Blood Shear Stress Calculation

$(1)\ \tau = \eta\gamma$

$(2)\ \gamma = \frac{8v}{d}$

$(3)\ v = \frac{l}{t}$

$(4)\ \tau = \eta\frac{8\frac{l}{t}}{d}$

τ = wall shear stress
η = viscosity (blood = 3.5 cP)
γ = shear rate
v = mean velocity
d = diameter
l = length
t = time

Assume 100 mm collateral arterial length and 0.7 mm collateral arterial diameter. Also assume 0.03 second calf muscle contraction during normal walking, and a 0.25 second pressure application time for the ArtAssist (model AA-100)

Using equation (4):

Shear stress from walking: $\tau = (0.035p)\frac{8\frac{100mm}{0.3\ s}}{0.7\ mm} = \mathbf{133\ Pa = 1330\ dyn/cm^2}$

Shear stress from the ArtAssist machine: $\tau = (0.035p)\frac{8\frac{100mm}{0.25\ s}}{0.7\ mm} = \mathbf{160\ Pa = 1600\ dyn/cm^2}$

Pressure/time ratios

Using a normal walking speed of 100 steps/min = 1.6 steps/sec
=0.83 steps/sec (for one leg) = 1.2 seconds/step
Muscle contracts for about a fourth of time of the gait cycle[1]

Each muscle contraction lasts ≈ 0.3 seconds

Applied pressures:
Soleus = 250 mmHg[2] = 33,330 Pa
Gastrocnemius = 215 mmHg[2] = 28,664 Pa
Machine = 120 mmHg = 15,998 Pa

Soleus $= \frac{33{,}330\ Pa}{0.3\ s}$ = **111,100 Pa/sec**
Gastrocnemius $= \frac{28{,}664\ Pa}{0.3\ s}$ = **95,546 Pa/sec**
ArtAssist Machine $= \frac{15{,}998\ Pa}{0.25\ s}$ = **63,992 Pa/sec**

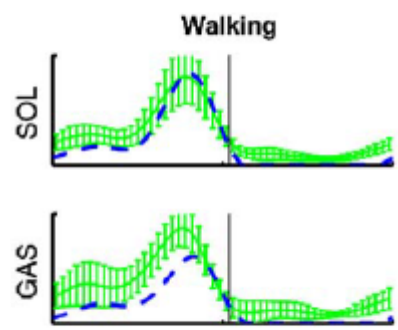

Figure 1: Muscle excitation patterns for walking[1]

[1] Sasaki, Koraro and Neptune, Richard R. 2006. “Differences in Muscle Function during walking and running at the Same Speed” *Journal of Biomechanics*. 39
[2] “ Strandness, Eugene D. and Sumner, David S., 1975, *Hemodynamics for Surgeons*. New York, NY, 137 p.