WINTER IS COMING NEONATAL THERMOREGULATION

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Course Objectives

- Discuss mechanisms of heat loss and recommended environment for thermoregulation in the neonate.
- Review equipment used to promote thermoregulation in neonates.
- Describe symptoms of cold stress and review rewarming techniques.
- Discuss risk factors and prevention for hyperthermia.

Thermoregulation in NICU

- Maintenance of an optimal thermal environment is considered one of the most important aspects of effective neonatal care and is basic to daily nursing practice in the newborn nursery or NICU.

HEAT LOSS AND RECOMMENDED ENVIRONMENT

Heat Production

- Adult body temperature control is achieved by a complex system of thermal receptors that create a balance between heat production, heat gain, and heat loss all regulated by the hypothalamus.
- At birth, the neonate rapidly cools in response to the relatively cold extrauterine environment.
- Newborns have a limited ability to control their body temperature due to an immature hypothalamus.
  - *Instead of shivering when cold, heat is produced through non-shivering thermogenesis-brown fat metabolism*
  - *Brown fat is controlled by the sympathetic nervous system through the release of norepinephrine*
  - *Norepinephrine stimulates the hydrolysis of brown fat into glycerol and fatty acids*
  - *Rapid hydrolysis of brown fat produces heat, warming the blood and perfusing the surrounding tissues*

Asakura, 2004

Immature Thermoregulation Factors

Insulation

Insulation

Infants may have little subcutaneous fat as it is not accumulated until after 32 weeks' gestation.

Motor Tone and Activity

Motor Tone and Activity

Low birth weight and/or sick infants are prone to decreased motor tone and less activity, resulting in decreased heat production. Infants with poor tone cannot use flexion posture effectively to reduce surface area, which helps to reduce heat loss.

Immature Thermoregulation Factors

Vasomotor Response

Vasomotor response

Though vasoconstriction and vasodilatation are developed even in low birth weight infants, often the vasoconstriction abilities are outmatched by the propensity for heat loss.

Behavioral

Behavioral

Infants cannot clearly communicate their thermal needs. Cues are subtle and nonspecific.

Mechanisms of Heat Loss

- Radiation
- Evaporation
- Conduction
- Convection

Radiation

- The transfer of heat via electromagnetic infrared waves between solid surface that are not in contact with each other.
- For example, an isolette or crib placed near a cold wall or window will radiate heat towards the cold object.

Heat is lost by radiation when the infant is near cold surfaces. Thus heat is lost from the infant's body to the sides of the crib or incubator and to the outside walls and windows.

Evaporation

- Evaporation causes heat loss because energy is used in the conversion of water to its gaseous state.
- Neonates >32 weeks have no ability to sweat
- Important factors to be aware of:
  - *Transepidermal water loss or insensible loss from the skin is correlated with gestational age.*
  - *Skin damage that strips the keratin layer promotes skin evaporative loss.*
  - *In very low birth weight infant, evaporative loss alone is greater than the infant's heat-producing capabilities.*
  - *Evaporation can account for 25% of the infant's total heat loss at delivery.*
  - *Evaporation rises with activity, tachypnea, radiant warmers, and phototherpy*

Evaporation can occur during birth or anytime the infant is wet, and from insensible water loss.

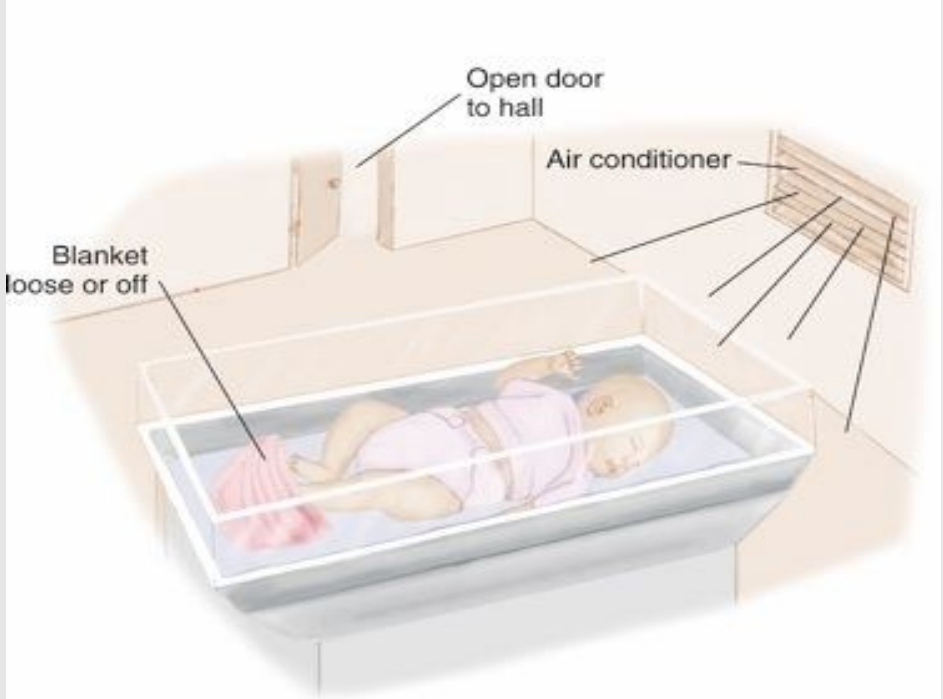
Conduction

- Conduction is the transfer of heat between two solid surfaces when they are in contact. The greater the conductivity, the greater the heat exchange.
  - *The larger the body surface area in contact with the object, the greater the heat exchange*
  - *In a supine position, an infant has approximately 10% of his or her surface area in contact with the mattress*
  - *Interventions include*
    - Prewarm surfaces (Mattress, scales etc.)
    - Preheat incubators, clothing, stethoscopes, blankets, heat shields, and knit caps

Conduction occurs when the infant comes in contact with cold objects or surfaces such as a scale.

Convection

- Convection is the transfer of heat between a solid surface and either air or liquid.
  - *Because neonates have a large surface area-to-body mass, heat loss by convection is increased.*
  - *The smaller the infant's limb diameter, the less external insulation there is, increasing the potential for convective heat loss.*
  - *Reducing the exposed surface area, by using clothing or blankets, is an effective means of reducing convective heat loss*
  - *Place infants away from drafts*
  - *Used warmed oxygen*
  - *Maintain raised side panes of radiant warmers to prevent cross-current airflow*



Convection occurs when drafts come from open doors, air conditioning, or even air currents created by people moving about.

Thermoregulation

- Newborns are unable to regulate their temperatures
- Unable to adjust to environmental changes
- Risk for cold stress, hypothermia, or hyperthermia
- *All affect oxygen and calorie consumption*
- *Increased risk factors include:*
  - *Prematurity*
  - *Skin irregularities (neural tube defects, ichthyosis, gastroschisis, etc.)*
  - *Neurologic impairments leading to thermal instability*
  - *Intrauterine growth retardations (IUGR)*
  - *Hypothalamus damage*
  - *Hypoglycemia*

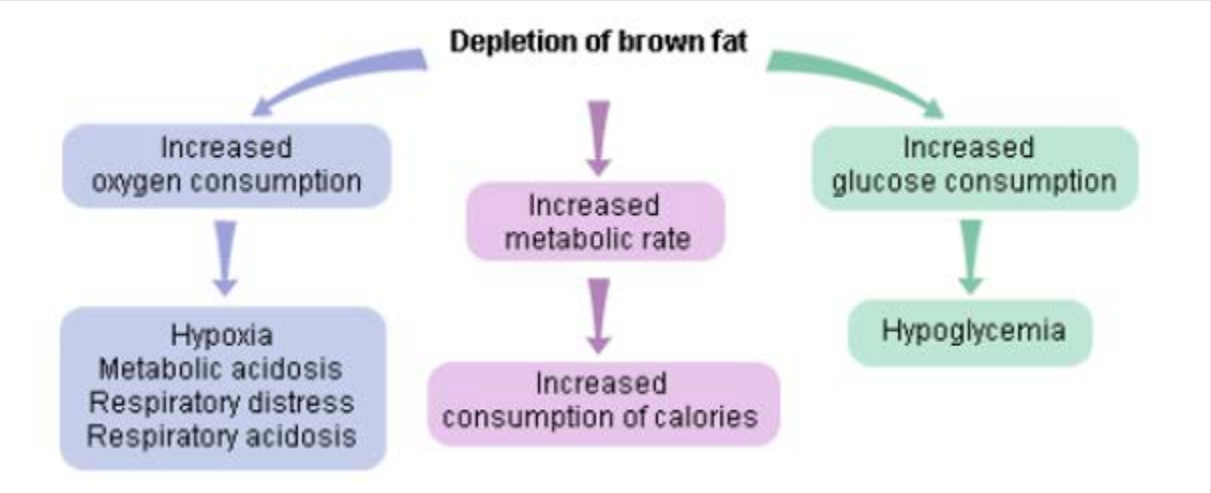
Definition of Hypothermia

- The World Health organization (WHO) defines hypothermia as present when the newborn's axillary temperature falls below 36.5 degrees Celsius.

- Hypothermia leads to adverse neonatal outcomes like:
  - *Impaired growth*
  - *Hypoglycemia*
  - *Generalized internal bleeding*
  - *Increased risk of infection*
  - *Metabolic acidosis*
  - *Respiratory Distress*
  - *Even Death*

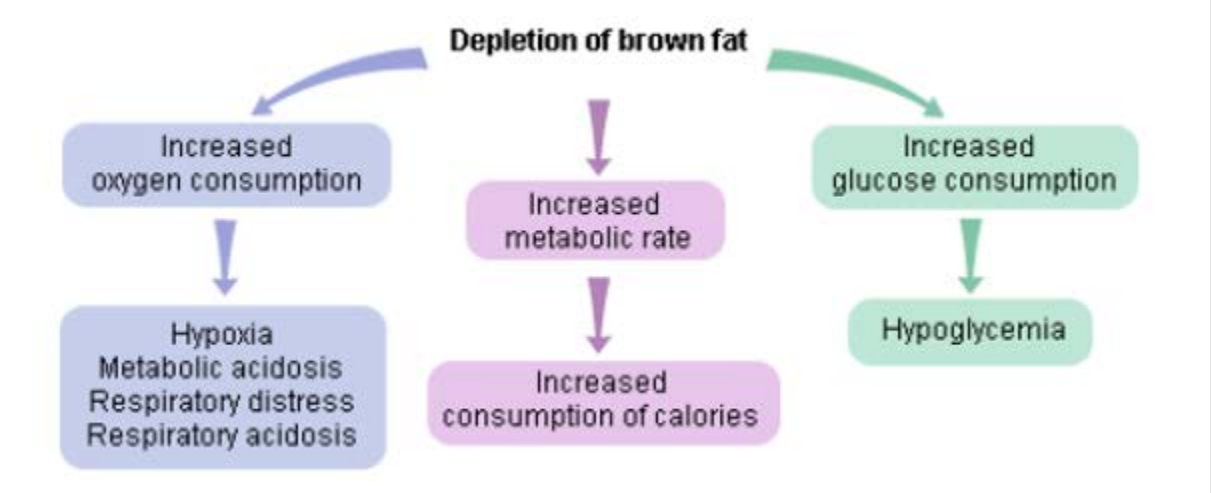
Consequences of Thermal Instability

- As the body temperature decreases the infant becomes less active and lethargic.
- After brief exposure to cold stress, the infant will present a poor suck, have a weak cry and respirations will be shallow.
- Sclerema will develop, predominately on the back of the limbs.
- The face may become bright red.



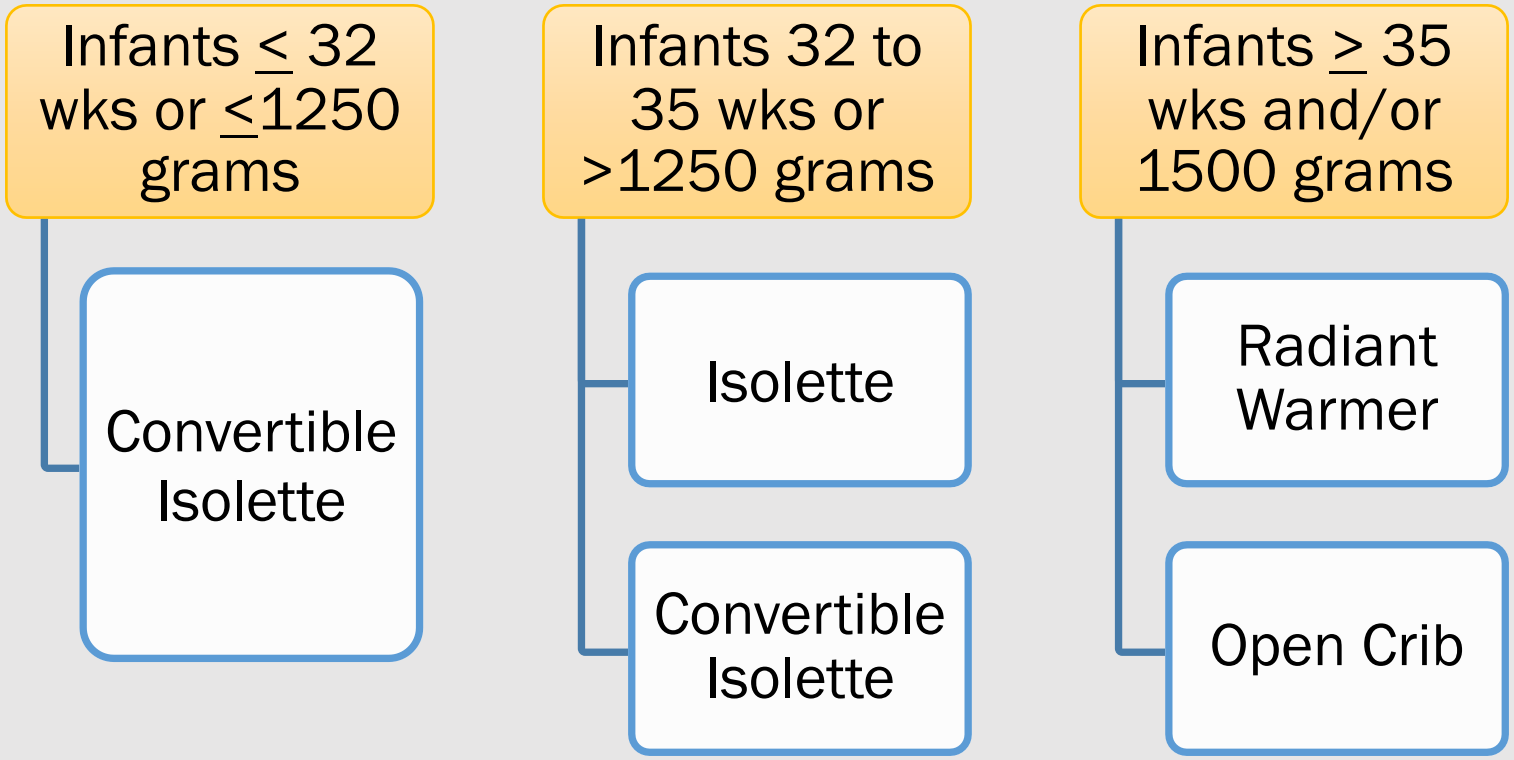
Consequences of Thermal Instability

- Hypoglycemia, hypoxia, and metabolic acidosis can occur, due to the metabolism of brown fat and the release of fatty acids.
- If cold exposure continues and exceeds the infant's ability to compensate, respiratory failure, depletion of energy stores and death may result.



EQUIPMENT

Recommended Environment



Maintaining a Neutral Thermal Environment (NTE)

Birth Weight and Temperature Range				
Age	1000-1200 grams ± .05 C	1201-1500 grams ± .5 C	1501-2500 grams ± .0 C	>2500 grams & 36 wks ± 1.5 C
0-12 hrs	35.0	34.0	33.3	32.8
12-24 hrs	34.5	33.8	32.8	32.4
24-96 hrs	34.5	33.5	32.3	32.0
5-14 days	n/a	33.5	32.1	32.0
2-3 wks	n/a	33.1	31.7	
3-4 wks	n/a	32.6	31.4	

Radiant Warmers

- Allow for easy access and visualization of the infant.
- Pre-warm radiant warmer (RW) prior to placing infant in on the bed.
- Use in servo control mode with properly placed temperature probe.
- During procedures that may block the radiant heat, warmed blankets and thermal mattresses may be used.
- Difficult to maintain NTE due to the changes in room temperature
- Increased oxygen consumption due to he increased metabolic expenditures
- Does not prevent heat loss, but provides powerful heat replacement at the expense of increased evaporative water loss.

Isolette/Radiant Warmer General Principles

- Place infant in prewarmed bed.
- Never use manual heat as this could cause overheating of the infant.
- Monitor infant using axillary route

Isolette General Principles

- Allow for closer observation of the infant and reduce convective heat loss by decreasing the gradient between air and skin temp.
- Always pre-warm isolette before placing infant inside.
- Remember: air and temp fluctuations can occur when the canopy, doors, or portholes are open. Use the air curtain to prevent cooler air currents/drafts.
- Avoid popping the top for assessments and cares unless extreme emergency.

Isolette: Servo Mode

- The infant's temperature probe is set at a desired temperature(36.2-36.5) and the isolette increases or decreases heat to maintain the set temperature
- Infant dressed in only diaper

Humidity Guidelines

- Recommended for all infants ≤ 29 weeks and or ≤ 1250 grams.
- Initiate humidity at 75%-90% for the first 7 days of life.
- DOL 7 wean humidity by 5% every 12 hours until 50%
- Humidity may be discontinued at 30-32 weeks AGA.
- Change out incubator every 14 days.

Isolette: Air Control Mode

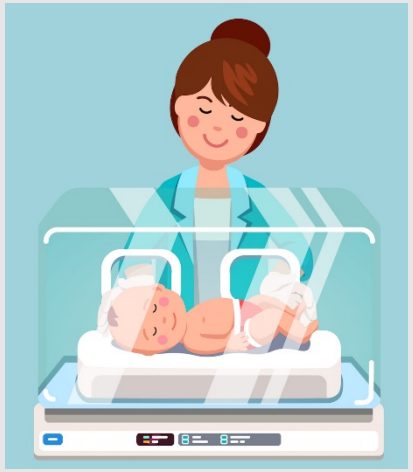
- Begin weaning from servo control mode to air control when infant is clinically stable, heat requirements are decreasing and infant weighs minimally 1250 grams.
- Place infant in clothes, hat, diaper, blanket and developmental products.
- Base starting temperature using the set point table in the policy.

Open Cribs

- Used for full term and healthier infants who are able to maintain thermal stability within a wider range of environmental temperatures.
- Infants should be clothed and covered/swaddled with a blanket.
- The addition of a cap will further prevent possible heat loss from convection.
- Cribs should be kept from close proximity to windows, heat sources, and drafts

Isolette: Weaning from Servo Mode to Air Control

- Begin weaning when infant is clinically stable, heat requirements are decreasing, and infant weighs minimally 1250grams.
- Place infant on manual control in the incubator with infant dressed in clothes, hat, diaper, and blanket and developmental products.
- Base the starting temperature on the infant's weight and age, adjusting temperature to maintain a neutral thermal environment



Isolette: Weaning from Air Control to Open Crib

- Infant is ≥ 1500 grams or ≥34 weeks gestation
- 5 days of consistent weight gain
- Deemed physiologically stable
- Few apnea/bradycardia episodes
- Tolerance of enteral feeds.
- Minimal heat requirement of ≤28°C for at least 8 hours before transition.
- Once criteria is met the air temperature should be decreased by 0.5°C every 6 hours to a low of 28°C.
  - *Once infant is in open crib monitor temp Q30minutes x2, Qhour x1 then routine. Postpone bathing for 24 hours*

Weaning from a Radiant Warmer to an Open Crib

- Depending on the stability and heat requirements of each infant, (s)he may be weaned from heat
- Begin the weaning transition when infant is stable
- Dress infant in hat, clothing (if appropriate), and swaddle in a maximum of 2 blankets and turn of radiant warmer
- Check axillary temp every hour for at least 2 hours
- Postpone bathing for 24 hours

Kangaroo Care

- Consider Kangaroo Care as a method of thermoregulation for babies who are medically stable.
- A randomized control trial published in the Journal of Perinatology in 2014 found that newborns in the skin to skin control group achieved rapid thermal control as compared with the control group.

Nimbalkar, Patel, Nimbalkar, Sethi, and Phatak, 2014

COLD STRESS AND REWARMING

Rewarming After Cold Stress

- The primary intervention for cold stress is the use of radiant warmers or isolettes.
- Since cold stress creates a demand of oxygen due to brown fat metabolism, it is important to keep the infant's oxygen consumption at a minimum.
- In order to achieve minimal oxygen consumption while rewarming, the difference in air and skin temperature should be kept at less than 1.5 degrees Celsius.

Rewarming After Cold Stress

- Monitor skin and axillary temperatures simultaneously
- Maintain an air temperature of 1 to 1.5 degrees Celsius in hourly increments until the infant's temperature is stable.
- Assess the infant frequently-typically every 15 to 30 minutes
- Remove plastic wrap, caps, and heat shields while rewarming to prevent an interface with heat gain. These items can trap cool as well as warm air.

Problems of Rewarming

Problem

- Temperature ceases to increase or begins to rise slowly

Intervention

- Maintain the infant's current environment and continue to monitor

Problems of Rewarming

Problem

- Temperature continues to fall

Intervention

- Raise the incubator temperature, evaluate for missed sources of heat loss and check that humidity is greater than 70 percent

Problems of Rewarming

Problem

- Infant becomes apneic; exhibits signs of shock

Intervention

- Slow the rate of rewarming. Rapid rewarming can cause apnea, shock, and death

HYPERTHERMIA

Causes of Hyperthermia

- Hyperthermia is typically caused by an iatrogenic (external source) or disease process (febrile state)
- Maternal fever
- Overheating from an isolette, radiant warmer, or phototherapy lights
- Excessive bundling or swaddling
- Infection
- Dehydration
- Central nervous system disorders
- Phototherapy lights, sunlight

Signs and Symptoms of Hypert

- Tachycardia and/or tachypnea
- Dehydration from increased fluid loss
- Increased insensible water loss
- Flushing
- Apneas
- Hypotension as a result of peripheral vasodilatation (facilitates heat loss)
- Seizures
- Poor feeding
- Decreased activity and muscle tone
- Shock
- Weak or absent cry
- Skin temperature greater than core temperature
- Secondary to hypermetabolism:
  - *Pale, cool extremities*
  - *Core temperature greater than skin temperature*

Risk Factors for Hyperthermia

- Poorly serviced equipment
- Rewarming too quickly
- Inappropriate use of warming lamps
- Placing the isolette too close to a sunny window
- Inappropriate use of temperature probe
- Neonatal Abstinence Syndrome
- Use of prostaglandin therapy
- Maternal hyperthermia in the immediate newborn period
- Brain damage to areas of thermoregulatory control

Management of Hyperthermia

- Remove anything that may block heat loss
- Assess temperature probe positioning for appropriate location
- Remove external heat source
- Check the incubator or radiant warmer for appropriate functioning
- Treat the underlying causes (e.g. infection, dehydration, central nervous system disorder)
- During the cooling process, monitor and record the temperature every 30 minutes (skin, axillary)
- Remove excess bundling/swaddling materials.

Conclusion

Thermoregulation is individual to the infant and directly related to the mechanism of heat loss and heat gain. Clinicians should refer to the NTE chart used within their organization when determining the appropriate temperature range for the given infant.

References

- Asakura, H., (2004). Fetal and neonatal thermoregulation. Journal of Nippon Medicine, 71(6), 360-370. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/15673956
- Engorn, B. M., Kahntroff, S. L., Frank, K. M., Singh, S., Harvey, H. A., Barkulis, C. T., … Greenberg, R. S. (2017). Perioperative hypothermia in neonatal intensive care unit patients: effectiveness of a thermoregulation intervention and associated risk factors. *Paediatric Anaesthesia*, *27*(2), 196–204.
- Mennella, H. D. A.-B. (2017). Thermoregulation Following Delivery: Maintaining. *CINAHL Nursing Guide*.
- Morehouse, D., Williams, L, Lloyd, C., McCoy, D., Walters, E., Guzzetta, C.,. . . Short, B. (2014). Perioperatvie hypothermia in NICU infants: Its occurrence and impact on infant outcomes. *Advances in Neonatal Care*, 114(3), pp. 154-164. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/24824300
- Nimbalkar, S., Patel, V., Patel, D., Nimbalkar, A., Sethi, A., & Phatak, A., (2014). Effect of early skin-to-skin contact following normal delivery on incidence of hypothermia in neonates more than 1800g: randomized control trial. Journal of Pernatology, 34, 364-368. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/24556982
- Porter, C., Borsheim, E., & Sidossis, L. (2013). Does adipose tissue thermogenesis play a role in metabolic health? *Hindawi Publishing Corporation Journal of Obseity*, Article 204094. http://dx.doi.org/10.1155/2013/204094

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