ACCOMMODATING STRATEGIES FOR PREVENTING CHRONIC LOWER EXTREMITY INJURIES

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Trauma or tissue damage is simply the result of applying too much stress to a tissue via an external load either directly or indirectly. The application of force to the system results in stress that can cause tissue damage, *i.e.*, injury. The problem can be viewed from two perspectives as stated by Nahum and Melvin in the preface of their book Accidental Injury, Biomechanics and Prevention (1993). One perspective is that of the professionals involved in injury diagnosis and treatment while the other is that of engineers and scientists (especially biomechanists) interested in the mechanics of injury. Both perspectives are well documented/represented in the professional and scientific literature.

Tissue damage/injury results when a tissue is stressed beyond some critical value/tolerance level. The stress is a result of the magnitude of the force, the type or direction of the force and the time interval between repetitive loading. Tissue damage can be acute (a single traumatic event) or chronic (developing/progressing over time). Most lower extremity injuries resulting from running and landing activities are chronic, resulting from repetitive loading to underdeveloped and/or unprepared structures. Chronic injuries can be avoided or minimized by adhering to a number of simple principles that are discussed in this paper.

Running is and has been one of the most popular forms of exercise and competition since the 1970s. During that time running mechanics has been a primary research focus in numerous biomechanics laboratories. Despite the extensive "scientific" literature that has been generated, relatively little, if any, progress has been observed when examining running injury statistics. Some representative injury statistics across the time span are given in Table 1.

Another statistic that has not changed appreciably relates to the most common running injuries. In a recent document from the American Orthopedic Society for Sports Medicine (AOSSM, 2008) the six most common chronic injuries are cited (Table 2). These are the same six common injuries identified by James et al. (1978) three decades earlier. A final comparison worth noting relates to the causes of injury. General agreement exists among publications by AOSSM (2008), Hoeberigs et al. (1982) and James et al. (1978) that the primary cause of injuries is and has always been training errors with anatomical factors and shoes and surfaces making a significant contribution.

Table 1

INJURY STATISTICS: RUNNING

KOPLAN et al, 1982	35%
LYSHOLM et al, 1987	65%
MARTI et al, 1988	46%
WALTER et al, 1989	48%
van MECHELEN, 1992	50%
ASPLUND, TANNER, 2004	50%

Table 2

Ten Common Injuries (AOSSM, 2008; Others)

Plantar Fasclitis	Foot
Stress Fractures (Foot & Leg)	Foot / Leg
Achilles Tendonitis	Leg
Shin Splints	Leg
Iliotibial Band Syndrome	Knee
Patellofemoral Pain Syndrome	Knee
Ankle Sprains	Other
Muscle Pulls	Other
Blisters	Other

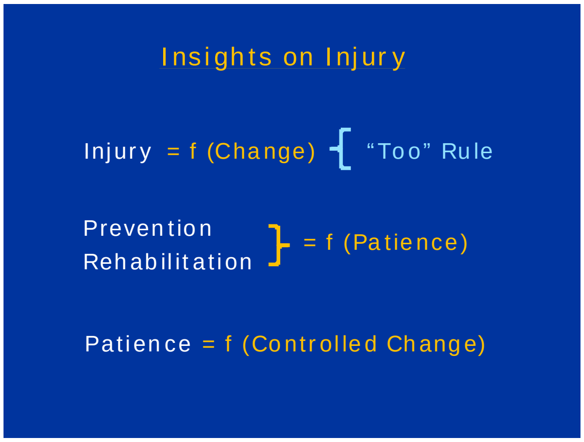
Why have we made so little apparent progress in our attempts to understand and prevent running injuries? Although most researchers claim to be evaluating similar/homogeneous groups of subjects this assumption must be questioned. Colonel John Stapp (Miller, 1979) observed that a human is a "fifty liter rawhide bag of gas, juices, jellies, gristle and threads movably suspended on more than 200 bones presiding over by a cranium, seldom predictable and worst of all living and presents a challenge to discourage a computer into incoherence." Given this expressed complexity do we really think that we can capture human performance in a simple model? Remember the human system feeds back on itself through continual experiences and changing perceptions never remaining in the same state. Is there such a thing as an average person/runner? If not, then it is unlikely that we can derive propositions about individuals from mean propositions derived from groups of people. Several examples will be discussed in the presentation.

Perhaps we have actually made more progress than the cited data suggest. During the past several decades many research studies have contributed to the scientific body of knowledge related to running mechanics and injury mechanisms. This knowledge certainly has positively influenced those professionals committed to the art and skill of diagnosing and treating running injuries. If this generated knowledge is being used by professionals to solve runners' problems more effectively and efficiently then science has made a positive contribution. Although no scientific data support this observation, anecdotal data suggest this to be the case.

CAUSE OF INJURY: The relationship between the prevention, cause and rehabilitation of injury is in the general sense relatively simple as shown in Figures 1 and 2. All are simply a function of change, however that change must be carefully controlled, *i.e.* avoiding too much, too soon, too fast, too similar, too different. The complexity of the problem results from the fact that we are all unique individuals structurally and functionally and have different experiences and goals that must be integrated into our exercise/running programs in an optimal satisfying way. In order to understand the complexity of this problem, it is important to examine selected aspects of change and their relationship to chronic injury.

Figure 1

Figure 2



PHYSIOLOGICAL ADAPTATION / ACCOMMODATION: The anatomical structures making up our system are in a continuing state of modification or adjustment as a result of environmental demands/stimuli.When these structures are modified positively the result is accommodation. Positive accommodation is the result of applying sufficient loads to obtain a physiological response for a specific activity (increase the acute threshold). The load must be varied enough to avoid cumulative stress/injury (increase chronic threshold). If the stress exceeds the tissue's physiological ability to accommodate, the tissue will be modified negatively becoming damaged resulting in injury. Remember, training errors account for as much as 60% of running injuries as a result of stressing the system with forces that are beyond its current physiological threshold, *i.e.* too much, too fast, too soon, too similar, too different. The physiological response of a tissue is constantly changing and at any instant in time is dependent upon such factors as age, gender, rate of loading, loading duration, and history (experience, tissue use or disuse).

Some response patterns are shown in Figure 3. The goal of any training program should be to increase the tissue threshold over time in addition to elevating the threshold overall. When the tissue is stressed beyond its ability to maintain or increase its threshold, the curve begins to plummet rapidly indicating the onset of tissue failure/injury. Preventing this rapid decrease is unlikely without rest and a significant reduction of the stressor.

MOVEMENT / MOVEMENT STRATEGIES: From a behavioral perspective movement is simply a tool for problem solving. The primary constraint of any movement pattern is the task or goal which is further constrained by our morphology, the current environment and the applicable biomechanical principles.

We are all creatures of experience turning into memories which determine our perceptions and expectations which in turn dictate our movement assumptions and actions. Our myriad of experiences combined with the complexity of our neuro-musculo-skeletal system suggests that we have multiple movement patterns to choose from to accomplish any particular task. We are able to select a particular movement strategy (a neuro-musculo-skeletal solution) within certain constraints to perform the motor task. As an example, Figure 4 shows possible response patterns to the impact forces during running or landing as a result of added load to the extremity. The overall dimensions of the parallelogram are determined by strength and tissue threshold. A pure Newtonian response results when the added load is ignored (the diagonal line). A pure neuro-muscular response results when no increase in impact force is observed as a result of an accommodating motor pattern (the horizontal line). All responses within the parallelogram are the result of a partial acknowledgment of the added load producing a complex biomechanical response. Additional response patterns can become available as shown in the figure to the right by increasing strength and/or tissue threshold.

Figure 3

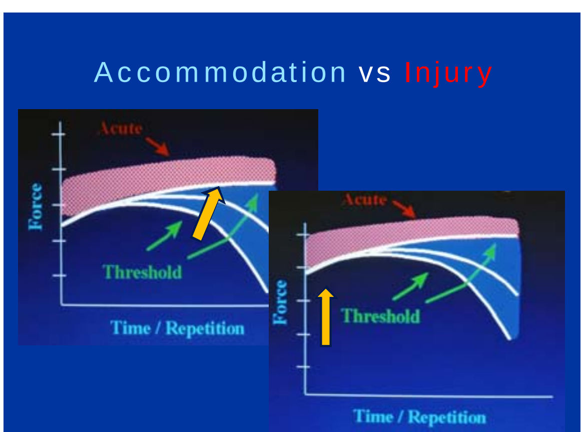
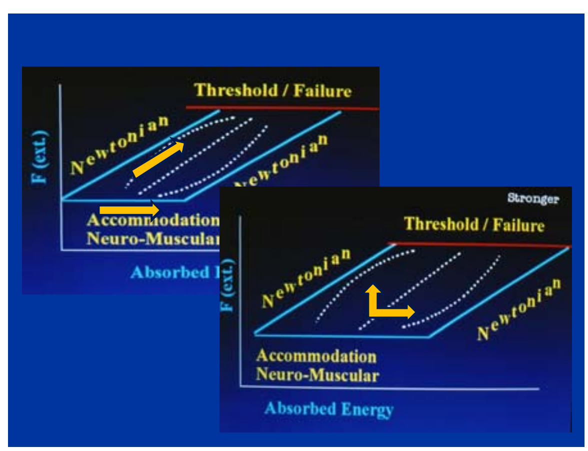


Figure 4



VARIABILITY*:* As previously stated injuries are caused by changes in force/stress. Injury prevention and rehabilitation are also the result of changes in force. The magnitude and/or direction of forces can be changed by variations within activity. Variations within activity can be accomplished by changing factors in the environment such as shoes, surface and terrain. A second option is to change performance characteristics such as foot strike pattern, knee angle, etc. Variations can also be accomplished by changing the activity, *i.e.* running, cycling, cross training. The purpose of these variations is to broaden the normal and healthy region of performance as shown in Figure 5 since the narrower the band of performance the more susceptible one is to chronic injury. Expanding the band of performance, however, must be accomplished very gradually since rapid change is also a risk factor. Another area of concern regarding this relationship is how one trains.

SPECIFICITY VERSUS VARIABILITY: Performer variability is inherent in all human movement as a result of system complexity and random perturbations. From an injury perspective this is a positive feature since it helps minimize chronic injury potential. For some activities such as gymnastics where the goal is precision/replication variability has negative connotations. In running, the elimination/minimization of variability is probably more critical for sprinters than distance runners. Relative to training and elite performance a certain amount of specificity is essential but specificity also increases the risk of chronic injury. Figure 6 shows the relationship between performance variability and risk of injury (left) and performance variability and skill development (right). What this figure illustrates is that risk reduction decreases dramatically with only small increases in variability while decreases in skill development are far less dramatic for similar increases in variability. The important point to be made is that it is important to consider this relationship when assessing performance goals. Remember, an injured athlete never improves performance.

Figure 5

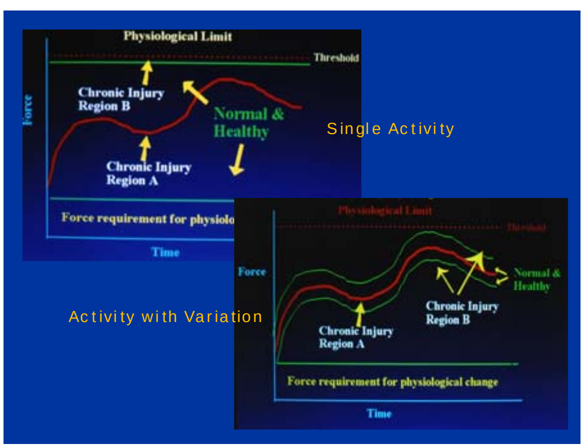
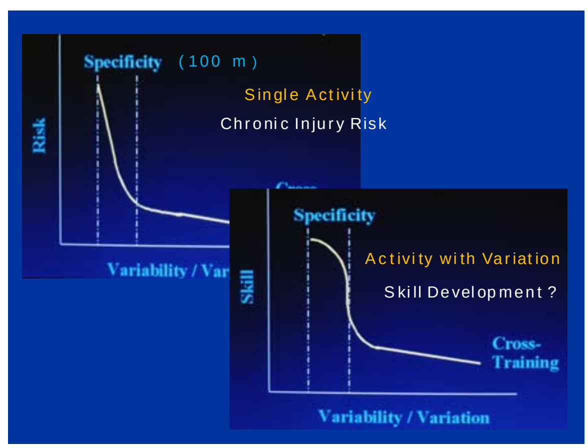


Figure 6



SUMMARY: Take-home lesson 1 is to acknowledge the possible dilemma between skill performance and injury risk. Each individual must weigh the choices among injury risk, performance and goals. Take-home lesson 2 is to remember that injury is a function of change, *i.e.* too much, too soon, too fast, too similar, too different. Just as injury is a function of change so are injury prevention and rehabilitation. All change must be carefully controlled through patience. Although this discussion tended to focus on running, it is equally applicable to other types of repetitive training and exercise. Some final suggestions include (1) set appropriate goals, (2) train/exercise smart, (3) get adequate rest, (4) do not ignore pain, (5) always think prevention, and (6) have fun.

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