o-ring between the two components ensures an air-tight join.

The compression spring and tensioner are located within the lower chamber; the tensioner runs inside the spring and articulates with the upper surface of the lower chamber via an o-ring. This arrangement is such that the upper surface of the lower chamber acts as the inspiratory valve seat. The male threaded element of the tensioner is coupled with the complimentary female thread on the tensioner knob. The arrangement is such that as the tensioner knob is rotated clockwise the chamber housing the spring is effectively shortened, thereby compressing the spring. The converse applies when the tensioner knob is rotated anticlockwise.

The outer sleeve fits over the lower chamber/tensioner knob assembly. The upper surface of the sleeve pushes on to the lip formed at the join between the main body and lower chamber, thus holding the sleeve in place.

Determining inlet area and spring specification

To achieve a range of pressure loads from of 0 to -150 cm H_2O, the inspiratory valve area, the spring rate and spring length all needed to be determined. A 17-mm internal diameter o-ring of 3 mm section was used to provide the inspiratory seal. The o-ring articulates with a 45° valve seat, thus the area under the o-ring, calculated in the manner described previously, is 387 mm^2. To achieve a maximum pressure equal to -150 cm H_2O it was necessary to utilize a spring capable of generating 5.7 N, the working range of the spring was fixed at 30 mm, thereby giving a spring rate equal to 0.19 Nm m^{-1} (-5 cm H_2O mm^{-1}).

The inspiratory load (threshold pressure) is altered by rotating the tensioner knob. As the tensioner knob revolves it travels either up or down the tensioner; the pitch of the tensioner thread is 3.3 mm. Hence, for each complete rotation, the pressure load is altered by ± 16.7 cm H_2O. The lower body has three gradations, 10 mm apart, these serve as a visual indication of load increment. Each gradation corresponds to $\pm$ 50 cm H_2O.

A summary of the training device in use

Upon initiation of an inspiratory effort, the user generates a negative pressure within the main body; when this pressure equals the positive force being exerted on the inspiratory valve, the valve starts to lift from its seat, thereby permitting air flow. Air passes through inlets on the underside of the tensioner knob, up through the lower chamber via the now open inspiratory valve, into the main body. The inspired air finally passes via the mouthpiece in to the user's lungs. The valve system remains open for as long as the user is able to generate a negative pressure in excess of the spring generated positive force acting on the valve. As the user's lungs become inflated, the pressure generating capacity of the inspiratory muscles at the increasingly higher lung volumes, becomes progressively lower. At the point when the negative pressure being developed by the user fails to exceed the positive force being exerted on the inspiratory valve, the valve closes. As the user initiates an expiration the expiratory flap valve is deflected by the ensuing air flow, unimpeded exhalation is thus permitted. This cycle is repeated as the user commences the next inspiratory effort.

The load profile of the threshold loading device

The most critical consideration in the design of any muscle training device is the loading profile generated by the given means of resistance. In this instance the specific concern is the pressure generation necessary to open a spring loaded poppet valve across an inspiratory effort. However, the matter is complicated by the relationship between pressure and flow. Whilst pressure generation is the parameter being manipulated it is flow production that defines the initiation of inspiration and flow cessation that determines end-inspiration.

Interestingly, it is in terms of flow that pressure threshold loading has been conceptualised traditionally. When the threshold pressure is achieved, flow is initiated; when the threshold pressure fails to be achieved, or can no longer be sustained, flow subsequently fails to be generated or ceases to be