18 is shown peeled back to reveal a 4"×4" piezoelectric sensor grid **30** that is cast into ballistic gelatin and positioned under the fat and skin layers, above the stomach muscles, outside of the rib cage **32**, and over the heart region. A second 4"×4" sensor grid (not shown in FIG. **2**) comprising flexure strip sensors was positioned directly behind the piezoelectric sensor grid **30**. Flexure strip sensors, which are used in computer gaming gloves, are based on a silver-carbon layered film that changes its resistance when bent. Although flexure strip sensors exhibit a non-linear response to bending, they are very robust and therefore suitable to some embodiments of the present invention. To simplify the embodiment shown in FIG. **2** and to save costs, a single gel-filled sack **34** was created to simulate the homogenous bulk behavior of the lungs, heart, and other internal organs. Finally, in FIG. **2**, lead wires **36** extend from the sensor grid **30** and are routed to instrumentation (not shown).

The number and type of sensors attached to a model torso **12** according to the present invention will vary depending on the intended use of the torso **12**. Ballistics testing likely requires more sophisticated sensors whereas a torso **12** used in martial arts training could include only a few sensors to provide feedback for example on the strength and technique of a punch or kick. Embodiments for training in other sports involving physical impacts against the body such as boxing and football would also use different numbers and types of sensors.

During a test operation on a torso **12** designed according to the present invention, the signals from the various sensors are wired or otherwise connected to signal conditioning devices such as charge amplifiers and Wheatstone bridges and then recorded using a high-speed data acquisition system.

Because the model torso **12** is designed to accurately simulate a real human body experiencing exceptionally powerful forces, portions of the model torso **12** may fracture, tear, or otherwise be damaged during use. Some embodiments of the invention may include component parts intentionally designed to receive irreparable damage during use. Post-test event visual inspections of the damaged components could then provide additional useful data for analyzing and understanding the test event. For example, simulated ribs **20** may be designed to fracture or splinter in modes similar to those of healthy real human bone. A material's ability to resist the propagation of a brittle fracture near a flaw is generally associated with the property named "fracture toughness" expressed in kJ/m^2. Healthy human bone has a fracture toughness of around 1.2 kJ/m^2. Whereas high-strength steels such as those used in the ribs of vehicle crash dummies have a fracture toughness of greater than 140 kJ/m^2. Many embodiments of the present invention would therefore include simulated bones having a fracture toughness that is of the same order of magnitude as real bone.

To enable model torsos **12** according to the present invention to be reused, some embodiments of the present invention therefore require that some components of the torso **12** be disposable and easily replaceable. Simple bolts, screws or snap-locks for bones, and zippers or Velcro® fasteners for skin and tissue, are examples of the many types of fasteners for attaching and quickly replacing disposable components that would be obvious to those skilled in the art.

An extended version of a torso **12** according to the present invention could be used in automotive crash testing to reproduce the correct mass of the human as well as the correct mechanical properties of the skeleton and internal organs. Data from the tests could then be used to assess injury to the skeletal structure as well as the internal organs during a crash, in real-time or post-crash analysis. An upgraded and ruggedized version of the torso **12** could be used in crash tests and the damaged structural pieces or internal organs could be easily and economically replaced.

Still other uses of the present invention include testing and training with "less-than-lethal" law enforcement weapons such as "bean-bags" and other devices that are used to disarm or disable individuals without killing them. Law enforcement personnel could use a torso **12** according to the present invention to perfect their skills in using less-than-lethal weapons. Resulting data from such training could indicate whether the weapons were used safely and effectively.

The above therefore discloses an instrumented torso model that simulates anatomical features and measures the effects on a body caused by various types of impacts. Alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements as are made obvious by this disclosure are intended to be included in this disclosure though not expressly stated herein, and are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only, and not limiting. The invention is limited only as defined in the following claims and equivalents thereto.

I claim:

1. An instrumented torso model for measuring the effects of high or low velocity impacts, comprising:

simulated bone, including anatomically correct simulated ribs and sternum shaped and configured like those of a real human, having a fracture toughness of less than 10 KJ/m^2;

simulated tissue surrounding said simulated bone; including simulated layers of fat and skin outside said simulated ribs and sternum, and

a gelatin layer between said simulated ribs and sternum and said simulated layers of fat and skin; and

a sensor array, including a sensor grid, cast into said gelatin layer for measuring the effects of the impacts on either said simulated ribs and sternum or said simulated tissue.

2. The instrumented torso model as recited in claim **1**, wherein said sensor array comprises sensors selected from the following group: accelerometers, force transducers, and displacement transducers.

3. The instrumented torso model as recited in claim **2**, wherein said sensors comprise piezoelectric sensors.

4. The instrumented torso model as recited in claim **1**, further comprising a plurality of sensor arrays attached to both said simulated bone and to said simulated tissue.

5. The instrumented torso model as recited in claim **1**, wherein said simulated tissue comprises polyurethane.

6. The instrumented torso model as recited in claim **1**, further comprising simulated organs embedded in said simulated tissue.

7. The instrumented torso model as recited in claim **1**, further comprising a covering on said simulated tissue that is marked with appropriate contact points designed to be impacted during athletic training.

8. The instrumented torso model as recited in claim **7**, wherein said contact points marked on said covering identify locations on the torso that should be struck during martial arts training.

9. The torso model of claim **1**, further comprising a second grid between the sensor array, including said sensor grid, and said simulated ribs and sternum.

10. The torso model of claim **1**, wherein said fracture toughness of said simulated bone, including said simulated ribs and sternum, is of the same order of magnitude as that of real bone, 1.2 KJ/m^2.

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