 | 64 ± 2.8 | 51 ± 2.6 | 64 ± 3.7 |
| Rearing | 44 ± 5.2 | 34 ± 3.4 | 30.6 ± 3.3 | 32 ± 3.3 |
| Grooming | 2.5 ± 0.6 | 2.9 ± 0.4 | 2.3 ± 0.5 | 2.4 ± 0.5 |

Ortolani et al., 2014

# Conclusions

The access to comfort food attenuates the corticosterone response to stress but did not prevent anxiety-like behaviors of rats exposed to chronic stress.

- Chronic oral corticosterone was recently reported to induce impressive metabolic changes in mice including weight gain, increased adiposity, elevated plasma leptin, insulin and triglyceride levels, and hyperphagia (Karatsoreos et al., 2010).
- This model has the added benefit of result in a late-night increase in plasma corticosterone, mimicking one of the most predictive factors in Cushing's syndrome (Yaneva et al., 2004).0




Sarabdjitsingh et al., 2012

# HCM system

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