UNIVERSTITY of DEN HAAG, ept. Human kenetics

Essential conclusions in Enlish.
Technical analyses of reactive impact.

Explanation of the effect of Reactive Impact.

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Introduction.
The XCO-Trainer is basically a Tube, closed with caps, partially filled with a free moving mass that consists of loose particles of irregular shape.
The XCO-Trainer is easy to handle and can be moved in a great variety of 3-D patterns; either by holding it in one or both hands or connected to the foot.
When moving the XCO-Trainer the direction of the movement should always be in the length of the Tube itself and the movement should be back and forth. The speed and length of the movement should be such that at the beginning and end of each movement the impact of the free moving mass against the end-caps can clearly be felt.

Reactive Impact.
The unique training effect of the XCO-Trainer is referred to as Reactive Impact.
This Reactive Impact occurs at the start and end of each movement and is very different from the normal energy that occurs with a dead weight [fig. A].
The most important aspect of Reactive Impact is that it creates the highest load to the locomotor system at the moment that is optimal for physical training. Meaning that the muscles as well as the collagen (connective tissue) receive the right stimulation for increasing strength and performance. Reactive Impact in fact is the result of the optimal combination of delayed impact together with soft impact.

Delayed impact.
When changing the direction of the movement, back and forth, the XCO-Trainer itself changes direction. However, the free moving mass within the Tube does not change its direction immediately but with a delayed impact in relation to the changing of the movement. This delayed impact releases its energy when the movement into the other direction has already been started; so actually just after the change of direction and at exactly the moment of acceleration. This moment of acceleration is actually critical in training the performance of the locomotor system. The Reactive Impact of the XCO-Trainer creates exactly the right kind of load at the most optimal moment for physical training. Because the impact takes place during the acceleration the release of energy is much higher than a dead weight [Fig. A].

Moreover, at the moment when a movement is reaching its end position (the position of the change of direction) there is a relatively lower energy as compared to a dead weight (so while slowing down) and when acceleration takes place then the energy is relatively much higher [fig. A].

Of course this Reactive Impact effect only increases in its relative energy when the speed and intensity of the movement is increased.

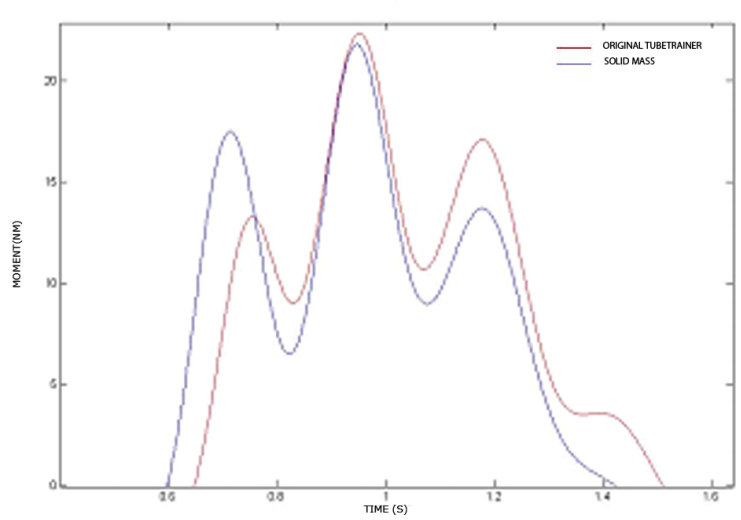
Soft Impact.
In order to achieve the right Reactive Impact it is of great importance that the impact itself is not a hard shock that concentrates all of the energy in one moment. That effect would occur when the XCO-Trainer contain a weight that functions as one entity, such as e.g. a large iron ball. Because the impact would be so concentrated it would actually create a short peak of energy at the moment of acceleration and that would be damaging to the muscle cells and connective tissues.

The free moving mass of the XCO-Trainer consists of smaller particles that have an irregular shape. This specific type of mass absorbs its kinetic energy. When the direction of movement of the XCO-Trainer container changes, the free moving mass of particles will reach the end-cap of the XCO-Trainer and be pressed against it. While the mass reaches the end-caps, not all the mass reaches it at the same time as a iron ball would. As a result the energy of the impact is divided over an extended moment in time. Most of all however, when the mass is being compressed against the end-cap, the irregular shape of the particles will allow the individual particles to change their respective positions in order to decrease the density of the free moving mass. This effect allows the mass to absorb kinetic energy and in this way creates a soft impact.

Test-Model and graphics.
In a test-model a mechanic arm with a number of sensors has been outfitted with a standard XCO-Trainer, an identical container but with a mass that consists of fine sand, an identical container filled with marbles and an identical container with a dead mass. In all 4 configurations the mass had exactly the same weight. The mechanic arm moves backward and forward and the sensors measure the energy and transmit this to a computer for analysis. The test were performed by the University of The Hague, department of Human Kinetics.

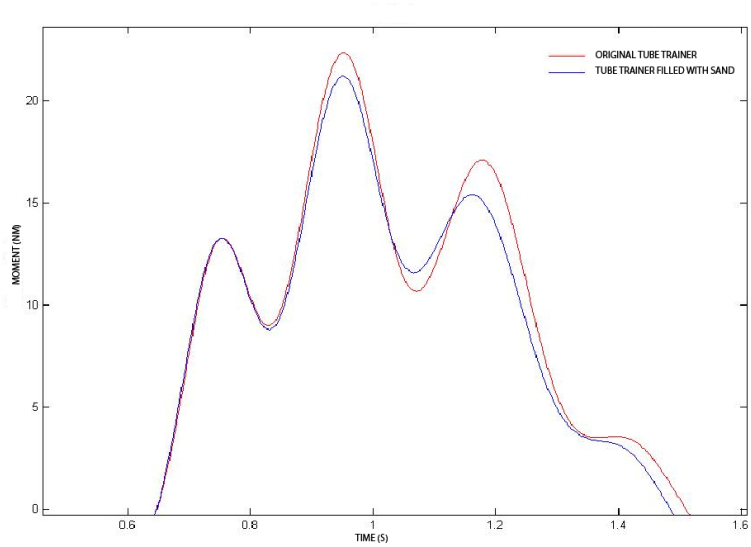
In all graphics we see 3 peaks. The first peak (at left) relates to the moment when to movement slows down in order to change direction. The second peak (middle) is exactly at the change of direction and the third peak (at right) is at the moment of acceleration into the other direction. The wider the peak the longer the period in which the energy is absorbed. Ideally the first peak should have a relatively low energy. The middle of the middle peak should be similar because all the weight is the same and the third peak should have the soft overload of energy that is ideal for training physical performance.

Fig. A. Dead mass in relation to the standard XCO-Trainer.



With the solid mass we see that actually there is a relatively high energy in the 'slow down' peak at left and a relatively low energy at the 'acceleration' peak at right. The XCO-Trainer creates exactly the opposite effect of the dead mass. Here we see that in the 'accelaration peak' the energy is approx. 25% higher for XCO-Trainer.

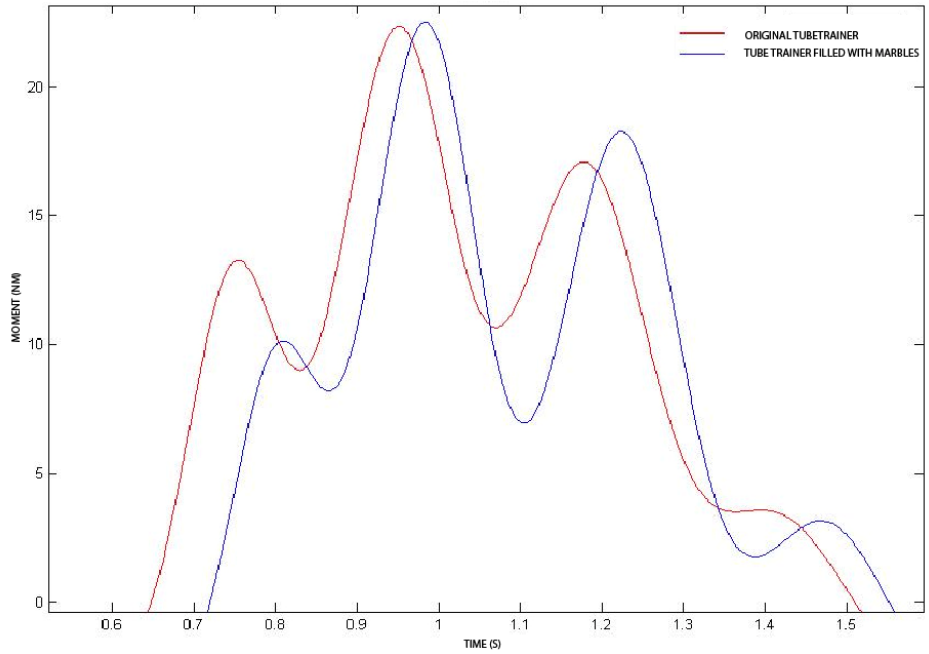
Fig. B. Sand in relation to the standard XCO-Trainer.



Sand is a rather fine material as compared to the irregular shaped particles in the original XCO-Trainer. Because sand is rather rounded the centre of gravity is also central in the sand particle. This means that at the moment of impact the mass of sand moves to a high density relatively fast and does not have the potential to absorb the kinetic energy very well. The finer and the more rounded the sand particles, the more the entire mass of sand will act as one solid mass.
In the graphic Fig. B this becomes clear.
The 'slow down' peak is identical because for both it is a loose mass that slows down in much the same way. At the third peak – the 'acceleration' peak – it is obvious that the original XCO-Trainer releases considerably more energy at the right moment (approx 15%). When we

increases the speed of movement or increase the moving mass, then this relative difference will only be greater because the energy involved will be at a higher level.

Fig. C. Marbles in relation to the standard XCO-Trainer.



Marbles are also a loose mass but completely round. This means that marbles will find their maximum density very fast and will transfer their kinetic energy easily to the next marble just as a billiard ball would do. However, in the test model as used, this could not be measured because the speed of the mechanic arm could not be increased enough in order to let the marbles move in a similar way as the XCO-Trainer with sand or the irregular shaped granulate. That is why the timing of the effect of the marbles is completely out of line with the timing of the normal physical movement and thus no positive effect can be expected. A similar container with marbles as the freely moving material can only be used at intense speed of movement and in such case would not create a soft impact at the right moment of overload.