Gravity Balancing Conditions for an Upper Arm Exoskeleton
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An upper-arm wearable exoskeleton has been designed for as-
sistance and functional training of humans. One of the goals of
this design is to provide passive assistance to a user by gravity
balancing, while keeping the transmitted forces to the shoulder
joints at a minimum. Consistent with this goal, this paper ad-
dresses the following questions: (i) an analytical study of gravity
balancing design conditions for the structure of the human arm,
(ii) minimization of transmitted shoulder joint forces while satis-
fying the gravity balancing conditions, and (iii) possible imple-
mentation of these conditions into practical designs using zero-
free length springs.

The Evolution of the External Left Ventricular Assist Device
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External counterpulsation is a noninvasive method of applying
eXternal pressures to vascular beds of the lower extremities syn-
chronous with the cardiac cycle. Numerous animal experiments
and a number of clinical trials have been conducted over the years
in patients with various forms of cardiac disease to evaluate the
effectiveness of external counterpulsation. The external counter-
pulsation machines (known as ECP and EECP machines) are cur-
rently widely available for use in the treatment of angina by ap-
plying positive pressure to the lower extremities during cardiac
diastole to increase coronary flow. External counterpulsation has
also been shown to be capable of perfusing the ischemic myocard-
dium following an AMI and of assisting the failing left ventricle
in patients with CHF. In these applications, positive pressure is
applied externally to the lower extremities during cardiac diastole
and negative pressure during cardiac systole so as to increase
coronary flow and reduce the work of the heart. This paper pro-
vides a review of the developments in the area of external coun-
terpulsation and the related devices. The paper also reviews the
experimental evidence that provides the scientific basis for the
design of a device now under development and called external left
ventricular assist device (XLVAD) that should provide effective
support of the left ventricle of a patient in congestive heart failure
or following an AMI. The evolutionary development of the exter-
nal counterpulsation devices into the XLVAD is presented in de-
tail. The clinical and mechanical advantages as well as the short-
comings of each device are described.