Using Supportive Techniques for Biomechanical Sucking Challenges

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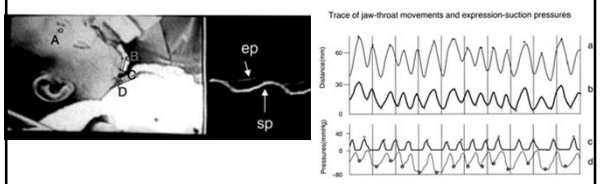
Biomechanics: Physics of movement in living organisms

- Kinetics – forces
- Kinematics – spatial & temporal
- Motor control
  - Open loop (too rapid for feedback)
  - closed loop (feedback)
- Motor development
- Motor learning

Analysis

- Quantitative – forces acting at a certain joint in Pascals or Newtons
  - trigonometry and measurements
- Qualitative – observations to identify critical features

Quantitative analysis



Throat movements (a) larger than jaw movements (b) in normal babies, suction pressure and expression pressure proportional to but not perfectly synchronized with these movements

Mizuno K et al 2006 Analysis of feeding behavior with direct linear transformation Early Human Behavior 82 p 199-04

Fundamentals

- Critical features – most invariant technique points required for effective, efficient, safe movement
- Qualitative analysis – identifies critical features
- Teaching cues – derived from critical features

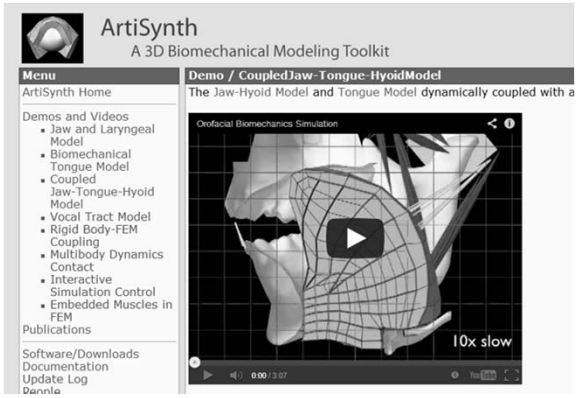
Qualitative Analysis-Kinematics

Qualitative Analysis

Component **Composite**

ArtiSynth

A 3D Biomechanical Modeling Toolkit



Motor learning in childhood (Bernstein)

- Freezing (reducing ROM)
- Releasing (releasing more and more joints)
- Exploiting (taking advantage of nuances)

'Freezing' Range of Motion in breastfeeding newborns

- Tongue and jaw movements linked
- Jaw 'falls open' - high flexor tone
- Tongue-Jaw Dissociation with experience bf

Muscle Action

Forces:

- Rotary movement around a joint
- Stabilizing (pull joint tighter)
- Destabilizing (separate joint components)

Reciprocal Action:

- Agonist/Antagonist

Modifying Factors

- Friction
- Gravity
- Type of Joint

Stability: Support against mom's body contours

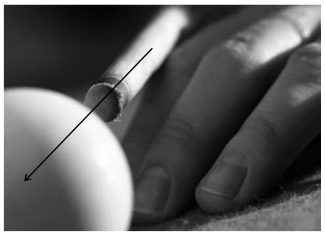
Less effort needs to go into stabilization, more freedom for mobilization at each relevant joint

Newton's Laws of Motion

1. Inertia
2. Dynamics (acceleration proportional to force)
3. Reciprocal forces (action/reaction)
4. Gravitation – attraction proportional to masses multiplied over distance squared.

Properties of force

- Direction
- Orientation
- Point of application
- Magnitude
- Line of action



Muscle Force Vectors

Resultant force:

- Origin
- Insertion
- Direction of fibers

For each muscle!

Motor units

Recruitment

Fatigue

New tasks are inefficient, insufficient integration of motor units to produce large resultant vector

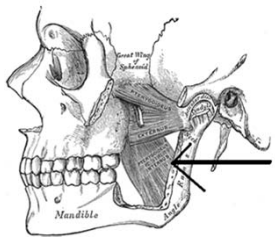
Shaking

Lack of synchronous, coordinated contraction of muscle units in early learning

Jaw Muscles - Balanced forces

Temporalis and Masseters (superficial)

Pterygoids (deep)



From Grey's anatomy, wikimedia commons license

- Excessive forces from the medial pterygoid muscles can contribute to a "biting" suck

- Try fatiguing the pterygoids (allow infant to chew finger at back sides of gums)
- Work on improving latch depth
- Tongue strength & grooving

Fatiguing Pterygoids Sharon Vallone, DC

- Allow baby to chew on fingertip placed between gums at back of mouth
- Alternate sides

Muscles

Normal Adaptation to increased Strain –

- Increased firing rates (neural)
- More efficient recruitment of motor units (neural)
- Hypertrophy (muscular)

Compensation

Adaptation elsewhere for abnormal movements in a segment

Reducing Forces Required

Nipple shield stabilizes teat in mouth; reduces need for baseline suction

Breast Compression

- Increase positive pressure in breast (increase differential)
- Negative resistance (stimulate sucking)

Isolated vs. Sequential Swallows

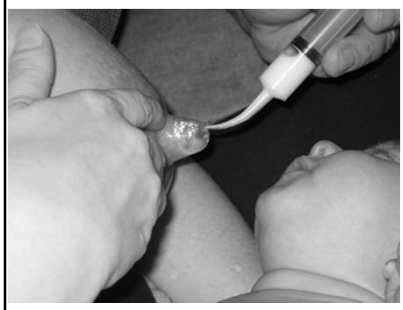
"Sequential swallowing, in comparison to discrete swallowing, elicits simplification or down-scaling of several kinematic parameters." Steele and van Lieshout ASHA 52:Oct 2009

Reducing flow: press on breast during MER (Carol Chamblin DNP, IBCLC)

Motor learning

- Reflexes and central pattern generators
- Modification - learning
- Practice only makes perfect if you practice doing it perfectly!
- Feedback makes the difference (reward)

Motor Learning: Feedback



Contingency

Rate of flow

Motivation

Structural deviations have functional implications

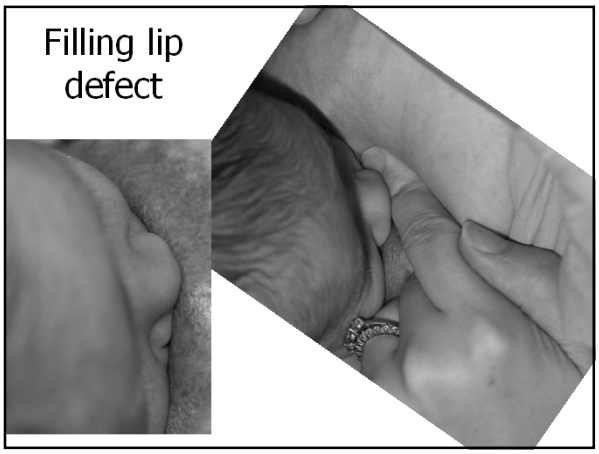
Biomechanical Challenges for Breastfeeding - Structural

- Torticollis
- TMJ Anterior Disc Displacement ("popping" jaw)
- Retrognathia
- Undeveloped buccal (cheek) fat pad
- Cleft lip
- Micrognathia

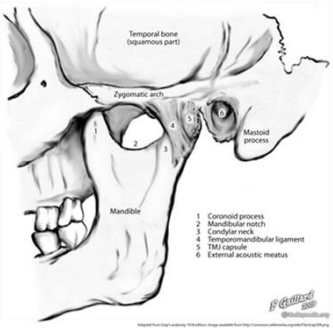
Shaping a Mouthful

compensate for small gape or reduced tongue protrusion

Filling lip defect



Temporomandibular Joint



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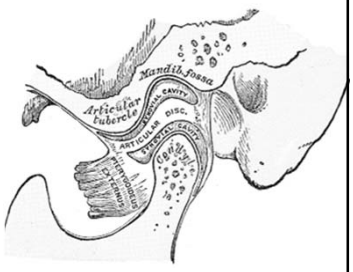
TMJ Articulation

Articular disc helps guide rotation of the mandibular condyle in its' fossa



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TMJ

- Normal TMJ Function http://www.youtube.com/watch?v=lP_VPiYnyNs
- Anterior disc displacement with reduction http://www.youtube.com/watch?v=DesYZQUmqus

Anterior Disc Stabilization

Supporting/Stabilizing Breast from Upper Quadrant

Biomechanical Challenges… CNS dysfunction

- Slower speech/sucking due to poorer coordination.
- Recruitment of muscle fibers in shivering or fasciculation reduces the number available for movement.

Tremor: rhythmic involuntary oscillation - fatigue or neurological impairment

Fasciculation: arrhythmic - extreme fatigue

Neurological Impairment

Developmental progression similar but slower

Challenges:
Strength
Coordination
Cognition

Cheek pressure (for wide jaw excursion that opens corner of mouth)

Courtesy of Betsy Hoffmeister

Dancer Hand Position

Cheek and jaw support

- Decrease intraoral space
- Prevent excessive jaw excursions

Cheek and jaw support

May provide too much flow

Hypotonia supporting breast in mouth

Hypotonia cheek support (inward and forward)

Hypotonia: Head & Jaw support

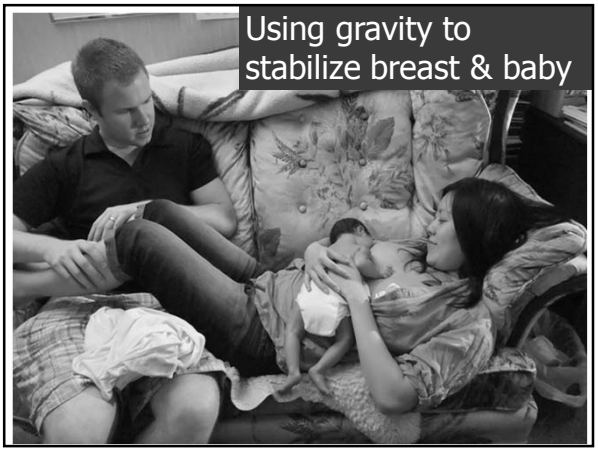
Sublingual massage

Jaw & Breast Support

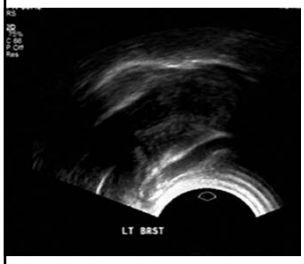
Containment

Organizing Touch

Pre-Feeding Massage: Improves Organization & Muscle Tone



Forces During Breastfeeding



Field forces vs. contact forces

- Breast /nipple strain
- Milk capillary pressure
- Nipple duct viscoelastic walls, hydraulic pressures, expansion
- Positive pressure myoepithelial cell cntrxn
- Tongue/jaw- negative pressure, expression pressure

Baseline negative pressure

Pressure = Force/Area

Friction

- Static – high force to overcome
- Kinetic
- Rolling (peeling between ground and wheel)

Material properties of breast

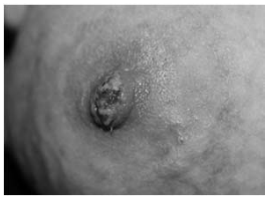
Ductile (pliant)

Co-efficient of restitution (increased by warmth)

Area under stress/strain curve= toughness

Material Properties Toughness

Toughness = total energy to rupture



Accumulated microtrauma lowers failure strength (sudden failure)

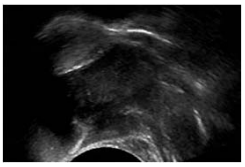
Set the pump on low

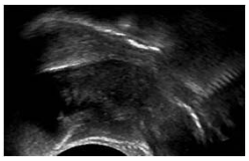
viscoelastic

fluid content

deformation is proportional to rate of loading and time under constant load

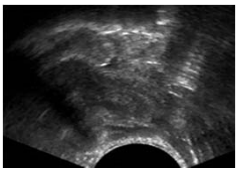
Strain $\varepsilon=\Delta L/L_i$

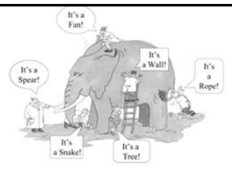




Nipple gets thinner as it elongates

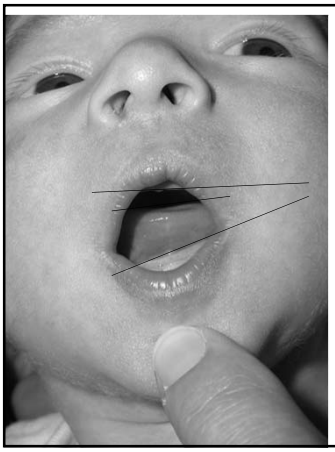
Stress orthogonal to direction of loading causes deformation





Medela Calma
- Suction only
- MER flow

Pigeon Peristaltic & Peristaltic Plus
- Peristalsis/expression
- + 4 'sizes' flows – 2 slow, 2 crosscut

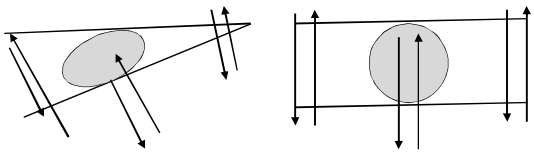


Torticollis – mandibular asymmetry

-deformation of oral structures

-imbalance of muscular forces

Effect of muscle/bone deformation on forces



Parallel forces can be treated as co-linear

Sublingual Pressure

- Improves base of support
- Draws tongue/hyoid into normal position
- Supports tongue movements

Jaw traction (toward breast)

Jaw Support (toward breast)

Torticollis Postural support, allowing head tilt/rotation

Mild Torticollis: Asymmetrical Positioning

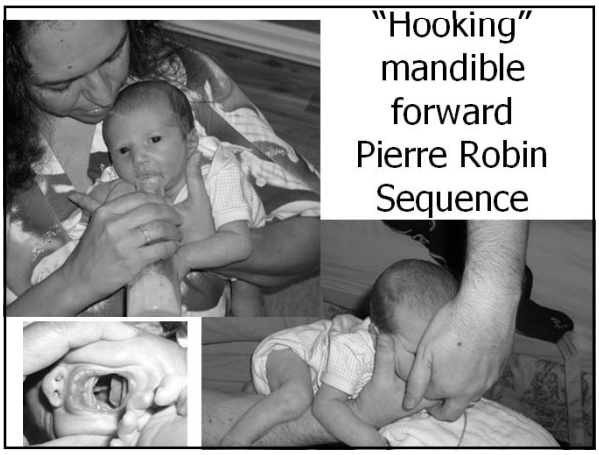
Sitting position reduced biting (n=1)

Micrognathia

- Misalignment of forces
- Short mandibular 'lever'
- Can force tongue back, reducing power and obstructing airway

Micrognathia & retroplaced tongue: prone feeding with head extension

If no respiratory difficulties sidelying with extension

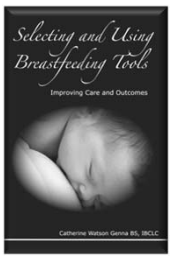


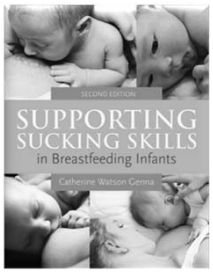
Positive pressure to increase milk flow

Summary

- Biomechanics – new solutions for bf difficulties
- Critical features – teaching points
- Motor learning – practice the right things!
- Support - improve alignment and stability
- Modify forces – tools and techniques
- Avoid injury by reducing strain

For more information:





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