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Thanks to the movies and television, the term “forensic medicine” is fairly well understood to mean the science that involves applying medical knowledge to answer certain questions of civil and criminal law—like time of death, cause of death, and so on. What, then, is “forensic biomechanics”? This term is relatively new to the legal industry, but gaining in popularity as the general field of biomechanics grows and matures. Stated simply, forensic biomechanics applies biomechanical knowledge to answer certain questions of civil and criminal law—but what do we mean by “biomechanical knowledge,” and what questions can this knowledge answer in the courtroom? Let’s see.

To begin with, we note that mechanics is the science that deals with how “things” react (in space and time) to being “loaded.” For purposes of analysis, “things” are classified as being solid, fluid (all liquids and gases), or some combination of both, i.e., viscoelastic—by “loaded,” we mean subjected to external force-couple systems that act to: 1) push on these things (compress and/or translate them, i.e., physically move them from one point to another); 2) pull on them (tension/translation); 3) twist them (torsion/rotation-in-place); 4) shear them (shave/shear/slide); 5) curl them (bending/rotation); and/or 6) otherwise subject them to external disturbances that result in some type of reaction. The reaction can range from passive resistance (static deformation) to dynamic movement (kinematics/kinetics), and both might occur with or without the thing failing—i.e., ripping, tearing, breaking, fracturing, or otherwise becoming impaired as it yields to the external disturbance.

Biomechanics, then, involves the application of the science of mechanics to biological things, including the human body. Among numerous diverse activities, biomechanical engineers deal with subjects such as the body’s response to a subgravity environment; vehicular impacts; work- and sports-related stresses and strains; environmental insults (extremes of temperature, pressure, acceleration, deceleration, vibration, etc.); combat conditions; and other issues, some of which have legal implications, hence, forensic biomechanics. How does this work? Let’s assume, for example, that a forensic biomechanical engineer is called upon as an expert witness to testify as to the likelihood that there is a biomechanical basis for an alleged work-related injury. What is his or her approach to making that determination?

Well, to begin with, the forensic biomechanical engineer is provided with the medical records that track the diagnosis and treatment of the particular affliction under investigation. Typically, such records are subjective—more art than science—and medical opinions resulting from them are purely speculative and conjectural. (I could do nothing more than speculate and note that the operationally defined loading to which the plaintiff was actually subjected in the incident itself, match the assumed loading excessive? How high is “high”? How awkward is “awkward”? And, to a reasonable degree of scientific certainty, did the actual biomechanical loading, quantified for the actual incident itself, match the assumed loading, as determined by the clinical/biomechanical mechanism-of-injury considerations discussed above? While the biomechanical literature has not yet completely defined the outer limits of what loading the “normal” human organism can tolerate without consequence, the body of knowledge regarding what we do know about human organism can tolerate, so far, without damage, is rather extensive, so it’s not like the forensic biomechanical engineer has no guidelines and criteria to go by in determining potential failure mechanisms and consequences thereof (i.e., “causes” of injury).

Plaintiffs often circumvent the above rigorous analysis by alleging that “it’s a moot point,” because the body in question was not normal, for whatever reasons, at the time of the alleged injury-causing incident. But if that is truly the case, then again, it should be incumbent upon the accuser to quantify that degree of abnormality, and to define, precisely, the extent to which it compromised the tissue in question, thereby narrowing its operating window, putting the individual at greater risk of injury. Of course, this never happens.

If one can show self-consistency between the clinical management of the patient and the presumed (biomechanical) mechanism of tissue failure, the next step is to define from what source of loading such a mechanism of failure would likely result. In other words, “What type of biomechanical loading would result in that type of tissue damage, at that time, in that anatomical location—loading which, to this point in the analysis, has to be assumed to have existed in order to maintain the self-consistency of the reasoning?” Moreover, based on the biomechanical engineer’s understanding of the envelope of human performance characteristics, it follows that, in order for such loading to have resulted in such tissue failure, the loading must have exceeded that individual’s ability to tolerate it without consequence.

In other words, if the tissue failed as diagnosed, due to the biomechanical failure mechanism consistent with that diagnosis—which failure mechanism resulted from a corresponding type of known biomechanical loading—then that loading must have exceeded the ability of that patient’s body to tolerate it without consequence. So the next obvious question is: Did it?

At this point, the forensic biomechanical engineer turns from a review of the medical records to an analysis of the biomechanical loading to which the plaintiff was actually exposed in the alleged work-related, injury-causing incident itself. Keep in mind that in the United States, innocence is presumed unless guilt is proven “beyond a reasonable doubt” in criminal cases, “with a preponderance of the evidence” in civil cases. Moreover, the burden of proof supposedly rests squarely on the shoulders of the accuser, not the defendant. Thus, one would hope and expect that it should be incumbent on said accuser to show that the biomechanical loading to which the plaintiff was exposed at work did, indeed, exceed that which the tissue in question could be expected to reasonably tolerate without consequence—and, hence, that the actual injuries are self-consistent with the presumed work-related cause of such injuries. Going one step further, that proof should be arrived at not by qualitative suggestion, or by the unconfirmed opinions of the patient’s treating physicians, but by rigorously quantifying the operationally defined loading to which plaintiff was actually subjected in the incident in question. In other words, when is biomechanical loading excessive? How high is “high”? How awkward is “awkward”? And, to a reasonable degree of scientific certainty, did the actual biomechanical loading, quantified for the actual incident itself, match the assumed loading, as determined by the clinical/biomechanical mechanism-of-injury considerations discussed above? While the biomechanical literature has not yet completely defined the outer limits of what loading the “normal” human organism can tolerate without consequence, the body of knowledge regarding what we do know about human organism can tolerate, so far, without damage, is rather extensive, so it’s not like the forensic biomechanical engineer has no guidelines and criteria to go by in determining potential failure mechanisms and consequences thereof (i.e., “causes” of injury).

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In fact:

1. Rarely does the plaintiff present any objective, quantified evidence of actual work-related biomechanical loading exposure. Quite to the contrary, treating physicians never quantify the biomechanics of the incident involved, and ergonomists do so only by “arm-waving” estimates and a reliance on what they call “known risk factors for injury” (whatever those are. . . see “Beware of Medical (and Scientific) Fads,” Am Biotech Lab 2005; 23[1]:1–6). In one case that comes vividly to mind, I remember the treating physician who was rendering an “expert opinion” as to the cause of his patient’s injury, openly admitting that, “I have no knowledge of plaintiff’s actual work activities, but from what he described, it sounds like these activities could have caused his injury.” This qualifies as “a preponderance of the evidence”!

2. Treating clinicians almost never know what condition the plaintiff was in prior to the incident in question. Indeed, even the “history” that they take leaves a
great deal to be desired, so they have no reference points, baseline values, or established criteria against which to base their opinions.

3. Treating physicians, as illustrated by the testimony alluded to above, rely almost exclusively on the plaintiff’s own version of what happened, and what he or she thinks caused his or her affliction (not tainted, of course, by any ulterior, litigation-related motives?). Then they back up their patient’s version with unsubstantiated “expert” testimony as to causation, with the result that, in actu-

tility, it is guilt that winds up being presumed unless the defendant can prove his or her innocence—by much higher standards than those to which plaintiff is held! The system, my friends, is broken.

In defense of the medical establishment, let me add quickly that clinicians are concerned more with diagnosis and treatment than with causation. Thus, they tend to justify their opinions in a rather cavalier fashion—not by hard, objective, quantified evidence on which to base a conclusion “to a reasonable degree of scientific certainty,” but by soft, subjective, qualitative conjecturing that goes something like this: “Look, patient says he (or she) was fine prior to the incident in question, and I have not really dug deep enough or hard enough to assume otherwise, so I arbitrarily take his (or her) word for it. Now he (or she) presents with these symptoms, is obviously hurting, and I don’t have the time to dig deeper into the issues of causation … my job is to treat the patient. Therefore, to a reasonable degree of medical certainty, it seems ‘obvious’ to conclude that…” As far as the treating physicians are concerned, that is all the reasoning and proof they need, and ergonomists don’t really shed much light on the real issues, either, which either strengthens the need for objective, forensic biomechanical engineering!

One of the problems with the above line of reasoning is that it often overlooks confounding variables (see Am Lab 2003; 35[16]:4–8) that are more intimately related to what actually happened than is the circumstantial evidence that is being accused of being the culprit. Thus, to get at the real cause, one must move beyond the initial assumptions—dig deeper—perform rigorous forensic biomechanical analyses; look for inconsistencies in reasoning, non sequiturs (conclusions that do not follow directly from the reasoning that led up to them), circular reasoning (conclusions inherently assumed in the very reasoning that leads up to these same conclusions), and so on.

Physicians are busy people—they see many patients a day, have little time to spend with any one patient, and really do not care about causation issues: Again, their primary role is to diagnose and treat. Causation, in the case of presumed work-related musculoskeletal issues, is of less concern to them; they are readily willing to simply take the patient’s word for what happened and what caused it. If the patient’s description seems to make sense, the treating physician is perfectly willing to accept it as fact, and testify to that fact in a court of law, “to a reasonable degree of medical certainty” (whatever that means!). By far, medicine is more art than science, so “to a reasonable degree of medical certainty” is a far cry from “to a reasonable degree of scientific certainty.” The difference between scientific certainty and medical certainty being, respectively: quantified assurance (variables lists) versus qualitative conjecture (attributes lists); double-blind, controlled, randomized, rigorous studies versus anecdotal, biased, uncontrolled, circumstantial evidence; logical reasoning to logical conclusions versus purely speculative reasoning to vague assertions; and objective criteria versus ill-defined (or conclusions inherently assumed in the very reasoning that leads up to these same conclusions), and so on.

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The trouble, of course, with the now-famous post hoc, ergo propter hoc (“after this, therefore, as a result of this”) type of reasoning is that it represents a common scientific trap—a fallacy in thinking that what immediately preceded an event, and the circumstantial evidence associated with it, must also be intimately related to its cause. The scientific literature (and, I might add, hundreds of detective novels) is replete with hard evidence to the contrary—evidence that what often appears to be the cause of an event—because of its spatial or temporal proximity to that event—is subsequently determined not to be the cause at all. In fact, such quick and superficial assessments and diagnoses of health-related issues are all too often downright wrong! (see Ultra-Prevention, written by Drs. Mark Hyman and Mark Liponis, New York: Scribner Publishers, 2003).

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