

# Heart Rate Variability (HRV) Biofeedback for Beginners



## HRV Instrumentation

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# Credit

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I especially want to recognize Didier Combatalade's (2009) *Basics of Heart Rate Variability Applied to Psychophysiology*, which is available from Thought Technology, Ltd.

# HRV Instrumentation

Heart rate variability consists of the beat-to-beat changes in the intervals between consecutive heartbeats.



# HRV Instrumentation

- We can measure the interbeat interval using:
- electrocardiography (ECG/EKG)
  - photoplethysmography (PPG)

# HRV Instrumentation

*Active ECG electrodes* are shown below.



Prepare the skin with an alcohol wipe.

# HRV Instrumentation

Pre-gelled electrodes are convenient and reduce the risk of infection.



# HRV Instrumentation

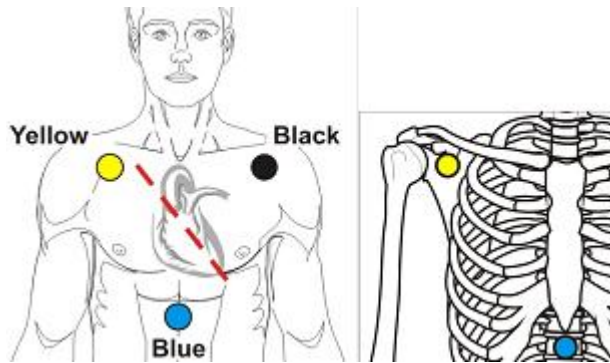
Four standard ECG placements include the:

- Chest
- Forearm
- Wrist
- Lower torso

These placements differ in vulnerability to movement artifact, and speed and degree of client comfort.

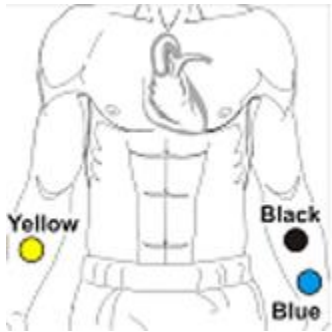
# HRV Instrumentation

## Chest placement



# HRV Instrumentation

## Forearm placement



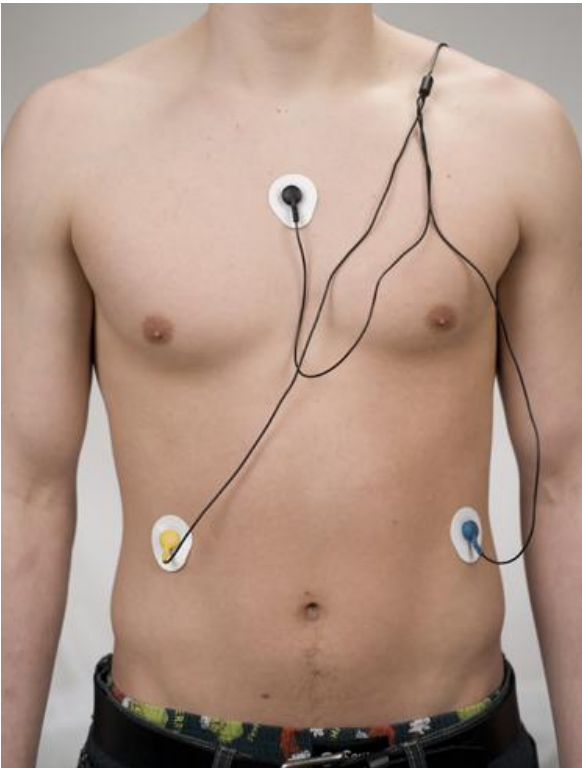
# HRV Instrumentation

Wrist placement



# HRV Instrumentation

Lower torso placement



# HRV Instrumentation

## **Clinical tips for sensor placement:**

1. Explain what the ECG sensor does and how it will be applied.
2. Instruct the client to wear clothing that allows easy sensor placement.
3. Ask for your client's assistance in applying the sensors to her own body.

# HRV Instrumentation

ECG sensors are vulnerable to *movement artifact*.



# HRV Instrumentation

## **Clinical tips to minimize movement artifact:**

1. Firmly tape sensor leads to client clothing.
2. Use a lower torso placement.
3. Provide instructions to minimize movement.
4. Carefully monitor movement.
5. Examine the raw signal for artifact.

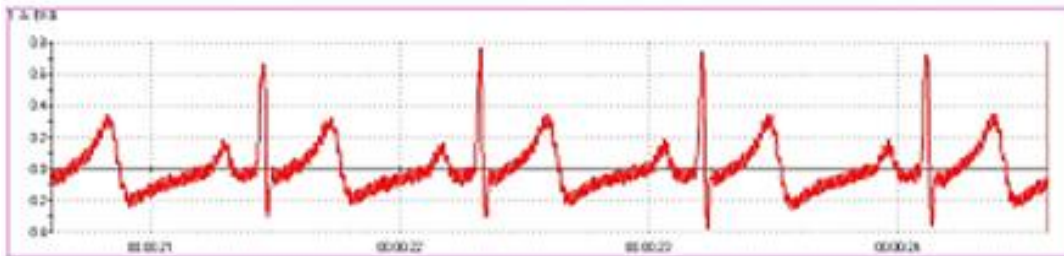
# HRV Instrumentation

*Line interference artifact* is a common source of ECG signal contamination.

Important sources of this artifact include the computer, fluorescent lights, and power outlets.

# HRV Instrumentation

The recording below looks fuzzy because high-frequency fluctuations are superimposed on the signal.



# HRV Instrumentation

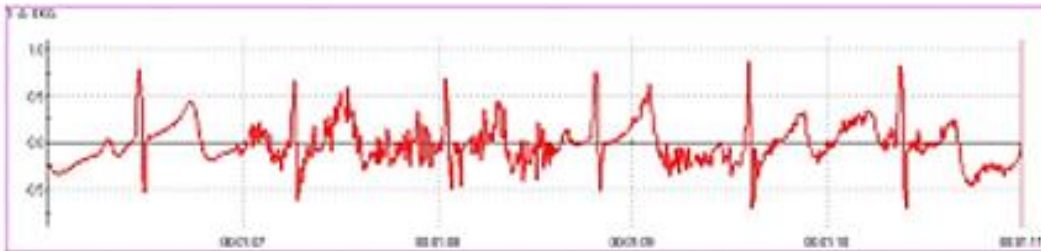
## **Clinical tips to minimize 50/60Hz artifact:**

1. Use a 50/60Hz notch filter.
2. Place the encoder box 3 feet (1 meter) from electronic equipment.
3. Remove unused sensor cables from the encoder box.
4. Examine the raw signal for artifact.

# HRV Instrumentation

***EMG artifact*** occurs when the frequency spectra of the EMG and ECG signals overlap.

Chest and arm muscle contraction can cause software to "see" many extra beats and calculate shorter interbeat intervals (IBIs).



# HRV Instrumentation

## **Clinical tips to minimize EMG artifact:**

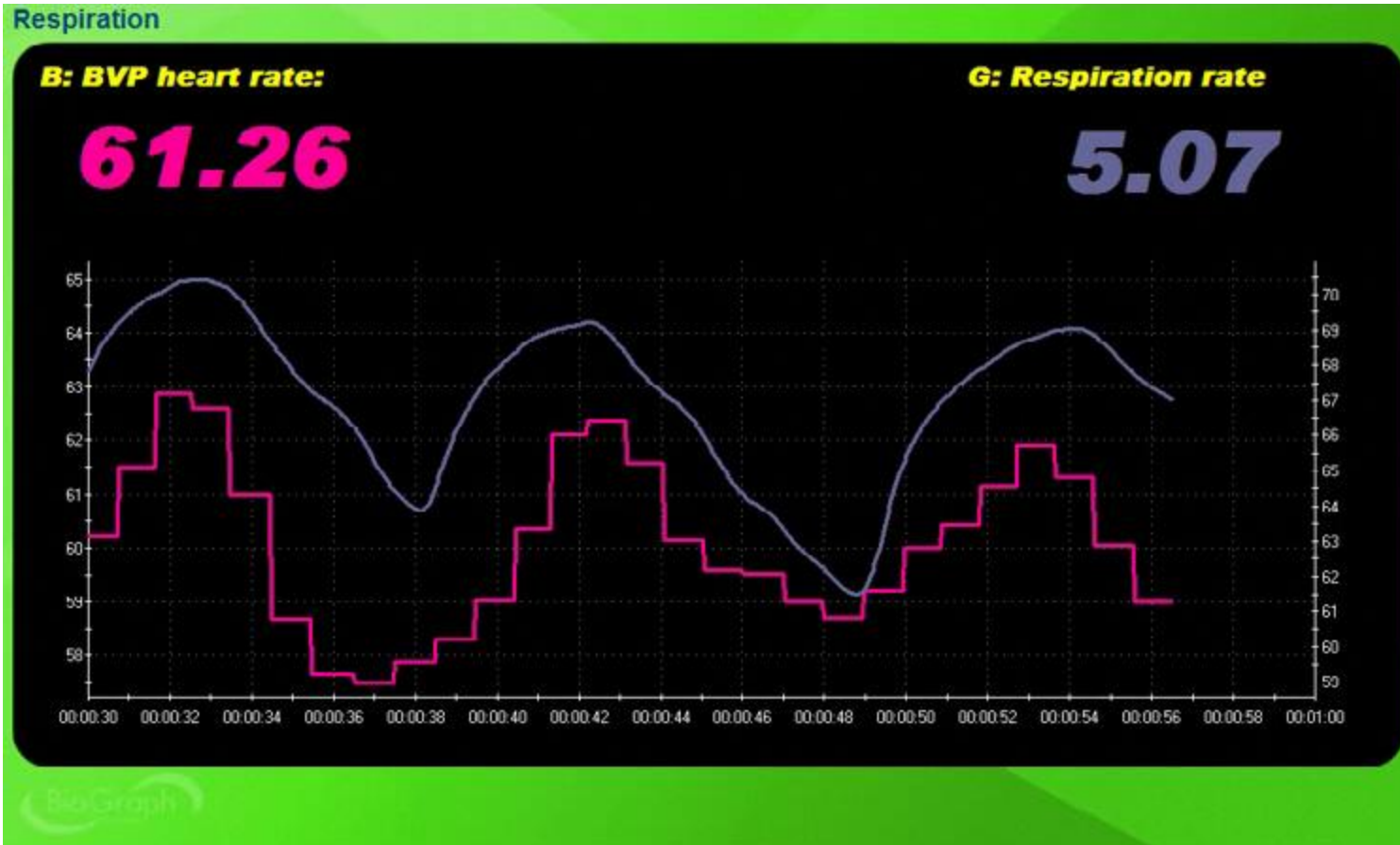
1. Use chest or lower rib placements, instead of forearm or wrist placements.
2. Instruct your client to sit in a relaxed position and restrict movement.
3. Examine the raw signal for artifact.

# HRV Instrumentation

## Tracking test:

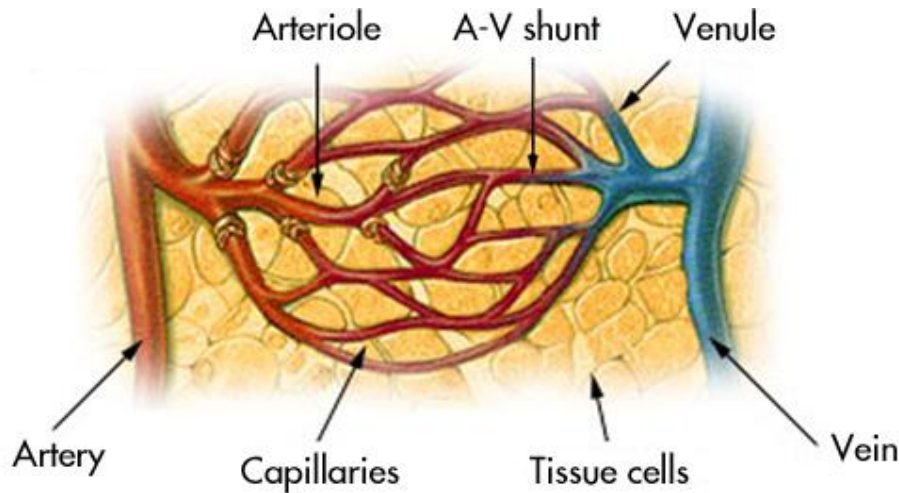
You can determine whether the ECG or BVP signals respond to your client's breathing by observing whether her instantaneous heart rate speeds during inhalation and slows during exhalation, a phenomenon called *respiratory sinus arrhythmia (RSA)*.

# HRV Instrumentation



# HRV Instrumentation

***Blood volume pulse (BVP)*** indexes rapid changes in blood flow and mainly reflects blood flow and arteriolar tone.



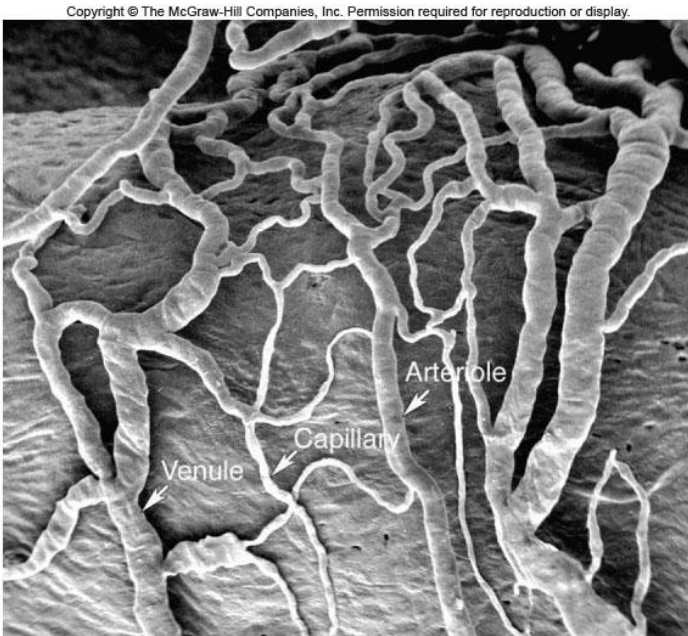
# HRV Instrumentation

BVP is detected using a *photoplethysmograph (PPG)* sensor, which measures the relative amount of blood flow through tissue using a photoelectric transducer.



# HRV Instrumentation

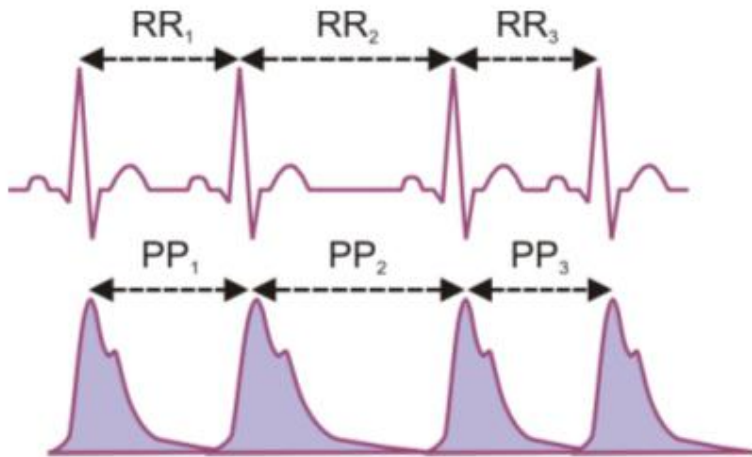
Each heartbeat briefly increases blood volume in the arteries and capillary beds.



From Nature Medicine, Vol. 9, pp. 713 to 724, "Imaging of Angiogenesis: from Microscope to Clinics" by S.M. McDonald and P.I. Choyke, et al

# HRV Instrumentation

The blood volume pulse signal can be used to calculate heart rate variability by measuring the interbeat interval.



# HRV Instrumentation

A PPG sensor may be placed on a digit or earlobe. Sensor attachment is critical since readings are sensitive to limb position and movement.

# HRV Instrumentation

For finger placements, attach the PPG sensor using an elastic band or Coban tape to the palmar side of a larger finger (or thumb) and confine the sensor to only one finger segment.

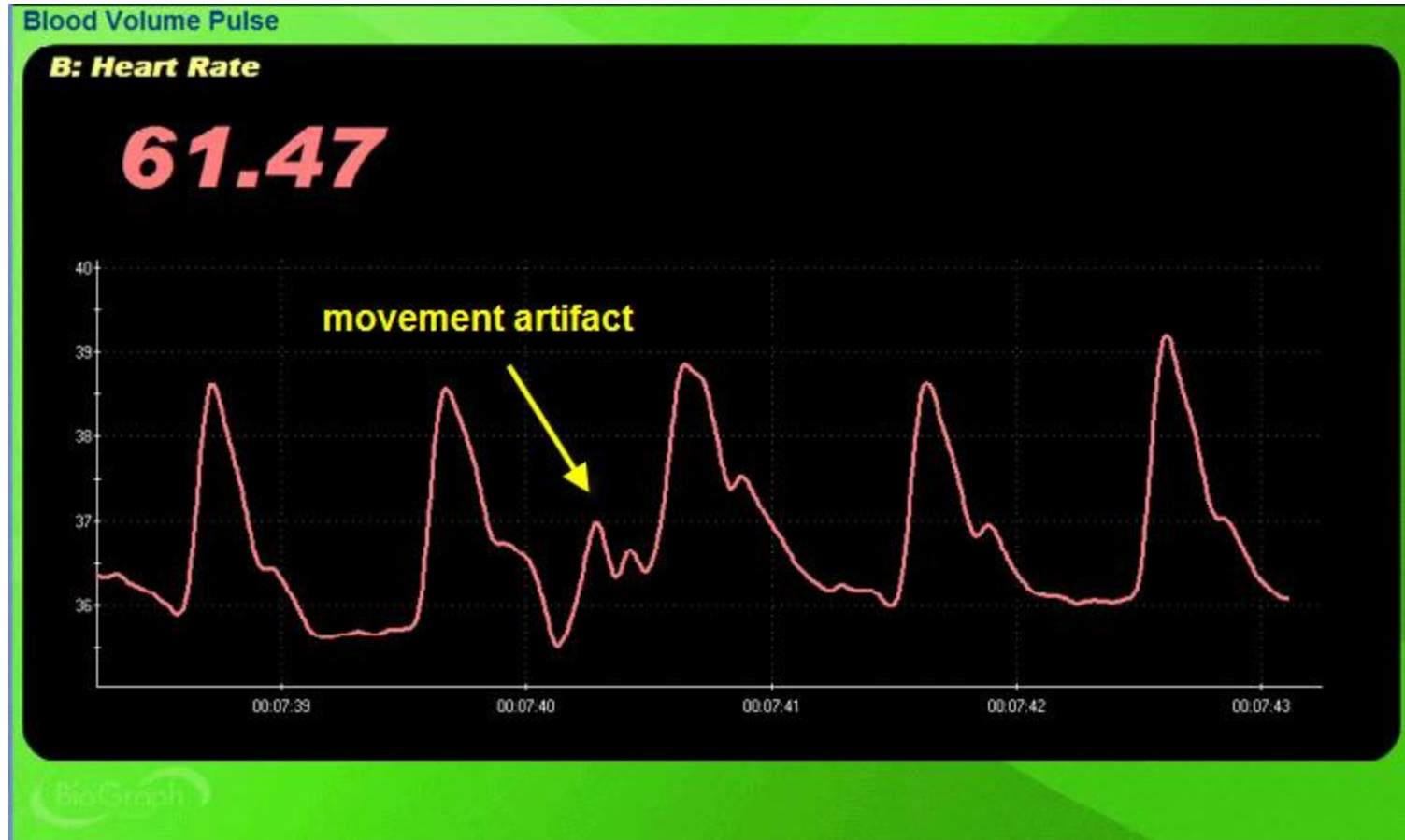


# HRV Instrumentation

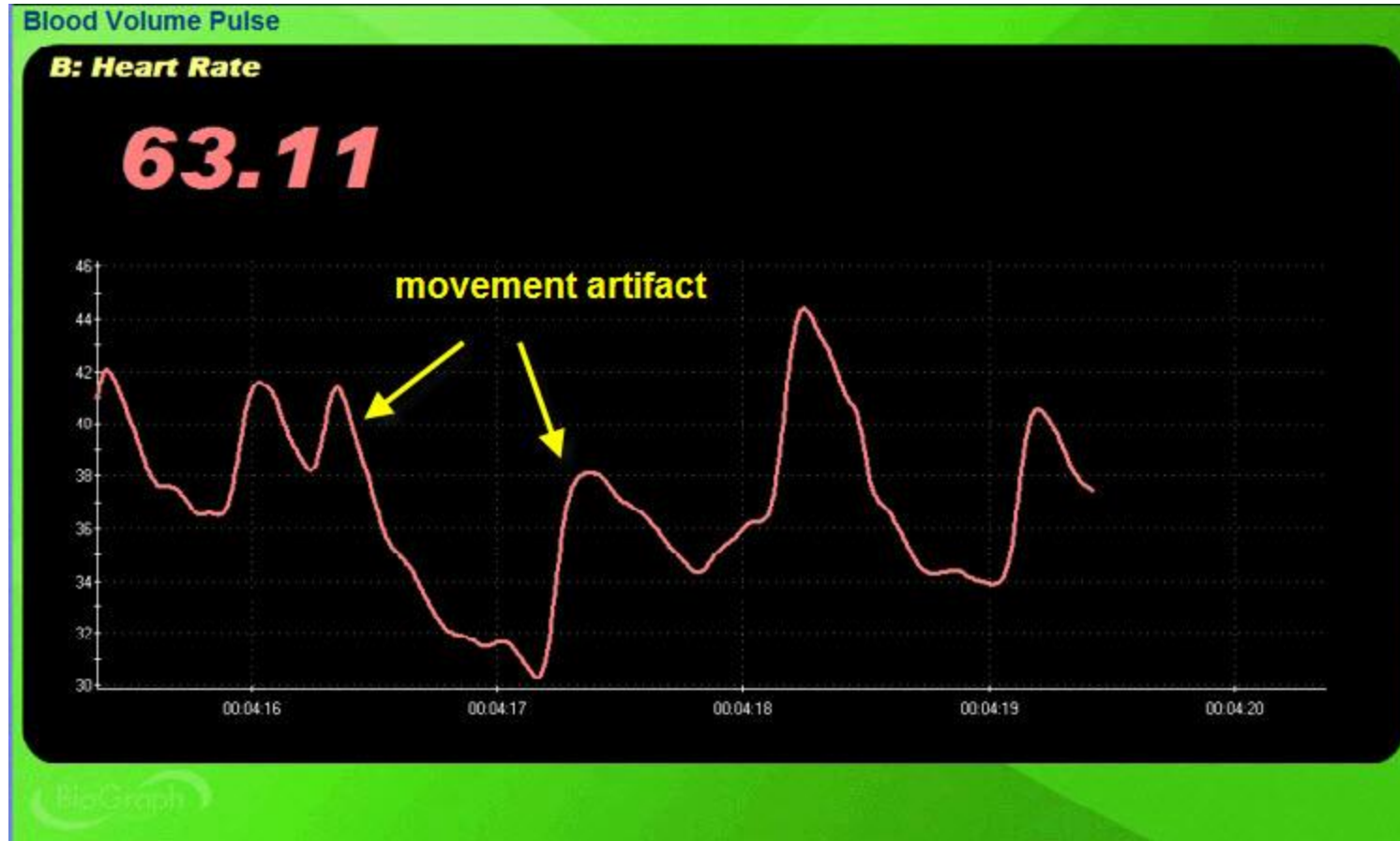
PPG sensors are highly vulnerable to *movement artifact*.

Take the same precautions as with ECG sensors and examine the raw signal for characteristic distortion of the BVP waveform.

# HRV Instrumentation



# HRV Instrumentation



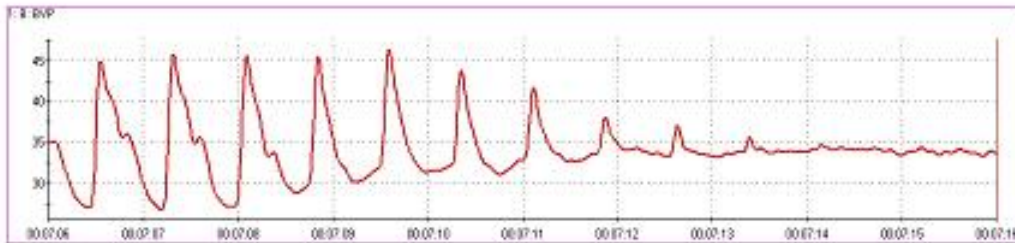
# HRV Instrumentation

*Pressure artifact* can be caused by wrapping a restraining band too tightly.

Patients often report throbbing when a Velcro band is wrapped too tightly around a finger.

# HRV Instrumentation

Pressure artifact reduces the amplitude of the raw signal resulting in smaller values and the inability to detect the peak of the pressure wave.



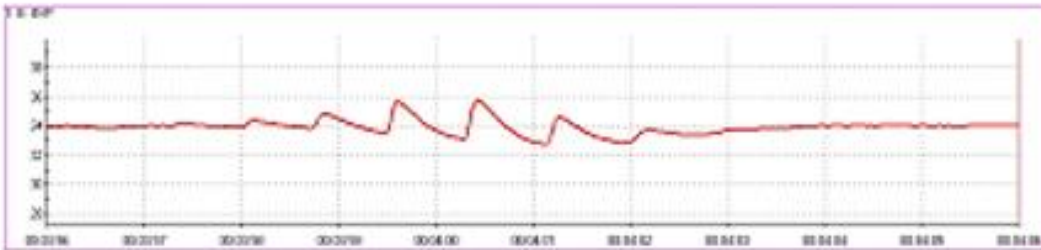
# HRV Instrumentation

## **Clinical tips to minimize pressure artifact:**

1. Readjust the tightness of the restraining band.
2. Examine the raw signal for artifact.

# HRV Instrumentation

*Cold artifact* can reduce the amplitude of the blood volume pulse signal so that the peak of the pressure wave cannot be reliably detected.



# HRV Instrumentation

## **Clinical tips to minimize cold artifact:**

1. Maintain at least a 74° F room temperature
2. Use an earlobe or thumb placement.
3. Allow your client to warm her hands in warm, running water before the session.
4. Examine the raw signal for artifact.

# HRV Instrumentation

## **Tracking test:**

You can determine whether the ECG or BVP signals respond to your client's breathing by observing whether her instantaneous heart rate speeds during inhalation and slows during exhalation.

# HRV Instrumentation



# HRV Instrumentation

The ECG method more accurately detects the interbeat interval, but involves skin preparation and may require removal of clothing.

The PPG method is simpler and achieves acceptable accuracy for clinical work, but it is especially vulnerable to movement artifact and vasoconstriction of the digits.

# HRV Instrumentation

Both the BVP and ECG methods allow us to measure global HRV using the SDNN, SDRR, pNN50, and HR Max – HR Min indices.

# References

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Berntson, G. G., Quigley, K. S., & Lozano, D. (2007). Cardiovascular psychophysiology. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson, (Eds.). *Handbook of psychophysiology* (3rd ed.). New York: Cambridge University Press.

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# References

Umetami, K., Singer, D. H., McCraty, R., & Atkinson, M. (1998). Twenty-four hour time domain heart rate variability and heart rate: Relations to age and gender over nine decades. *Journal of the American College of Cardiology*, 31(2), 593-601.