EXERCISE PRINCIPLES

Regarding any facet or "area" of reality, including exercise science, there can be only one valid theory. However, since it is obvious that there are more than one way or method to exercise, it has been suggested that there must be *different theories* of exercise science. This is not true for the following reason: regardless of the *application*, each method must still follow the *same principles* of exercise science. In other words, whether exercising for twenty sets or one set, or whether exercising with weights, machines, or endurance training on a bicycle, an individual:

- Exerts effort (intensity)
- Performs a certain amount of activity (volume)
- Does so on a schedule (frequency)
- Must progress in order to improve (overload), and
- Adapts specifically, relative to the nature or type of exercise program.

In effect, these general principles make up exercise theory, whereas how we apply these principles and their *measurement* determines the method or style of exercise. Consequently, different methods of *how to* exercise are not theories, but recommended measurements of the principles that govern and that make up exercise science.

Currently, the only valid, complete, and non-contradictory theory of exercise science is the *Theory of Prescribed Exercise*™, which I have coined. This is not to say that the theory cannot be expanded upon, but that its principles remain unquestioned and true for everyone – based on what we do know about exercise. This theory includes a group of principles that I have not discovered; they have been known and implemented for several decades, but never officially catalogued, related, or detailed under one *formula* for successful action. Why this has not been done, I'm uncertain.

The *Theory of Prescribed Exercise*™ subsumes the relationship of seven principles of stress physiology and human psychology. They are 1) intensity, 2) volume, 3) frequency, 4) progression/overload, 5) adaptation, 6) diminishing returns, and 7) individualism. The relationship of these principles, under the *Theory of Prescribed Exercise*™ states:

> The measure of progression, maintenance, or delayed regression of physical function or appearance considers the magnitude of the weight and its relationship to intensity, volume and frequency, which three factors are inversely proportionate to each other, and that all of the demands, if ideally applied, to be specific and in the least measure relative to an intended and optimal response as governed by an individual’s needs, goals, abilities, limitations, and preferences.

Now, that position statement certainly is a mouth full. Here is an explanation of what it all means, and if you re-read the definition as we progress through the details, it will become quite clear. The ability to *progress* in function, or to *maintain* or *limit the loss* of function as we age is dependent on certain factors. The first factor is how much weight or resistance a person uses. For example, if a person successfully uses more resistance than last workout in a particular exercise, then he or she will increase function because the heavier weight acted as a stimulus and challenge for the body to increase function. The extra weight and challenge tells the body "you better get stronger, in order to prepare yourself for similar future assaults." At the very least, the heavier weight will challenge function enough to maintain a certain level of function. As one rule of exercise states, either "use it or lose it." If the weight stays the same or reduces, there likely will be enough of a challenge to maintain or limit the amount of functional loss. Therefore, exercise is not always about improving, but keeping what you currently have or slowing down the loss of what you have built up.

Next, how much we progress, maintain or limit any physical loss is also based on how hard we exercise (intensity), how much activity we do in a workout (volume), and how often we repeat the activity (frequency). The harder we exercise, the less we can do in a workout and the less often we could or should exercise. Conversely, the more we do in a workout, the easier we must make exercise and the less frequently we should do it. Similarly, the more frequent we exercise, the less we could or should do in a workout and the easier the exercise should be. An obvious pattern should be noticed, in that there must be a balance among these three factors, and with the remaining principles as a whole.

These three factors (intensity, volume, and frequency) have a bearing on how much weight should be used in a workout. For example, if a person exercises very hard then heavier weight can be used than if a person does not try very hard. If a person decides to exercise for a long period of time or quite frequently, then he or she cannot use as much weight. This last aspect is true because all the fatigue that results from exercising too often would not allow a person to exercise with heavy weights, and the use of heavy weights would not allow such lifting to occur very often; at least not for long before a person feels lethargic.

Sometimes very frequent exercise is a good thing, depending on the goals of the individual. Obviously someone who is interested in muscular endurance would exercise more frequently and for longer periods of time than someone who is interested in maximizing the development of muscle mass and strength. In this regard here is another rule: "you can exercise hard or you can exercise long, but you can't do both." Don't confuse this with an exhausting activity such as marathon running. Running a marathon may be fatiguing and may be demanding, but it is not "intense." On the other hand, a 100-yard sprint is so intense that it can only last for a very brief time. Therefore, there is a difference between the concepts of "demanding" and "intense." Both the long distance run and the 100-meter sprint are demanding in their own ways, relative to the time frame it takes to complete each task and the energy utilized by each task within those time frames. However, in order to make a long distance run last for several miles, the intensity of effort cannot be high. This will be explained in greater detail shortly.

Next, the theory states that exercise demands need to be specific to the individual and the goals and needs of the individual. This was explained in the above paragraph, in that if a person wants to have very good muscular endurance, he or she should train differently than a person who wants to maximize muscular mass or strength. In effect, to "adapt" in a specific way requires the exercise method to be "specific" so that a person can adapt, or improve particular abilities accordingly. A sprinter would not train with long distance running techniques, and a volley ball player should not practice baseball.

Next, the theory states that exercise should be done in the least possible (or necessary) amount to produce an optimum response. Think of it this way: In order to make the <u>same</u> amount of progress or results, would you rather do 30 minutes of exercise or 60 minutes of exercise? Any rational person would choose 30 minutes, unless exercise is more of a psychological addiction and there is a preference to exercise more than is necessary. Moreover, we have to consider the quality of exercise and how hard a person exercises. If a person does not like to exercise very hard, that person will need "more" exercise to equal the benefits of "less" and harder exercise.

Lastly, all the above factors must take into account an individual's needs, goals, abilities, limitations, and even a person's psychology (preferences). In other words, everyone should not follow the same exercise program, or even consider an exercise program of an elite athlete or some other drug using "genetic superior" found in fitness magazines. What is ideal for each of us can be quite different, based on our individuality and what we are attempting to achieve, i.e., a specific exercise effect. This is not to say that most of us would not respond fairly well to the same program, if the program's overall structure is not too excessive and it is reasonable. But if the goal is to *maximize* a particular exercise effect or characteristic relative to a person's genetics, then the exercise program must be more specific to that individual. This is the difference between a general conditioning program, to get someone in shape and lose some fat, and a *personalized prescribed* program. A similar example would be to provide school students general methods to help improve study quality, but to allow each student to find his or her personalized methods to help maximize the effect of the general study methods.

So far, all this should make sense. Individuality should be considered as much as possible and all the factors that make up an exercise program (intensity, volume, frequency, progression, specific adaptations, and diminishing returns/how much is necessary) are to be prescribed accordingly. Therefore: An individual needs to lift a certain amount of weight so that the muscles can resist against *something*. An individual puts forth a certain amount of effort and that effort is relative to how heavy the weight is, how much activity is performed in a workout and how frequently the person exercises. The method/structure or nature of the exercise program should reflect the goals of an individual and what is to be achieved, so that he or she makes progress relative to those goals. And, it is only rational that the least amount of exercise be performed in order to achieve the desired results, and that any more exercise than is necessary is pointless.

This last factor is important since exercise theory recognizes that any amount of exercise strain represents a *negative* factor to the body and mind, in that, to a degree, any exercise performed at all causes an *inroad* (a reduction in function) into the body’s recovery ability. In other words, the more you do, beyond a certain limit, the harder it is to recover from exercise and the less progress you will make overall. Consequently, exercise demands must be regulated properly to ensure the greatest benefit at the lowest cost – the cost is "effort and strain" on the body and mind, and the benefit is a strong, healthy body.

Since each bout of exercise affects our energy resources, some of the body's remaining resources must be used to replenish and compensate for the fatigue cased by exercise. Unfortunately, like anything else, we only have so much recovery ability, and doing too much too often can make us weak and ill, the opposite effect of what exercise is supposed to do. Consequently, we have our next rule: "that which can make us strong can make us weak." Most important, since individuals vary in their capacities to tolerate exercise, i.e., some people have better tolerance whereas some have less, <u>exercise must be prescribed on an individual basis</u>. Therefore, what may be ideal for one individual may be *inadequate* or *excessive* for someone else.

Obviously there must remain a balance among the exercise principles' measurements. Sometimes this means that if one thing increases (intensity of effort) the other things (volume and frequency) may need to decrease. Sometimes if only one element decreases – e.g., exercise volume, whereas the measurement of all principles were *ideal* before – the stress of exercise can become so high that a person may require several weeks or a few months layoff from exercise to feel energetic again.

There is an exception to this, as will be explained in Chapter Seven. Sometimes it is good to increase exercise to higher levels in order to "surprise" the body and to make the body want to become even stronger and better conditioned. In a sense, this could be called "forced conditioning" since one would be forcing a higher state of physical function; a state that the body would not have achieved under normal non-exercising conditions. Olympic athletes do this all the time: they start off slowly and do a little exercise, then they pick things up and exercise a bit harder, then just before the Olympic games they pull out all the stops and train harder than ever before. However, they only train super-hard for a brief period of time, in order to maximize the body's response to be in the best shape and condition ever. If they trained like that all the time, they would quickly overtrain and lose strength.

I don't want to make the idea of how to balance the principles too complicated right away, but consider the following and why things may need to be adjusted or not adjusted. Suppose a person is following an exercise program that is well within his limits and the program is appropriate. If he were to put forth a bit more effort or add another set of exercise, this would not, necessarily, cause him to overtrain since every person has a "range" in which exercise can be tolerated. It's like having a range or tolerance to heat: one temperature feels good, whereas a higher or lower temperature may not be as comfortable or "ideal" for our bodies, but the temperature differences can be tolerated. If you have exercised in the past, you may have noticed this: you can either do a bit more or a bit less than usual, now and then, without any negative consequences.

But suppose that, at this moment, the individual's program is ideal, and any more exercise *would eventually* cause him to overtrain and feel lethargic because of too much exercise. I say "eventually" because an increase in exercise demands is not necessarily a bad thing if the increase lasts for a short period of time, whether for a few workouts or a few weeks, as explained above. But, if this person were to maintain such an exercise program for too long, then he would overtrain. This is what happens to a lot of people: they follow a routine from a fitness magazine, and everything is fine at first. They make some progress, then *eventually* they hit a stalemate and no longer make progress. And, eventually, they begin to lose strength, and look and feel worse. These are telltale signs that an overtrained state has begun, and if they don't reduce the exercise demands, things will only get worse until they have to stop exercise altogether for several weeks or months while they recover from the stress of doing too much exercise for too long. As stated, all this will be discussed and expanded upon throughout the book, and it is a point that is vital to understand, although most exercise "experts" seem to neglect the importance of "the right amount of exercise."

And this is where the Theory of *Prescribed* Exercise™ differs from *general* exercise theory. For exercise to exist as a concept, it need only account for four of our seven factors: intensity, volume, frequency, and a weight (load). However, for exercise to be *specific* relative to an *individual*, it further must consider *specificity of exercise* and whether the exercise is *ideal and in the right amount*. Beginning on the next page is an overview of how the principles of The Theory of Prescribed Exercise™ relate to one another. Do not worry about how complex this all looks since each principle will be discussed thereafter and in greater detail.

General Exercise Rules

1. **Use it or lose it.** Lack of activity makes muscles and our immune system weak.

2. **You can exercise hard, or you can exercise long, but not both.** Sprinters cannot sprint for several miles. Similarly, if the goal is to increase strength and muscle tissue it is wrong to believe "more exercise is better." In this instance exercise should be hard and brief, whereas muscular endurance would require less intense and longer workouts.

3. **That which can make you strong can make you weak.** We should do just enough exercise to provide a benefit relative to our needs, goals, and tolerances. Doing too much, especially if we exercise hard, can do more harm than good.

RELATIONSHIP OF INTENSITY OF EFFORT

Volume	Frequency	Overload	SAID	Diminishing Returns	Individualism
Number of sets (more intensity = less sets per workout)	*Rate of occurrence* (more intensity = less frequency, unless volume diminishes to sustain frequency)	*Increase in weight or TUT* (more intensity = greater chance of using heavier weights or exceeding previous TUT*)	*Strength, muscle mass, endurance* (more intensity = greater ability to achieve goals up to a point; see Diminishing Returns and Individualism)	*Benefit subsides or regresses from exceeding a particular limit* (more intensity may not produce better results relative to the measure of the other factors)	*Goals, needs, ability, appropriateness, and preferences* (level of intensity must account for individual specifics)

RELATIONSHIP OF VOLUME

Intensity	Frequency	Overload	SAID	Diminishing Returns	Individualism
Mental and physical effort (greater volume = less intensity unless frequency reduces to allow for additional recovery time)	*Rate of occurrence* (greater volume = less frequency unless intensity reduces to allow for adequate recovery)	*Increase in weight or TUT* (greater volume = less chance of using heavier weights or exceeding TUT because of greater inroading unless overloading in volume is the directive)	*Strength, muscle mass, endurance* (greater volume = less ability to achieve goal of added strength and muscle mass (and even endurance) beyond a certain limit; see Diminishing Returns)	*Benefit subsides or regresses from exceeding a particular limit* (greater volume may not produce better results, relative to individual tolerance levels)	*Goals, needs, ability, appropriateness, and preferences* (level of volume must account for individual specifics)

RELATIONSHIP OF FREQUENCY

Intensity	Volume	Overload	SAID	Diminishing Returns	Individualism
Mental and physical effort (greater frequency = less intensity unless volume reduces to allow for adequate recovery)	*Number of sets* (greater frequency = less volume, unless intensity reduces to allow for adequate recovery)	*Increase in weight or TUT* (greater frequency = less chance of using heavier weights or exceeding TUT unless volume reduces to allow for adequate recovery)	*Strength, muscle mass, endurance* (greater frequency = less ability to achieve goals beyond a certain point; see Diminishing Returns and Individualism)	*Benefit subsides or regresses from exceeding a particular limit* (greater frequency may not produce better results)	*Goals, needs, ability, appropriateness, and preferences* (level of frequency must account for individual specifics)

* **Time Under Tension (TUT)** refers to the measure of minutes and seconds of a set, regardless of the number of repetitions performed during that time, *minus* any resting that may take place between repetitions, such as locking out the joints in a squat or bench press. **Time Under Load (TUL)** refers to the measure of time *including* any brief rests that may occur between repetitions.

RELATIONSHIP OF OVERLOAD (PROGRESSIVE OVERLOAD)

Intensity	Volume	Frequency	SAID	Diminishing Returns	Individualism
Mental and physical effort (greater overload = dependence on sufficient intensity in order to overload)	*Number of sets* (greater overload = less sets per workout to limit negative effects of excessive inroading and reduced functional ability)	*Rate of occurrence* (greater overload = limited frequency to overcompensate, unless volume diminishes to sustain frequency)	*Strength, muscle mass, endurance* (greater overload = greater ability to achieve goals up to a point; see Diminishing Returns and Individualism)	*Benefit subsides or regresses from exceeding a particular limit* (greater overload may not produce better results if recovery is inadequate)	*Goals, needs, ability, appropriateness, and preferences* (level of overload must account for individual specifics)

RELATIONSHIP OF SAID (SPECIFIC ADAPTATION TO IMPOSED DEMANDS)

Intensity	Volume	Frequency	Overload	Diminishing Returns	Individualism
Mental and physical effort (low to moderate intensity for endurance; higher intensity for strength and muscle mass)	*Number of sets* (higher volume for greater endurance; lower volume for greater size and strength, but relative to intensity of effort and individual tolerance)	*Rate of occurrence* (greater frequency for greater endurance; less frequency to tolerate heavier, more intense exercise)	*Increase in weight or TUT* (overload can increase strength, muscle mass, or endurance, which measure is relative to intensity, volume, and frequency)	*Benefit subsides or regresses from exceeding a particular limit* (beyond certain limits, exercise can produce negative adaptation, i.e., atrophy; also, too little demands can result in wasted effort and no progress)	*Goals, needs, ability, appropriateness, and preferences* (the measure of adaptive response is relative to individual specifics)

RELATIONSHIP OF DIMINISHING RETURNS

Intensity	Volume	Frequency	Overload	SAID	Individualism
Mental and physical effort (effort beyond certain limits, relative to volume and frequency, will not produce better results and may cause negative adaptation, i.e., mental burnout and muscle atrophy)	*Number of sets* (sets beyond a certain limit, relative to intensity and frequency, will not produce better results and may cause negative adaptation, i.e., atrophy)	*Rate of occurrence* (frequency beyond a certain limit, relative to intensity and volume, will not produce better results and may cause negative adaptation, i.e., atrophy)	*Increase in weight or TUT* (overload beyond a certain limit, relative to intensity, volume, and frequency, will not produce better results and may cause negative adaptation, i.e., atrophy or injury)	*Strength, muscle mass, endurance* (specific adaptations are relative to all factors with positive benefits diminishing beyond a critical threshold of individual tolerances)	*Goals, needs, ability, appropriateness, and preferences* (the magnitude of positive return and over-stimulus is relative to individual specifics)

RELATIONSHIP OF INDIVIDUALISM

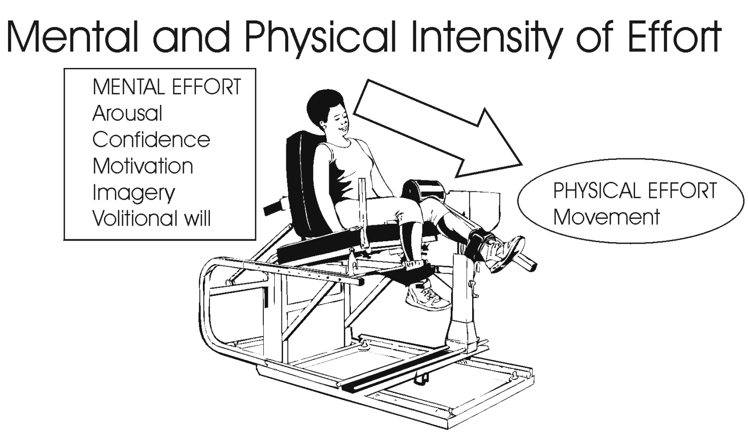
Intensity	Volume	Frequency	Overload	SAID	Diminishing Returns
Mental and physical effort (effort can be subjective; some people cannot or should not train to maximum capacity; goals and needs will dictate it's measure)	*Number of sets* (dependent on rate of fatigue, magnitude of frequency, intensity, goals [SAID], ability and preferences)	*Rate of occurrence* (dependent on rate of fatigue, volume, intensity, goals [SAID], ability and preferences)	*Increase in weight or TUT* (dependent on intensity, volume, frequency, goals [SAID], ability, and preferences)	*Strength, muscle mass, endurance* (measure and nature of adaptation is dependent on all factors within an individual's program)	*Benefit subsides or regresses from exceeding a particular limit* (extent of cost/benefit ratio dependent on all factors within a program)

Principle of Intensity

Intensity is the possible percentage of momentary muscular and volitional effort exerted. This means that at any one moment when exercising, you produce or exert a certain amount (percentage) of effort that is possible (or required) to complete a task. Consider lifting a 10-pound weight, whereas 50 pounds could be lifted. In this instance, the amount of effort exerted might be 20% of one's maximum strength ability, whereas 100% effort is required to lift the much heavier 50 pounds.

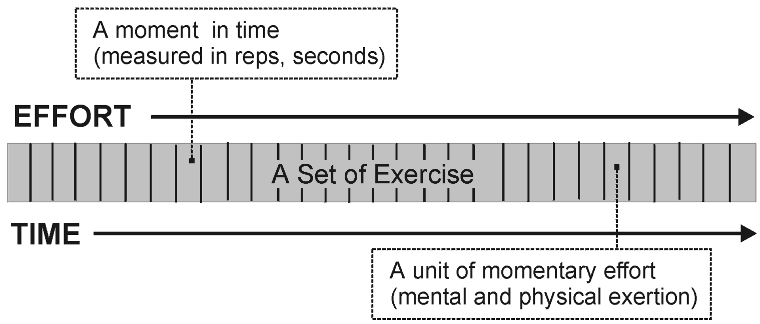
There are two key elements in this definition: *muscular* and *volitional*. This is important to realize, since there is no mind-body dichotomy in exercise: the mind and muscles work as a unit. Skeletal muscles are voluntary, and this means they must be told to work – they cannot lift a weight without a person's mental consent.

In regard to how much effort is being produced at any given moment, it is impossible to say what the measure is, such as "46% effort at *this* point." But it can be concluded that if a person were to exert maximum mental and physical effort (by the final repetition of a set or if attempting a maximum lift), then intensity of effort would be 100%. Complete rest, such as sleeping, would be 0% effort. Not many people exercise to 100% effort. Most people think that once the muscle begins to hurt and when exercise becomes uncomfortable that they are pushing themselves to the limits, but that is rarely the case. Training to muscular failure, to 100% effort, occurs when a weight will no longer move after a final repetition, regardless of one's best attempt. Training to "the max" will be discussed later.



Obviously, the amount of mental and physical effort alters from one moment to the next. Consequently, in order to think of intensity as a concept, it is necessary to do so within a moment or frame in time. For example, think of a set of exercise that comprises of lifting 100 pounds ten times. The first repetition would not be very intense, whereas the fourth repetition would be somewhat intense and the final repetition, when a person can barely make the lift, would be very intense. Of course, how hard or intense each repetition feels is a subjective experience since some people can tolerate exercise discomfort better than other people. But these subjective experiences can be quantified objectively with experience. What I mean is, as a person continues to exercise over the course of weeks, months and years, he or she can learn what it feels like to exercise hard. And the intensity of exercise at any time, from the beginning of a set or middle of a set can be related accordingly. Therefore, although it would be impossible to suggest that 37% effort was being produced "now", a person can say that the effort is a "4" on a scale of 10.

As with any aspect in life, each moment of effort in exercise is influenced or governed by previous moments, with all moments making up a continuous flow over a period of time (see diagram below). In weight training, this influence is obvious, as effort becomes more extreme from one second or from one repetition to the next. Twenty percent effort of all available mental and physical resources may be all that is required to complete the first lift, then 35% on the second repetition, 50% by the third repetition, etc.



The aerobic industry

Referring to the amount of effort produced as "intensity" is not just for weight training. The aerobic exercise industry refers to intensity as “physical effort”, measured by how high someone increases heart rate as a consequence of muscular exertion. Endurance-based exercise is further measured in a more scientific manner using Watts, with a "Watt unit" being equivalent to one unit of power, i.e., 1 joule per second. However, don't worry about those words or means of measurement since they are unnecessary to know in order to understand exercise intensity.

Intensity of effort, relative to time, indicates the extent of functional loss as a result of exercise. This means that the harder a person exercises, the greater and faster the strain experienced by the mind and body. Consider how quickly a person "runs out of steam" after a 100-meter sprint (high intensity) as opposed to a 25-mile jog (low intensity). Consequently, there needs to be a balance between effort and time, since too great an effort reduces work time so much that a cardiovascular effect cannot be achieved. Conversely, if the effort is too low, then exercise becomes too easy and extended, and optimum health or fitness benefits are harder to achieve. This is why heart rate measures (intensity of effort) were established in the aerobic industry, to recommend how hard one should exercise (how fast the heart should beat) during activity in order to achieve adaptive health benefits, e.g., neither too little nor too much intensity of effort. This aspect will be discussed in Chapter Seven.

Similarly, strength training and bodybuilding must incorporate sufficient volume (sets) and frequency, and the extent of those aspects are relative to the intensity of effort. When exercising to build strength and muscle, the effort must be higher than what it is for endurance-aerobic exercise and great enough to make exercise *anaerobically* demanding. "Anaerobic" simply means "without oxygen." Both the concepts *anaerobic* and *aerobic* will be explored in the upcoming pages, so that the reader can understand what those terms mean in the context of exercise application.

Borg's Perceived Exertion Scales

Another *industry standard* is the Borg Perceived Exertion and Pain Scales, as formulated by researcher Gunnar Borg. The study of psycho-physics is the scientific field that deals with the measure of sensory perception; or the physics behind that which we perceive and feel. Borg established scales of exertion (similar to the scales at the bottom of page 22 of this book), and these scales were designed to reflect the perception of exertion from his many test subjects. These scales took into account several aspects, including local muscle fatigue and breathlessness. The greater the mental and physical strain, the greater the rating on the Borg scale of exertion. In other words, the greater the demands of exercise, the higher the overall perceived exertion.

Do note that perceived exertion or intensity of effort may not be related directly to how much weight is lifted, i.e., the "heaviness" of the weight, but *how* the weight is used. A much heavier weight for a few repetitions, whereas six reps may be possible, does not place the same burden of mental and physical demands (perceived exertion) as a slightly lighter weight that is lifted to muscular failure.

The reader may be confused or quite not understand why a lighter weight can be more intense to lift than a heavier weight, and so allow me to explain. Suppose a trainee performed *only one* lift with 90% of a maximum weight (whereas 6 repetitions are possible), then with 85% of a maximum weight he performed eight repetitions to muscular failure (he could not budge the weight for a ninth repetition, no matter how hard he tried). What would seem bizarre is if the trainee declared the first set with greater tension (more weight) was more mentally and physically intense or demanding; yet, in the second set, he struggled with the weight and after the set he briefly felt physically incapacitated because of the extreme effort. A contradiction should be obvious, in that a heavier weight does not mean a need for a greater intensity of effort. Even consider when you had to lift a heavy object once compared to when you had to carry something a bit lighter, such as furniture up several flights of stairs; the overall effort of the second task is much greater. On this basis, the weight should not be a factor in defining the word intensity, i.e., "a heavier weight is more intense." Rather, how the weight *is used*, or its *nature* within the grand scheme of things (in the context of the set or workout) is most important. Because of this, a person can make the same weight feel more intense by *how* the weight is used, and it is not always necessary to increase the weight in order to challenge the body the a higher level. Different training techniques and methods, to make exercise more intense, will be discussed beginning on page 206, Chapter Six.

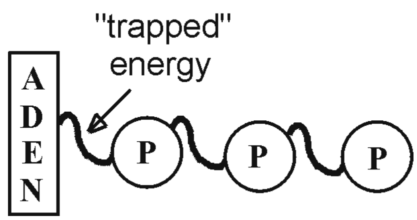
Energy systems – anaerobic vs. aerobic

It's time for a little biology and how this subject ties into human physiology and the concept of "intensity". Energy metabolism, or the production and use of energy depend on the availability of food. The by-products of energy metabolism include:

- Carbon dioxide,
- Water, and
- Heat.

Heat is the result of energy production, and the *calorie* (cal) is the unit of energy measurement. The calorie is the amount of heat required to raise 1gram of water 1 degree Celsius. Since the calorie is such a small quantity, the *kilocalorie* (kcal: 1 kcal = 1000 cal) is the preferred unit of measurement. In other words, when a person says he or she eats 3000 calories a day, what is meant is 3000 kilocalories are eaten.

The main type of energy formed is called *adenosine-triphosphate* or ATP. A great deal of energy comes from the chemical bonds between each atom that make up ATP (the atom **A**denosine is joined by three [or tri] **P**hosphate atoms).



Energy releases when ATP breaks down into ADP (*adenosine***di***phosphate*) and one of the chemical bonds break.

ATP is not synthesized only in one part of the body, then transported where energy is needed. All cells (including muscle cells) can synthesize and use ATP when energy is required. However, there is a limit to the amount of ATP available within each cell and the re-synthesis of ATP must occur by other means. Because of this limited supply of energy, very intense exercise, such as weight training, can be sustained for only short intervals, before rest is required prior to another set or bout of exercise.

All physiological functions within the human body require energy. As we move, our systems convert chemical energy, such as glycogen, to mechanical (muscle) energy, and this is where we get ATP:

Food
↓
Digestion
↓
Molecules
↓
Cellular Respiration (O_2 present)
↓
CO_2 → Energy ← H_2O
↓
ATP synthesis
↓
ATP* (3 systems)
↓
ATP Breakdown
↓
Energy
↓
Muscle Contraction

*The three systems available for ATP breakdown and energy production:

1. **Anaerobic alactic system** (creatine phosphate system)
2. **Anaerobic lactic system** (glycolysis system)
3. **Aerobic system** (oxidative phosphorylation system)

On the following page are breakdowns of what each of these systems is about and the type of activity involved in each. In a nutshell, "anaerobic alactic" means that there is no oxygen involved in the energy system and no lactic acid production (lactic acid is explained below). An example of when a person utilizes the anaerobic alactic energy system is during a heavy lift, such as picking up a large rock or when you see Olympic weight lifters pick up a heavy weight off the ground and lift it overhead. Activity is brief and intensity, and this energy system survives on pure ATP energy sources.

Once most of the "immediate" ATP energy sources deplete, the sugar in our muscles (glycogen) must be used to provide energy for the "anaerobic lactic" system; again, anaerobic means "without oxygen", and this energy system does produce lactic acid. Lactic acid (among other chemicals) is the "burn" you feel in the muscles when you exercise. The muscles burn because this "waste product" is blocking normal blood flow and other chemical processes that are necessary for the continuation of muscular contraction. Do note that lactic acid really is not a waste product, since it reconverts and is absorbed by the cells to manufacture more ATP. It happens to be a "waste product" and a nuisance at the time of exercise, but it does serve a function in energy production eventually and during rest between sets or bouts of exercise. This system kicks in within 10-20 seconds of vigorous activity, just after the anaerobic alactic system can no longer sustain vigorous activity. Typical weight training sets that last between 30 and 90 seconds in length would use this energy system.

Next is the "aerobic" energy system. Aerobic means "with oxygen." This system kicks within two-minutes of steady state or continuous activity. After a few minutes, the muscles require oxygen to sustain activity, and the method by which the body supplies energy to the muscles consists of both muscle sugar (glycogen) and fatty acids. Jogging and any other endurance-based exercise that lasts for two minutes or more without rest are examples of "aerobic" activity. The important thing to note is that the aerobic energy system kicks in within a few minutes, and this tells us that an "aerobic" or endurance effect can be achieved with brief 5-10 minute workouts and that 60-minute workouts are unnecessary to obtain a physical conditioning effect. This will be discussed later.

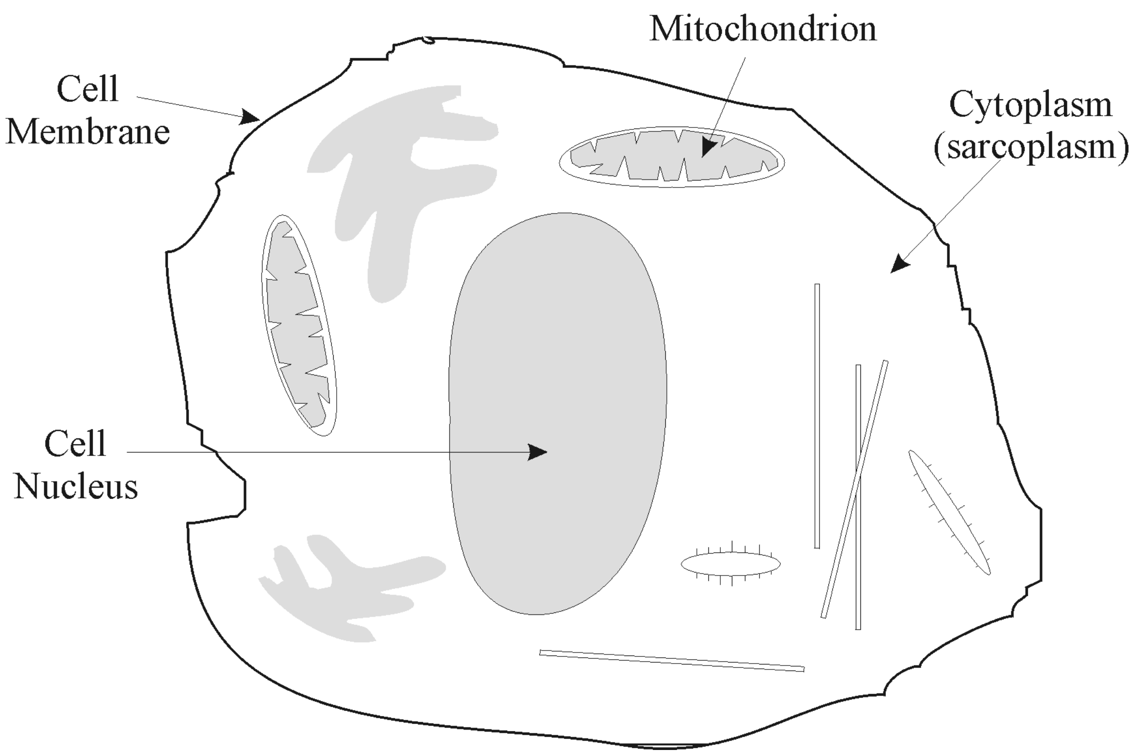
Anaerobic alactic system (Creatine Phosphate system)
• CP most rapid source of energy • Least amount of chemical reactions – no oxygen required; no (or minimal) lactic acid production • Fastest and strongest muscular contraction • Limited source of energy; peak power occurs within one second, with a capacity of 20-30 seconds • Primary energy source for *fast twitch* fibers* • Used in very brief exercise, e.g., powerlifting, Olympic lifting, shot putting, sprinting
Anaerobic lactic system (Glycolysis system)
• Production of ATP occurs without oxygen with more chemical reactions than the alactic system • Carbohydrates used as primary fuel source – chemical process results in glycogen as energy source – which breaks down to form additional phosphate for CP reaction • Peak power occurs within 20-30 seconds with a capacity of about 2 minutes • Used in moderately brief exercise, e.g., bodybuilding
Aerobic system (Oxidation system)
• Uses oxygen to produce ATP – more chemical reactions • Uses primarily fats and some carbohydrates as energy source • Supplies energy at a slow rate • Peak aerobic power occurs within 2-3 minutes with a capacity of several hours • Energizes *slow switch* fibers* • Involved in endurance activity, e.g., long distance running

* For an explanation of fast twitch and slow twitch fibers, refer to page 23.

Sites of Energy Production

Energy production occurs in all cells including muscle cells. The anaerobic alactic system (CP system) occurs in the *cytoplasm* of the cell (termed as *sarcoplasm* when referring to muscle cells), which is the liquid around the *nucleus*. The anaerobic lactic system (glycolysis) also exists there. The aerobic system occurs in structures known as mitochondria. These rod-like filaments are in great numbers in the sarcoplasm of the cell. Endurance athletes have more mitochondria in their cells than anaerobic athletes, e.g., weight lifters, powerlifters, bodybuilders, sprinters, since endurance athletes require greater aerobic (mitochrondrial) capacity and their bodies have adapted accordingly.

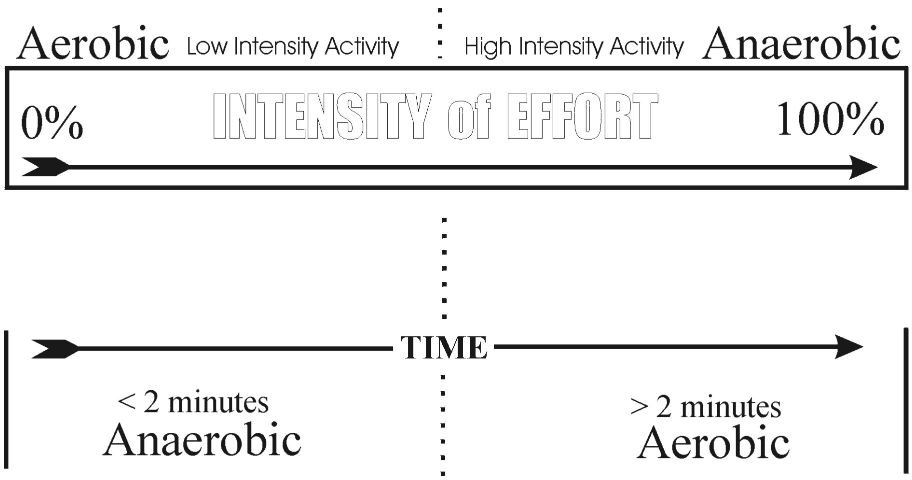
Animal Cell



Aerobic & anaerobic activities' relationship to intensity of effort

To recap: The terms aerobic and anaerobic refer to energy systems. Generally, the greater the effort, the more the activity reflects an anaerobic environment because of a very short time in which great effort can be sustained. This does not mean oxygen is not present during anaerobic energy production, but that the amount of oxygen is inconsequential to anaerobic (high effort) peak performance. Conversely, the lower the intensity, the more activity generally reflects an aerobic environment because of a longer time in which a lower level of effort can be sustained.

Below are two continua that reflect this relationship. The top continuum indicates that the greater the effort put forth, to a point of 100% mental and physical effort, the greater the level of intensity. The bottom continuum depicts effort relative to time, in that being able to tolerate exercise demands for two or more continuous minutes better reflects an aerobic (and typically lower intensity) environment.



However, this is how exercise is viewed traditionally, in that aerobic = low intensity, whereas anaerobic = high intensity. But it is important that they not be thought of as follows: "a high level of intensity cannot be experienced in an aerobic environment", or that "high intensity effort means a person is exercising within the anaerobic energy system". Consider that it is possible to exercise to muscular failure (a high level of intensity during the final repetitions or seconds of activity) after three minutes of muscular exertion and within the aerobic system. Remember that the aerobic energy system kicks in after about two minutes. Or, a person can swat at a fly once or twice, an action which is low intensity of effort, but doing so would not require the aerobic energy system. This is a moot point, but I wanted to bring to your attention that aerobic does not always mean low intensity and anaerobic does not always mean high intensity.

As intensity increases, stress becomes less tolerable, and repercussions magnify...

Stressor	Low Intensity	Moderate Intensity	High Intensity
Heat (Touch Perception)	warm water (perceived warming of the skin)	hot water (retraction of body part to avoid pain)	boiling water (burn)
Light (Optical Perception)	candle (constricted pupils)	bright light (squinting)	Sun (temporary blindness)
Sound (Auditory Perception)	whisper (ear drum vibration)	rock concert (temporary loss of full hearing)	sonic blast (deafness)
Precipitation (environmental)	Sun shower (wet ground)	heavy rain (increased mud, waterlogged terrain)	flood
Poison	nausea	Severe illness	death
Force	bumping into an object (slight pain and/or bruise)	dropping a 10-pound barbell plate on your foot (broken toe)	being struck over the head with a sledge hammer (loss of consciousness or life)
Exercise	first repetition of a 10-repetition set to momentary muscular failure, or the ability to sustain sub-maximal contractions for several minutes	middle (5-7) repetitions into a 10-repetition set (increased FT response; labored breathing begins, greater perceived exertion)	final 1-2 repetitions in a set of exercise carried to momentary muscular failure, inability to sustain further contractions

Just as the other factors in the above table necessitate brief exposure as their intensities increase, the same is true of exercise. Evidently, anaerobic exercise is the opposite of aerobic exercise; they are two different types of activity that produce different effects on the body, i.e., the body adapts differently to each type of activity. Therefore, in regard to maximizing muscle strength and size, the following can be presumed with absolute certainty based on empirical evidence:

- If *low to moderate intensity* exercise developed abnormally high levels of strength and lean muscle tissue, long distance runners, aerobics instructors, and laborers would also be the strongest and best developed physically. This does not reflect reality.
- If *aerobic* activity developed abnormally high levels of strength and lean muscle tissue, the above individuals would, again, be the strongest and best developed. This is not the case.
- Consequently, high-intensity effort within an *anaerobic* environment must be the key factor in stimulating a maximum response for strength and muscle growth. And because effort is high, exposure to such a strain must be brief and infrequent in order to make minimal inroads into the body's recovery ability and to allow time for recovery and improvement in function (physical adaptation) to occur. Any exposure over and above the *ideal* amount necessary to produce an *optimum* response will produce an over-stimulus, and this increases the risk of overtraining, or doing so produces sub-optimal results at best.

The nature of intensity

Intensity of effort is a basic component required in any exercise program to stimulate physical change – the higher the effort, the better (but within reason and relative to a person's ability to recovery and how much volume and frequency is being performed). This should seem apparent if we consider that *some* effort – regardless of the magnitude or degree – is necessary to stimulate growth.[1] Without effort, there can be no disruption or agitation of the muscles' current function, and there would be no reason for muscles to become stronger or more resilient. Consider sitting all day, just waiting to stimulate growth as a result of "near zero" effort; it won’t happen. Rather, to stimulate the muscles to become larger and stronger, an unusually high and intense effort is necessary, combined with a *sufficient* amount of volume and frequency.

Depending on a person's exercise experience and physical status, training to the point of muscular failure – wherein another repetition in good form is impossible – may be unnecessary to promote further change in the body. But the higher the intensity, the greater the agitation and the more probable that a change in the muscles can be made. But there are exceptions, as I will illustrate later in this section.

Fundamentally, someone new to exercise will not require very intense exercise to produce results. The strain of exercise is so new to the body that any amount of effort and regular activity will bring about changes. For a person with several months or a few years experience, the quality and extent of intensity of effort will need to increase, and this increase may require that both volume and frequency reduce. In this regard, *quality* replaces *quantity*.

[1] Evidently, if 10 repetitions were performed, the tenth would be the most difficult (more intense than the ninth), and the ninth more difficult or intense than the eighth, etc. And, obviously, the closer a person approaches muscular failure, *when the weight can no longer be lifted in good form*, the more demanding each ensuing repetition becomes. Moreover, the greater the effort, relative to one's physical abilities and limitations, the less total work (set volume) one is capable of performing.

Intensity of effort on each ensuing repetition also varies in measure. At the beginning of a set there exists 100% of possible strength in reserve, of what is possible “at that time”. After completing the first of ten repetitions, there is a loss of some strength. Continuing to the tenth and final repetition, more strength is lost, but in greater amounts, e.g., 10%, 22%, 38%, etc. In other words, as metabolic demands increase, so too will the reduction in overall strength – but NOT proportionately from repetition to repetition. This is true since fatigue and metabolic wastes, from energy production and usage, increases the rate of fatigue we experience. This means that it takes greater effort to complete each ensuing repetition, while the ability to generate muscular effort decreases.

Reducing volume and frequency is an important consideration for the advanced exercise enthusiast. Performing more and more exercise is rarely the solution, and doing so is often the cause of poor results or the loss of strength. After a few years of exercise, and if the goal is to continue improving, it is necessary to exercise "hard" in order to stimulate further strength and muscle gains. Even long distance runners, people who focus on endurance training, must run "harder" in order to complete a 25-mile run in less time. *Hard training* is defined as challenging exercise demands that are both *ideal* for the individual in question, and *sufficient* in measure to reduce the extent of functional loss, to maintain function, or to produce further gains in function, relative to one's genetic ability and goals.

It should be noted that exercise that becomes “harder”, or is as hard as one can make it, does not always refer to "effort". Harder exercise can mean an increase in volume and frequency since they, too, are part of "exercise demands." In this instance, a person can put forth the same amount of effort in each set, but perform more sets or exercise more often. But volume and frequency must be increased appropriately and sparingly to help a trainee out of a slump, such as increasing exercise demands to “shock” the muscles. However, to increase volume and frequency too much will cause a person to decrease the intensity of effort, a direction that is the opposite of what people should do. This is true whether the goal is to increase strength and muscle or even endurance. Again, marathon runners do not attempt to run further and further. Rather, they will condition themselves to particular distances and attempt to run those distances more quickly – thus exercising more intensely within a certain volume (distance).

Regularly attempting more repetitions with the same weight and/or using more weight for the same number of repetitions – the *overload principle*, see page 27 – is another method to increase training demands, to make exercise harder. And adding weight or repetitions to exercises regularly eventually results in extreme effort (and a need to exercise to muscular failure). This is true since everything in the Universe is finite, including human strength, which cannot continue to be challenged with more weight or more reps without, eventually, hitting a critical limit and necessitating all-out effort. Consider your own ability to lift, say, 50 pounds on an exercise machine for 12 repetitions. Very few people, if any, will be able to continue improving until the entire weight stack of 300 pounds (or whatever the weight) can be lifted for 12 repetitions without having to push themselves to the maximum... at least once in an exercise career.

The effect and nature of intensity can be exemplified if only one lift was performed, whereas ten repetitions are possible. If stopping at one lift, it would not be expected that growth or more strength in the muscles would be stimulated. Why should it since that one lift was so easy to complete? The same is true if 2, 3, or 4 repetitions of a 10-repetition set were performed, a level of effort that would do little more than maintain current strength levels at best. It is only when muscles approach muscular failure, when intensity of effort is high that muscles receive a "signal" to improve their function or resilience. It is this “difficulty” that signals the body that the effort was unusually strenuous, and in order for the muscles to protect themselves from future assaults of such great effort, they need to become larger and stronger. Once they become larger and stronger, they do not have to work as hard to complete the same amount of exercise. This explains why muscles become larger and stronger, and it also explains why it is necessary to continue increasing the weight or the number of repetitions with the same weight in order to increase strength and muscle even more. This is true, however, only if there is a corresponding and *sufficient* amount of volume and frequency present. Performing far too few sets of exercise, too infrequently, will not cause greater muscle growth even if a person exercises with 100% intensity of effort. And, of course, there must be sufficient rest between exercise sessions so that the body has time to "heal" and become stronger and more muscular.

It should, then, be evident that the greatest quality of effort a person can produce – relative to individual ability – best guarantees growth stimulus. Increasing volume and frequency also produces greater “difficulty” but, as explained, these factors must be applied sparingly to limit *overuse injuries* (e.g., sore or achy joints), and to avoid having to reduce intensity to too low a level in order to make exercise effective. Hence, there is a fine line between prescribing an appropriate or ideal balance of intensity, volume, and frequency and doing too much or too little.

Do note, and as suggested above, that training to muscular failure is no guarantee that strength and muscle growth will be stimulated. Many people who exercise very hard, and who still have potential to grow even more muscular, may not improve. This can be because of:

- Not enough, or too much, volume or frequency
- Becoming too adapted to the training demands (i.e., not altering the exercises and method of exercise often enough)
- Following a nutritionally inadequate or poor diet
- Not coordinating the stress of training with various biological cycles (i.e., women who train too hard during menstruation can become very fatigued)
- Low mental capacity to push the muscles as hard as the muscles can work.

...or any other possible factor or combination of factors. Moreover, not everyone should or can exercise to muscular failure, as presented below.

Those who should not exercise to muscular failure:

Exercising to the point of muscular failure is not easy. It takes a considerable amount of mental and physical effort, sometimes exceeding how hard most people are willing to work. Consequently, there may be instances whereby maximum effort training is not warranted. They include:

1. **Beginner trainees**, whose focus should be on learning proper mechanics, breathing, and mental focus, i.e., learning to isolate the working muscles. Moreover, most beginners lack the mental skills to exercise to muscular failure, and they likely will not be able to train very hard anyway or know how to do so without some practice.

2. Those requiring a reduction in training demands **to accommodate recovery or mental strain**, since training "very hard" is more demanding mentally than training “somewhat hard”, and periods of less demanding exercise is an effective method to help maintain motivation to exercise hard most of the time and for several years.

3. Trainees who must work during the initial stages of soft tissue **injury rehabilitation** should avoid maximum effort exercise. The focus should be on achieving normal range of movement, proper form, and learning to “get over the hurdle” and adapt to any pain associated with normal movement. Also, training to muscular failure likely would be too painful for most people trying to recover from an injury.

4. Those with **special conditions** that preclude them from exerting and fatiguing the muscles to extremes, particularly nervous conditions such as spinal muscular atrophy and injury, post-polio syndrome, and Lou Gehrig’s disease. There are many other conditions that must be considered, such as heart attack rehabilitation. These individuals would fare better with slightly higher volume and frequency and lower intensity, to sustain a manageable heart rate for longer periods of time to enhance overall conditioning, rather than focusing on maximizing strength and muscle mass. Pushing the limits of intensity of effort may also place a dangerous and unnecessary strain on the heart of those with heart conditions. An individual with a special condition should seek professional advice from his or her physician before starting any fitness program.

5. The **elderly** need not perform to-failure exercise, unless they enjoy the challenge. The magnitude of muscular growth and strength diminishes past age 50, and training with maximum effort will not produce much more benefit than exercising with “good” effort. With the elderly, usual goals include an increase in functional ability (range of movement and strength) and a reduction of fat stores (and possibly the correction of minor

injuries or poor body mechanics). Senior exercise is less about maximizing physical appearance and transformation – goals often attempted and valued by younger individuals.

6. Those who simply **do not enjoy training to muscular failure**, and who are uninterested in obtaining optimum results (most people are happy with 'good' results relative to their abilities), would fare better with slightly higher volume and frequency and reduced intensity of effort. This would ensure compliance to a regular exercise program by accommodating the individual's mental status, i.e., preferences.

7. Those individuals or muscle groups that produce **a greater response with a volume increase, while intensity of effort is reduced**, would fare better on such a program. Most women tend to respond better to this type of exercise, whereas men respond better to to-failure exercise. However, the measure of volume and the extent to which this type of person needs to avoid muscular failure varies. Also, this is not to say that such a person could not benefit from to-failure exercise sometimes, but that doing it all the time does not produce the best results.

8. **Athletes** who train intensely outside the weight room should avoid to-failure exercise, or include it cautiously and sparingly. Athletes who must focus optimum attention, time and effort on sport-specific activities must be careful to avoid overuse or taking too long to recover between very intense workouts. Being too fatigued or having extreme muscle soreness from very intense exercise can also interfere with proper movement of sport specific skills. In these instances, stopping short of muscular failure by 1-2 repetitions, but still exerting sufficient effort to stimulate gains, may be more appropriate when focus is on sport skills. However, this will depend on the nature and extent of exercise within sport specific training and competition, as well as the tolerance of the athlete.

Importance of sub-failure exercise

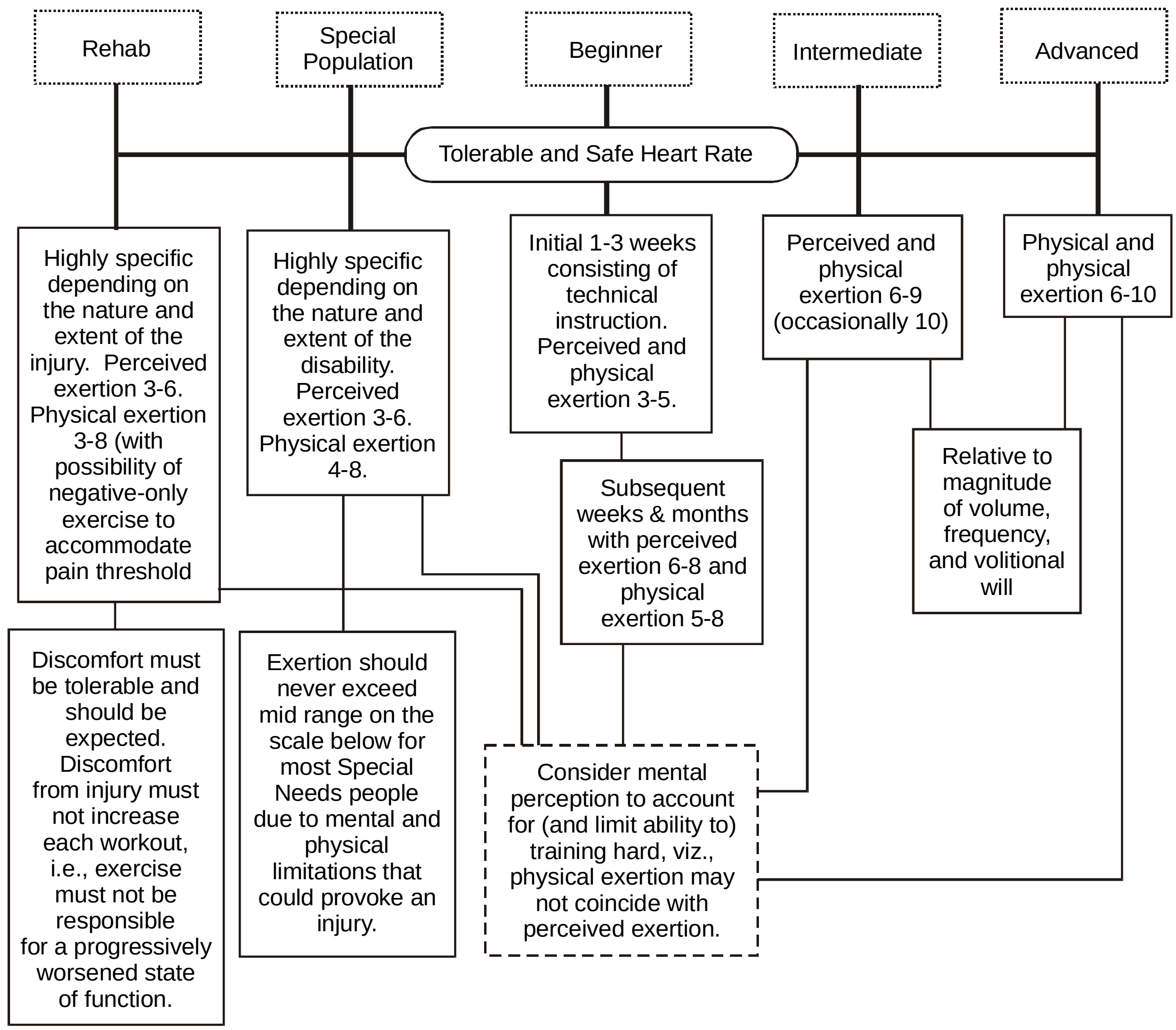
It is demanding mentally to exercise with maximum intensity every workout, regardless of any potential physical benefit. It can be devastating motivationally having to improve each and every time and to exert one's self to the maximum in order to make those improvements – particularly within a training career that spans several decades. Moreover, no one can make steady gains indefinitely – especially if a trainee has at least 2-3 years of serious exercise experience. Nor would it be expected of a 60-year old man to better accomplishments achieved 10 years previous. If a trainee could make gains every workout for the rest of his or her life, that person would be sporting a world-champion physique and would have super-human strength. It simply will not happen, and reality needs to take root when designing a long-term and appropriate program for a trainee at any level.

Empirical evidence indicates that training to muscular failure often, but not necessarily all the time <u>and if</u> balanced properly with volume and frequency, is the fastest way to realize goals fastest. This becomes more apparent as a person becomes stronger and more muscular. Increased strength and size places greater demands on the body because of the heavier weights lifted, as well as the energy requirements to move those heavier weights and for adequate recovery between workouts. These factors make to-failure training more demanding later in a person's exercise career than at the beginning of an exercise career.

There are still ways to train hard, but in a "cyclic" or rotational approach. One recommendation is to duplicate or triplicate workout accomplishments before attempting a new personal best record – and *not* to feel guilty in the process, thinking that progress must occur in every workout. However, if the trainee desires to progress more frequently, and is capable of doing so, that preference should not be ignored. Another approach is to perform sub-failure exercise for 2-3 weeks followed by to-failure exercise for a week or any other pattern to the liking and tolerance of a trainee.

On the following page is a flow chart that describes how to measure and prescribe intensity of effort and perceived effort.

Determining Appropriate Intensity



Perceived Exertion Scale

(Relative to either or both weight load and/or discomfort due to fatigue or injury)

1. No effort
2. Very easy
3. Easy
4. Somewhat easy, but tolerable
5. Somewhat difficult, but tolerable
6. Difficult, but tolerable
7. Very difficult, but tolerable
8. Extremely difficult, but tolerable
9. Extremely difficult and hard to tolerate
10. Extremely difficult and cannot tolerate at all or very infrequently

Physical Exertion Scale

1. No effort
2. Very low effort
3. Low effort
4. Low to moderate effort
5. Moderate effort
6. Stop short > 1 rep to muscular failure
7. Stop short 1 rep to muscular failure
8. Train to muscular failure
9. Muscular failure with training variables that do not extend beyond muscular failure, e.g., stutter repetitions
10. Beyond muscular failure with training variables, e.g., forced and negative reps

Volume Principle

Volume refers to the amount of exercise performed in a workout. When discussing weight training, volume can refer to a few things, including: *time under tension* (TUT – how long a set lasts in seconds and minutes), the number of repetitions (units which make up the TUT), and the number of sets (a series of repetitions followed by a brief rest) performed.

The greater the number of sets performed in a workout, the less frequently and intensely a person should train to maintain a balance in the exercise equation. For example, and with a focus on maximizing strength and lean tissue, intensity must be kept high to stimulate muscular strength and growth; therefore, set volume must be prescribed in an appropriate amount to avoid over stimulus, or doing too much hard work. As stated previously, you can train hard or you can train long, but not both. As intensity reduces, volume can increase, although this direction is not ideal for strength and hypertrophy, and is best reserved if the focus is on enhancing endurance and cardiovascular conditioning. Further, volume must be balanced with workout frequency in that the more volume performed that is beyond what is "ideal" for a person, the less frequently that amount of volume can be tolerated.

Muscle fiber types & exercise application

Our muscles consist of different types of fibers. These different fibers have different characteristics, and they "work" under different circumstances. Some fibers fatigue very quickly, whereas other fibers take longer to fatigue. The fibers that fatigue very quickly will reach their peak in ability (force production) very quickly, whereas the fibers that do not fatigue quickly require a bit of time to work up to "full steam." With that in mind, let's take a look at the different types of muscle fibers.

Fast-twitch (FT) fibers contract very quickly, and are called upon to complete heavy, strenuous work. Whenever you exert very intensely, whether exercising or lifting something heavy in the house, you are using mostly FT fibers. The other fibers tend to lay dormant because they don't have the capacity to help. It's like having a stronger friend (FT fibers) defend you against a bully (a demanding situation). FT fibers exhaust very quickly, and are responsible for most muscle size and maximum strength potential, and so when we see someone who is very muscular or strong, they likely have a lot of FT fibers in their muscles. FT fibers are very sensitive to stimulation, and too much exercise too often can cause them to shrink from "overuse." This happens for good reason. FT fibers are more "costly" to the body to maintain; it is unnatural for muscles to be very large and strong and that is why bodybuilders have to exercise regularly so that they can maintain their muscles' size; they are *forcing* their muscles to remain big. But if a person exercises too much, then the focus becomes one of muscular endurance and not strength and size. Consequently, the FT fibers will shrink in order to "adapt" to an environment that prefers endurance rather than big muscles and a lot of strength. As a result, in order to maximize the strength and size of FT fibers, exercise sets should last no longer than 50-60 seconds, and be limited to what is necessary to stimulate more growth and size. Many people in gyms tend to do something quite different: they try to see how much they can tolerate, or they exercise for 60 minutes because "one hour" of exercise seems like a nice round number. Many people also believe that "more is better", but that is not the case with exercise, unless you mean to say "more quality" is better.

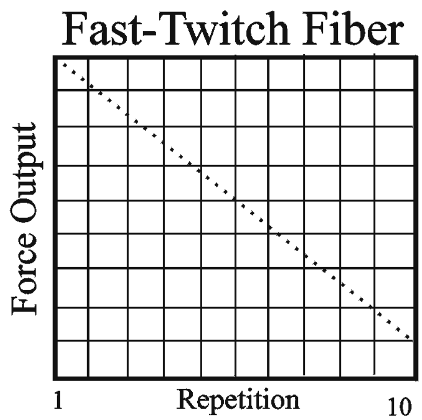
Slow-twitch (ST) fibers are very slow to fatigue and their ability and other characteristics are opposite of FT fibers. They *can* tolerate very brief exposure to intense exercise, but they do not work very well under such conditions. They prefer longer tension times of at least 60 seconds, and upward of 120 seconds or more. Also, they are responsible for activity lasting several minutes or hours of light, sub-maximal effort, and they do not contribute very well to muscle mass or strength gains. Long distance runners are good examples of athletes who do have and need an abundance of ST fibers – to sustain steady-state activity. It is interesting to note that a muscle with a lot of FT fibers still contains some ST fibers, but it is possible for muscle with a lot of ST fibers not to have any FT fibers. No one know why this is, but it appears to be true.

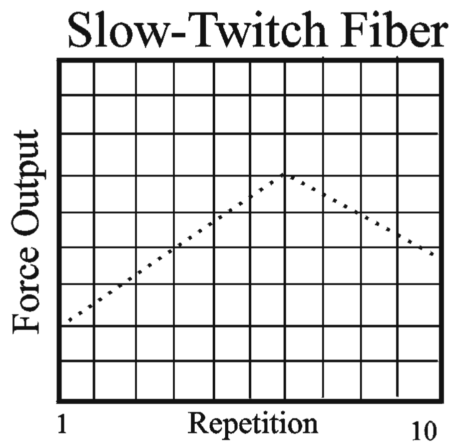
The **Intermediate/mixed fiber type** is somewhere between FT and ST. This fiber type responds best to an exercise tension time of 50-90 seconds. Most males have a mixed fiber type throughout their bodies, although this can vary and some men could have a lot of ST fibers or a lot of FT fibers. That is why we see physical differences in people, from the very thin or skinny, to the very muscular. Most females tend to have a high percentage of ST fibers, possessing good endurance with little ability to be very strong and muscular, although there are some exceptions.

Something should be pointed out: I stated above that FT fibers prefer an exercise time of no more than 50-60 seconds, intermediate fibers prefer 50-90 seconds, and ST fibers prefer at least 60 seconds and upward of 120 seconds. This is something to keep in mind if the goal is to maximize strength and muscle mass. If that is the case, then an exercise program should be designed with an individual's "fiber type" in mind; and fiber type and the different ratios of those fibers can vary from muscle to muscle. For example, if a person's biceps are mostly FT, it would not make sense to perform sets lasting 90-120 seconds, or if a person's chest muscles had a lot of ST fibers, it would not make sense to do heavy sets lasting only 30 seconds long. Although some results are possible under either instance, results will not be the best possible.

SLOW-TWITCH	**FAST-TWITCH**
• Endurance fibers • Long time-to-peak tension (80-100 milliseconds) • Low to moderate intensity work • Fats and some carbohydrates main source of fuel • Slow fatigue rate & high tolerance to exercise • Aerobic (with oxygen) • Found in abundance in marathon runners and triathletes, for example • High volume training (120+ seconds time under tension. Note: do not exceed 120 seconds if training ST to maximize hypertrophy and strength)	• Short-term work • Short time-to-peak tension (40 milliseconds) • High intensity work • Creatine Phosphate and Carbohydrates main source of fuel • Fast fatigue rate & low tolerance to exercise • Anaerobic (without oxygen) • Responsible for most strength & mass increases • Found in abundance in top-caliber power lifters and bodybuilders, for example • Low volume training (<60 seconds time under tension)
INTERMEDIATE/MIXED FIBER TYPE • Combined characteristics of both ST and FT fibers. • Median endurance, moderate fatigue rate, moderate to high intensity work, providing some mass and strength increases, moderate volume training (approx. 60-90 seconds time under tension).	

Since FT fibers have a low tolerance to exercise (i.e., they fatigue quickly), they decrease in force output on each subsequent repetition. Conversely, ST fibers gradually increase in force output on each subsequent repetition – up to a point – then gradually they decrease in ability to produce force. See below:





These facts have some implications when a person wants to know how much volume or sets to perform in a workout:

1. The warm-up prior to intense exercise must be very brief for FT muscles, since all activity, even a low intensity warm-up, will cause some fatigue. On the other hand, to enhance performance and force output (how much strength can be generated), a warm-up should be somewhat longer for muscles that have a lot of ST fibers.

2. A FT muscle appears to respond best with a time under tension (TUT) less than 60 seconds. A predominantly ST muscle favors up to 90-120 seconds of tension (or more if the focus is endurance rather than strength or muscle). A mixed fiber type, which is typical of most muscle groups within the average male population, responds best with a tension time of 50-90 seconds. These figures do vary depending on fiber type ratios, and are only approximations.

3. The number of sets for FT muscles must be restricted appropriately to avoid muscle shrinkage because of overuse. Sets for ST muscles possibly could be 200-300% greater than what is appropriate for FT muscles without any negative effects i.e., loss of strength or function. It takes longer for ST muscles to reach optimum capacity to perform well, and a slightly higher volume of reps, TUT and sets help in that regard. However, the total number of sets eventually depends on quality of effort, frequency of training, specific needs and goals (endurance vs. strength and muscle), and a person's genetic abilities and limitations.

Muscle fiber type relevancy in exercise prescription

The amount of appropriate tension time for a muscle group is based partly on fiber type makeup, but also individual goals and needs. The more ST fibers in a muscle, the better the response from a higher tension time and more sets. On the other hand, the more FT fibers in a muscle, the fewer the sets and the shorter the tension time required. However, consider that a person may have a high ratio of FT fibers throughout his or her muscles, but with a desire to maximize endurance. This is an example of how the exercise prescription can influence or challenge genetic potential, and that an exercise prescription can be inconsequential to the type of fiber a person has in his or her muscles.

Next, consider someone who is attempting to maximize strength, such as a powerlifter who lifts maximum weights in competition. This person would need to lift very heavy weights in his workouts, regardless of whether he had a lot of FT or a lot of ST in his muscles.

From the two examples above, it can be concluded that how long sets should last or how many sets should be performed is not always dependent on the genetics of the individual, but what the individual is trying to achieve in his or her goals.

How quickly a muscle fatigues (FT vs. ST) is a very important consideration if the goal is to maximize lean muscle tissue. This means prescribing an ideal number of sets and frequency so a person does enough work and frequently enough, but not too much work nor too frequently. For example, suppose a person were to perform only the bench press exercise in order to develop the chest muscles. What if the triceps had a lot of FT fibers? The fiber type of the triceps would cause the triceps to fatigue very quickly. Next, consider that the chest muscles had a lot of ST fibers and that the chest had very good endurance as a result. What would happen is that the chest muscles would hardly be stimulated by the time the triceps were fatigued. To work around this problem, a person would have to choose chest exercises that did not affect the triceps too much or at all so that more repetitions, sets, and a higher tension time could be performed in order to maximize chest development. In effect, maximizing muscular development is often about working around "weak links" and problems rather than focusing on strong points in a physique.

Frequency Principle

Frequency refers to the rate of occurrence of exercise sessions. The more frequently or often a person exercises the lower the volume and intensity must be in order to balance the exercise equation. For example, if maximizing strength and lean tissue, intensity must be kept high, and so frequency must be prescribed in an ideal amount to avoid doing too intense work too often. In essence, the more intense the effort and the more volume performed, the more recovery time – and the less frequency – required.

There must be adequate recovery time between exercise sessions to allow the body to regain any fuel resources that were used during exercise, to compensate (i.e., replacing used up fuel and the healing of damaged tissue), and eventually overcompensate in the form of greater strength and more muscle. Although stress has a *localized* effect on the trained muscle in question, in that there is muscle damage in the worked muscles, stress also has a *general* effect on the entire body. Consequently, the amount of recovery time between any workout is just as important as the amount of recovery time between workouts for the same body part. Exercising again, before the body in *general* has had sufficient time to recover from exercise for any specific muscle hampers progress, eventually resulting in general fatigue and tiredness.

ST fibers *recover* very quickly, enabling an endurance athlete to train several times each week. On the other hand, FT fibers *fatigue* very quickly and require a much longer recovery time – several days usually. However, the amount of recovery time for FT fibers depends on how intensely a person exercises and the length of each workout.

Now, based on the above, you may think that if exercising with weights, it would make sense to train ST muscles more often than FT muscles. This is not a good idea since, as stated, the more exercise you do the more it affects your body and ability to recover *as a whole*. Consequently, for muscles with a high rate of endurance, it would be best to increase volume (reps and sets) per workout than to train those muscles more often. Essentially, training only as often as necessary produces the best results.

More will be said about frequency in Chapter Six, page 229.

Progression – Overload (load) Principle

The term "load" refers to the weight that a person lifts, and there is a difference between "load" and "overload". For exercise to exist a load must be present; otherwise, there is no resistance for the muscles to work (exercise) against. "Overload", on the other hand, indicates that something is increasing, or that the load (or some aspect of the workout) is *over and above* what it was in previous exercise sessions. However, and to illustrate, a 70-year old man who has exercised seriously for several decades will not be overloading much of anything (if anything) and will likely struggle just to maintain weights or to decelerate a loss of strength as a result of normal aging and diminishing hormonal levels.

In the above regard, it could then be stated that the *load principle* is a fundamental of exercise science (that a load must exist), whereas the *overload principle* (progressive improvement of the load lifted) is merely a desirable effect or direction if and whenever possible. Since it is obvious that a load must be present, further discussion in this section will focus on the concept of "overload" as it relates to the other principles.

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Overload has a direct relationship to intensity of effort. Overload refers to <u>the application of progressively greater demands through regular progression.</u> Progression typically refers to how much load [hence, overLOAD] is lifted. However, since "overload" outside exercise science refers to *an excess load or burden*[2], then any factor that adds to the burden of exercise can be considered an overload, and this includes time under tension (TUT), repetitions, set volume, intensity of effort, and frequency.

In order to increase the body's functional ability, so we become stronger and more muscular, current capabilities must be challenged. If we challenge our strength limits we can stimulate more strength gains. Performing the same number of sets, for the same TUT, and with the same weight, does not give reason for the body to become stronger. Yet, a person must avoid any exercise challenges until he or she is recovered adequately from previous exercise; otherwise it is very difficult, if not impossible to improve. What this tells us is that <u>exercise *stimulates* growth, whereas rest *allows* growth to occur</u>.

Three factors that have a direct bearing on how hard a person exercises, factors that comprise the Overload (load) Principle, include:

1. Strain (how much weight is lifted)
2. Time under tension or TUT (the length of the set measured in *seconds* and *minutes*)
3. Set volume (the number of sets performed in a workout)

Overload methods

<u>Increasing the number of sets</u> is the most abused method of overload. This is not to suggest that increasing demands by increasing volume cannot be used as a means to overload, but that approach must be used sparingly and sporadically. For example, a person could perform "x" sets for 2-3 months, then increase it to "y" sets for a few weeks to increase the challenge on the muscles before returning to fewer "x" sets for another 2-3 months. The point is that if progressively more sets were the answer to more strength and more muscle, then 50 sets would be better than 10, and 100 sets would be better than 50. It should be obvious that this is not rational. Eventually, including too many sets requires a person to reduce intensity of effort in order to complete more and more sets. Reducing effort is not ideal if the goal is to maximize muscle and strength. As stated previously in this chapter, the same is true of endurance: Consider that long-distance runners do not try to run greater distances every workout, but they try to improve performance (an increase in effort) over a certain distance.

[2] *Oxford's English Dictionary*.

Overloading is best accomplished by increasing the weight and *time under tension* (TUT). How much to increase the weight and TUT each workout depends on a person's stage of development and individual ability. When first beginning an exercise program, during the initial 2-3 weeks, progression should be rather slow, so as not to overstress the body too quickly. This can cause extreme muscle soreness and the discomfort is enough to turn off anyone from an exercise program. Moreover, the focus should be on proper form and skill practice (how to lift weights properly) as opposed to pushing the muscles to their limits.

After a 2-3 week break-in period, an appropriate overload is approximately 5% increase per workout or an additional 5-10 seconds TUT at most, while learning proper form. For instance, a person could maintain 60 seconds TUT every workout while increasing the weight by 5%. The set would terminate after achieving the 60-second TUT, even if the set could continue. Or, once reaching a target time, e.g., 60 seconds, the trainee would increase the weight by 5%, drop the TUT down to 40 seconds (or an appropriate amount), then climb back to 60 seconds over the course of a predetermined number of workouts. After reaching that goal, the pattern would repeat with an increase in weight and a decrease in TUT. Either method works, allowing for regular, predetermined progression. It also instills a mathematical structure and purpose to a program.

Of course there are limitations to increasing TUT. Maximizing lean muscle mass, for example, would not benefit from increasing TUT to the point of performing sets of 120 seconds or greater, since that would invoke the aerobic energy system, as discussed on page 13. The building of lean tissue requires a sufficient weight to stimulate the muscles to become larger and stronger. If the weight is too light, and the TUT too long, the muscles adapt specifically toward greater endurance, even if training as intensely as to muscular failure. The absurdity of such a direction is more apparent if increasing TUT progressively to five or ten minutes, or longer. It wouldn't take long for a person to realize that maximum strength (the ability to lift heavy weights) and muscle mass are not increasing very much.

After 4-6 months and once having learned proper technique, exercise demands and tolerance change. The following few years often mark a person's greatest potential for making gains, and progression should not be held back or reserved if maximization, of some physical aspect, is the goal. In other words, do not limit progression to 5% if 10% is possible. Consequently, because progress happens very quickly during this time, it can be difficult for exercise enthusiasts to know how much to increase in overload, such as the recommended 5% during the initial months. It is not unusual to *underestimate* progress and ability as muscle size and strength increase dramatically. Conversely, nor is it unusual to *overestimate* ability in some workouts, as the body attempts to recover from previous exercise sessions that implemented a lot of overload. In sum, it takes practice and trial and error to determine how much of an increase can be made, depending on how well previous workouts were performed and the person's motivation to improve.

After a few years of serious exercise, progress slows significantly, particularly in regard to gaining muscle mass. The goal, then, for the advanced trainee, is to focus on modest strength increases from workout to workout, resorting back to the beginner’s strategy of moderate and appropriate weight or TUT overload. Advanced and strategic exercise methods to maximize muscle mass will be addressed in Chapter Seven.

Although some people do not have the genetics to make very good progress, the aim is to overload whenever possible, and in the greatest amount possible, to insure best whatever growth and strength improvement is possible. This is important since not working hard enough, to challenge our bodies, provides no reason for strength and muscle mass to increase. However, overload should not be considered more important than proper lifting technique.

Lastly, it should be noted that exercise movement selection also influences how much we can overload. It is easier to improve in a multi-joint exercise, like the barbell squat, than is possible with a single-joint exercise, like the leg extension. In effect, the more muscles working and the less restrained the exercise, the greater the ability to improve. With the squat, the thighs, buttocks, and even the lower back perform work, and as the exercise becomes harder, people have a tendency to lean or bend over more. Changing body mechanics helps a person to lift more weight or to keep the set going for more repetitions or TUT. The leg extension, on the other hand, is a very strict exercise and the only muscles working are the quadriceps, the four muscles that make up the front of the thigh. Because of this phenomenon, it is more difficult to improve with *simple* exercises that affect only small muscles like wrist curls for the forearms, than with *complex* exercises like deadlifts, an exercise that stimulates a large percentage of the body’s mass.

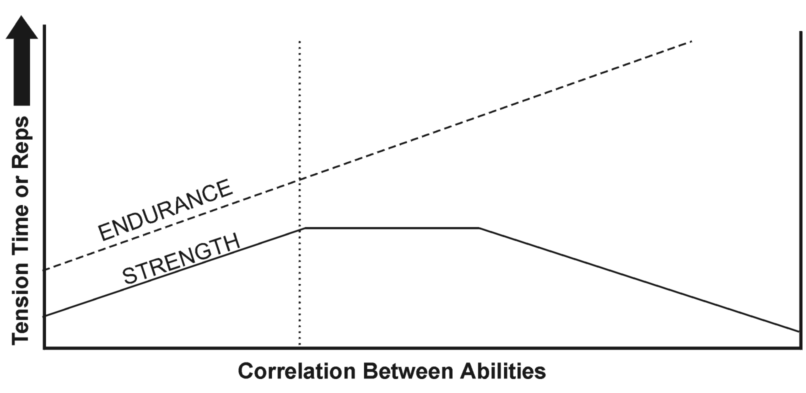
Overload and TUT

Volume in exercise refers to *time under tension* (TUT – duration of a set) and the *number of sets* performed. Both must be regulated properly to insure a quality workout, but without doing too much. Doing too much can lead to either overtraining (overuse stimulus) or poor results. At the same time, it is important to do enough exercise to meet our goals and needs since doing too little can result in under-training and poor results. It's easier to discover how much to do for endurance than if the goal is to maximize strength and muscle mass. With endurance, a person only needs to get the heart rate up to an appropriate level (see page 283, Chapter Seven), and sustain that heart rate for at least 5 minutes. To maximize strength and muscle, there has to be enough TUT and sets, but not too much. The reason that it is trickier to maximize strength and muscle, than endurance, is that the effort is much more intense and the weights lifted are much greater, so the amount of TUT and sets (and frequency) need to be balanced even more carefully. These factors make it easier for a person to do too much exercise and to cause the body to overtrain.

It is best to track TUT as opposed to repetitions (the number of times a weight can be lifted), although both may be done. It is more difficult to determine progress if one were to track only repetitions. Consider performing seven repetitions over the course of 60 seconds, each rep lasting a different measure of time, but totaling 60 seconds. Then in the following workout, eight repetitions were completed, also in 60 seconds – eight reps were completed the second time because the velocity (speed + direction) of movement was increased slightly. The eighth repetition is not really an improvement over seven reps last workout since *style of performance* changed in order to fit those eight reps in 60 seconds. As a result, some people mistakenly might increase the weight if eight repetitions were the "top repetition goal", without realizing or considering that the quality of performance was not as good as last workout.

Strength and endurance relationship

To a certain extent, there is a direct relationship between endurance and strength. For instance, the more weight lifted for a maximum lift, the more weight can be lifted for a predetermined number of repetitions based on a percentage of that maximum. For example, if a person can lift 100 pounds once, then he may be able to lift 70 pounds fifteen times. If he later can lift 120 pounds once, then the amount of weight he can lift fifteen times would also increase. The opposite is true, in that being able to lift more weight for a number of repetitions results in an increase in the ability to lift a heavier weight once. However, if a person focused more on either endurance or a maximum lift, the result of the other would not be as good. In other words, it is impossible to obtain optimum results in endurance and muscle mass/strength at the same time. Hence, the ratio or difference between strength and endurance is not always equal. As a result, if a person exercises with a TUT that is too high (and even too many sets) the building of maximum strength and muscle eventually reduces (see diagram below). However, do not get the idea that a person has to lift maximum weights in order to maximize strength and muscle; that is not the case. The point merely was to illustrate the relationship between strength and endurance.



As strength increases so, too, does the ability to lift heavier weights for a predetermined number of repetitions/TUT – and vice versa. For example, lifting 100 pounds for one lift may permit the lifting of 70 pounds for fifteen repetitions. And if lifting ability improves to 90 pounds for fifteen repetitions, then the one-lift maximum should also increase to some extent. This correlation has limitations in that enhancing endurance ability with progressively higher repetitions/TUT requires the *practice* of higher repetitions. Performing higher repetitions, however, can have a negative influence on maximum strength output because the body has adapted specifically to *being good at* lifting for higher repetitions.

Cautions of weight overload

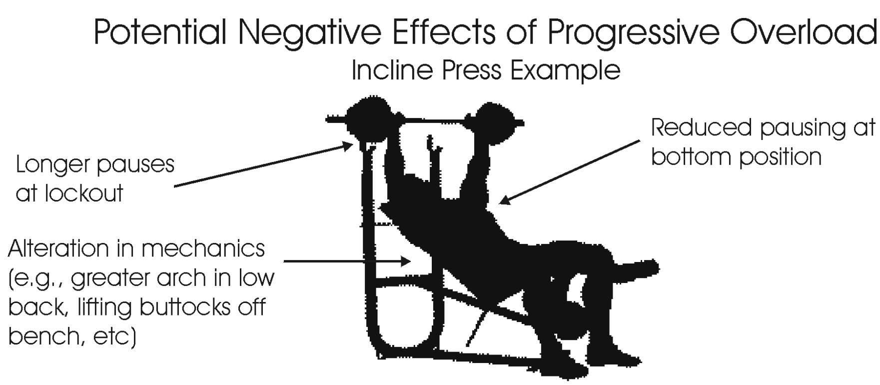
When overloading weight – a situation not always noticeable – improvement that is too quick could result in progressively careless technique. In other words, it becomes increasingly difficult to lift progressively heavier loads, and so there is a tendency to "cheat" the weight upward, ever so slightly, to complete the desired number of repetitions.

Jerking/heaving weights is not the only way to cheat, however. An additional 10-pounds on a barbell squat could result in a person altering leverage to lift the heavier weight better or more easily. This is a usual exercise tactic and not always noticeable by the person exercising. Therefore, it is best to use exercise machines whenever possible since they require sharper technique and allow for more realistic weight increases when the time is right. Conversely, free weights (dumbbells and barbells), particularly if moving quickly, allow a greater margin of error in maintaining technique.

Also, over time weight overload can increase *inter-repetition rest intervals* (IRRI), or *the pauses that occur between repetitions*. Pauses between repetitions is common with heavy multi-joint exercises, like the squat, particularly if those exercises are performed for higher repetitions and the person becomes more "winded" and fatigued from one repetition to the next. What happens is that *time under load* (TUL) increases, and this gives the perception of improvement, since the person was able to exercise for longer with a weight. However, there would not be improvement if the *time under tension* (TUT) were to remain the same or decrease. Remember, *load time* minus rests (i.e., lockouts) between repetitions = *tension time*. It is necessary to know how much time is spent *not* exercising *while* exercising.[3] Unless moving weights with continuous tension and no pauses, or at least establishing standardized pauses between reps, such as stopping for "one second between repetitions", IRRIs can increase and reduce TUT. Consider the following:

> *Workout A*: 300 pounds x 10 repetitions with 2 seconds rest between reps on average.
> *Workout B*: 320 pounds x 10 repetitions with 3 seconds rest between reps on average.

Although there are 20 extra pounds in Workout B, the 9 additional seconds of IRRI (10 reps x 1 extra second rest between reps) possibly nullified any benefit of the overload, since the added rest merely allowed the person to use the heavier weight under more favorable conditions. Also, changes in body positioning, to improve leverage, would have to be considered, as well as reducing time spent (or lack thereof) in the more difficult "zone" of an exercise, such as the bottom position of a squat or bench press. Evidently, exercise technique, performance and style can be complex and remain relatively consistent from workout to workout.



[3] It is imperative that the intervals (at both the top and bottom positions) between repetitions are either eliminated with constant tension or that any resting be measured (with a stopwatch or metronome); then the set can be recorded accurately in an exercise journal. If rests between reps are ignored, it becomes difficult to analyze an exercise program and to determine its results.

Overload and set number

The number of sets has a direct bearing on the degree of how much a muscle is challenged, i.e., the more sets performed, the more fatigued muscles become and the more function (strength) they lose over the course of the workout. Consequently, it is possible that a “reasonable” increase in sets, beyond what is typically appropriate, can have positive effects for improving functional ability. This is true since doing more sets adds to the workout challenge. The increase in set overload must take into account two questions:

1. How many sets should be added?

2. For how many workouts should the increase in sets be maintained before reverting back to the original workout?

To answer these questions, it is important to distinguish what is "ideal", based on a time value. What is ideal means the same as "what is tolerable" and optimal relative to an individual’s needs, goals, abilities, and limitations. What can be tolerated over the long-term, for several months or years, is quite different from what can be tolerated over the short-term, for a few workouts or weeks. For instance, a trainee may be able to cope with 10 exercise sets for a particular muscle group if doing so for only a few weeks, but he could not tolerate that many sets (and would overtrain) if those 10 sets were performed for a few months or years. On this basis, adding one additional set is not that much more of a challenge – and it likely can be sustained for a long time. But adding 100% more sets above what is appropriate certainly cannot be tolerated for long; an amount which must be implemented for a short time. Brief periods of increased set demands, within reason, is a useful method to challenge the muscles to maximize conditioning and muscle mass. This "cyclic" method of training will be addressed in Chapter Seven, *Muscle Enhancement*.

However, progressively and constantly increasing the number of sets, and particularly above the minimum necessary to stimulate the best gains possible over the long-term, must not be viewed as a good exercise method. Short-term as a "muscle shock", yes; long-term, no. As stated previously, the greater the set volume, the less the intensity of effort must be, in order to balance the exercise program and to cope mentally and physically with the added sets. Although enough sets must be performed to meet goals and individual tolerances, the intensity of effort must also be high enough. The important point is that every individual has his or her "critical limit" in regard to how many sets are required and how hard those set should or can be performed. The idea is to find the balance and the right combination, and this takes practice and experimentation. The effort must be high enough, and there must be enough sets, but no more than is necessary.

The ideal number of sets may be only one per muscle group – if the quality of movement and intensity is high enough, and depending on current conditioning levels of the body and of the muscles, and a person's goals. In other instances, the optimum number of sets may be two or three for a muscle. In other instances, no direct sets may be required since the crossover effect of one exercise is sufficient stimulus for another muscle, e.g., hamstrings perform work during squats or leg presses, and so leg curls may not be necessary. Once you discover how much exercise is necessary and appropriate, and what you can tolerate over the long-term, then you can overload with more sets now and again, for brief intervals, to help encourage your muscles and strength gains to reach higher levels.

Overload and intensity of effort

Overloading, by an increase in the working weight or TUT, has a direct relationship on intensity of effort. Lifting progressively heavier weights for the same or greater TUT results in progressively challenging work. As the demands through overload increase, trainees eventually must train to muscular failure to meet those demands. Needing to train to muscular failure, in order to lift heavier poundages, is especially evident of advanced trainees whom have neared a genetic peak in strength. This group struggles to gain a few seconds or weight overload. This phenomenon occurs since everything is finite or limited, including human strength. Consequently, the closer a trainee approaches his or her genetic potential to increase strength, the more likely "to-failure" training takes root in order to continue progressing.

As weight and TUT overload continues over months and years, it may be necessary to decrease workout volume and frequency to accommodate recovery and sustain intensity. It is impractical to decrease intensity since the struggle to add more weight or repetitions magnifies and a high level of effort is required as a consequence. Therefore, the careful application of volume and frequency is vital.

However, it erroneously has been suggested that advanced athletes and exercise enthusiasts adapt and can tolerate a progressively higher training volume of sets, and that increasing set volume is essential to producing larger and stronger muscles. This is true only within a limited sense, as explained previously when a person wants to increase sets for a short time to challenge the muscles more than usual. But consider that testosterone levels, a primary factor in recovery ability and building strength and muscle, decrease with age. Second, also explained before, only so many sets can be completed before quality of effort reduces, and reducing effort reduces the quality of the sets and the workout as a whole. Volume is rarely a long-term solution and is often the problem; or, at least, it can be a problem if abused.

The opposite problem should not be ignored, that volume and frequency can be reduced only so much. An example of a *minimalist* approach to exercise is the *consolidation program*, a routine consisting of minimum overall volume to work all the major muscles of the body e.g., one set only of squats (lower body), bench presses (chest, shoulders, and triceps), and chin-ups (back, biceps, forearms, and shoulders). Doing too little is not much better than doing too much if the goal is to produce the best results possible. Those who promote consolidation training have also gone on record stating that frequency can reduce to the point of performing each exercise once every 14-28 days. Again, doing too little can cause problems, such as losing muscular strength and "deconditioning" the body to the point that the heart and lungs are not as efficient as they can be.

This aspect of exercise will be discussed later. However, for the time being, do note that strength/lifting proficiency is maintained longer than muscle size or cardiovascular conditioning because of *neurological factors*. What this means is that lifting ability and the skills we acquire as we practice lifting weights become “hard-wired” in our systems, just like the ability to ride a bicycle after years of not doing so. These "hard-wired" patterns in our nervous systems allow us to lift progressively heavier weights even with little practice. On the other hand, it is more difficult to entice the body to develop muscle and there is less need to sustain built-up muscle mass. As a result, and as we exercise over the years, the body will attempt to sustain as much strength with as little muscle as possible for basic reasons of survival. After all, why would the body want to hold onto 150 pounds of muscle if the body can get the job done with 140 pounds of muscle? This is why it is important to change an exercise program regularly; to keep the muscles guessing and to keep them from relying on the established nervous patterns that were developed from doing the same old thing over and over.

Moreover, how long it takes before a person loses any aspect of function, including strength, muscle mass, and heart and lung conditioning, depends on a person's level of conditioning and how hard the trainee has worked to acquire the strength and muscle. A person who is very muscular and well conditioned has more to lose than someone who is weak and out-of-shape. However, because the "highly conditioned" and muscular person worked hard to achieve his or her body, it takes a bit longer for any loss to be noticed or realized.

Long-term overload reality

It is unreasonable to suggest that weight or TUT can and will increase each and every workout indefinitely. There will be times when improvement cannot be made, or the trainee may even lose a bit of strength or muscle. Moreover, failure to improve regularly does not mean a person is overtraining. Rather, progress must be viewed in its proper context. Consider a 16-year old boy who is still maturing, who will most likely progress each and every workout for a number of months or years – that is, if his program is suited to his needs. Once that boy matures to a 60-year old man, it is unlikely he will continue increasing strength, and will likely struggle to maintain lean muscle tissue and strength – an accomplishment in itself as we get older.

In that regard, between the ages of 30 and 70, people lose much of their muscular strength if they do not exercise vigorously. Strength losses in untrained individuals have been estimated or suggested to be 5% for the first decade beyond age 30, and thereafter losses increases in magnitude with each ensuing decade. If an older trainee of 50 or more years of age, who has exercised for most of his or her adult life, can sustain strength or lose less than 5% strength for each subsequent decade, that person is on the right track. In that respect, the program can be considered a success although progressive overload is not evident or no longer possible. Conversely, if that same person did not start exercising until age 60, then it is reasonable to suggest that there will be *some* strength increases for a certain length of time before reaching a limit.

Obviously improvement is relative to each person, and there are many other instances of being unable to progress regularly. Consider any "special group", such as heart rehab patients, those with AIDS, Down Syndrome, Alzheimer's, a spinal injury, or a woman in her 3rd trimester of pregnancy. For either mental or physical reasons, limitations exist as to why such people cannot improve each and every workout, and any measure of improvement, or lack thereof, must be looked at objectively.

Also, a person with the capability to improve physically for several workouts may decide to ease off for a while and perform one or more less demanding exercise sessions. This could be necessary from a psychological or motivational point of view, or for a physical need, such as wanting to avoid aggravating past injuries or to give the body a break. In either respect, lack of progression is obviously accommodating this individual's abilities and limitations, and taking it easy now and again can be deemed "progressive" since the easier exercise sessions are appropriate in the context of the program <u>as a whole</u>.

SAID Principle

Specific Adaptations to Imposed Demands (SAID) means the demands imposed upon the body (i.e. the number of sets, TUT, volume, and frequency) will result in specific adaptations. Hence, the SAID Principle reflects the concept of *cause and effect*, in that results (the effect) are determined by the nature of an exercise program. To put it another way, to adapt specifically toward an intended goal, e.g., larger muscles, the demands imposed must be specific so that the results will be larger muscles. The exercise program cannot be contrary, such as endurance exercise or yoga, and the program must appropriate to the individual in question. It is no different than adapting to the guitar by practicing the guitar, and the desire to be a good guitarist would not require a person to practice the violin or piano.

To illustrate, maximizing muscle hypertrophy requires each individual to train *specifically* in accordance to his or her *rate of fatigue*, i.e., a muscle's ability to sustain or tolerate activity, including factors such as muscle fiber type (p. 23) and neurological efficiency (p. 86), and recovery ability. For instance, ST fibers tolerate more volume than FT and intermediate fibers, and so they need more sets than the other two fiber types if you were to challenge them maximally. Consequently, providing *sufficient* stimulus (enough sets to achieve the best results possible) must be a consideration, and the measure of that stimulus is relative to the tolerance of the individual in question. Doing too little produces less than optimal progress, and doing so can even cause regression (muscle shrinkage) because of *under-use* or lack of use Conversely, performing exercise that is more than the minimum required for optimal results produces three possibilities – from best to worse case:

1. The person progresses to the same extent, but the cost-benefit is not ideal, i.e., the person is doing more without getting more in return.
2. There is some progress, but not to the same extent as with the "ideal" program.
3. Strength and muscle mass does not increase (barring genetic limitations to keep a person from progressing).
4. Strength levels regress and muscle shrinks because of overuse or too much activity.

With powerlifting, an athletic event that requires the lifting of heavy weights, other goals also must be taken into account beside optimum muscle inroading to maximize muscle growth. In this instance, although larger muscles are helpful, they are not completely relevant to the powerlifter. Fundamentally, this athlete needs to demonstrate maximum lifting in competition, and exercise should consist of relatively few repetitions and low TUT to best reflect the powerlifter's exercise requirements. The powerlifter's goal is to lift as much weight as possible (at the lightest body weight possible) in the squat, deadlift, and bench press exercises. The addition of lean muscle mass is merely an afterthought or a potential consequence of exercise rather than a goal.

As a result, how a powerlifter needs to adapt his or her body is different than what a bodybuilder tries to accomplish. Having the greatest amount of strength relative to the size of the muscles is not important to the bodybuilder. The bodybuilder wants to look good, whereas how much he or she can lift should not be a concern.

To maximize cardiovascular efficiency, exercise based on endurance methods is necessary – and, more particularly, the style of exercise should reflect the sport or activity in which the individual wishes to improve. For instance, it is irrational to have a long distance runner exercise on a rowboat, unless that person desired a change of pace from running. Nor should an Olympic cyclist exercise excessively on a treadmill. The long distance runner needs to run and the cyclist needs to cycle. Specificity!

The *nature* of an exercise program is the first thing a person should look at when designing an exercise program. For example, there are certain guidelines that make a bodybuilding program unique, compared to powerlifting. These include higher set volume and repetitions, as well as multi-angle training (a wide variety of exercises) to maximize development of all muscle groups. The term "higher" does not have to mean that much higher; it could mean 25% more sets or 10 reps rather than 5 reps. Few powerlifters, although stronger pound-for-pound than most bodybuilders, possess the muscle mass or aesthetics of a bodybuilder. This result in body types between bodybuilders and powerlifters is due to the method of exercise, both of which are different and unique. Powerlifters perform fewer exercises and attempt to increase leverage as much as possible. They try to make the exercises *easier* by shifting tension from one muscle to another so that more weight can be lifted. Bodybuilders need to make exercises harder so that they challenge their muscles even more and "force" them to grow.

However, avoid being too general by prescribing “blanket programs” to fit a particular situation, i.e., train "this way" for powerlifting, or "that way" to be a bodybuilder, boxer, cyclist, or any other type of athlete. An often-neglected aspect of the SAID Principle is that the demands imposed must also reflect the limitations and abilities of each individual. Questions to ask are: What is the individual capable of doing and not doing, relative to the “method” in which that person needs to exercise, to achieve specific and desired goal(s)? What design/change should the general “method” include in order to accommodate those conditions? *Specific* demands produce *specific* adaptations, but only if prescribed *specifically* to an individual in question. In sum, a person should exercise specifically (in a certain manner) to achieve certain goals, but the program needs to be custom-made for him or her.

Sport specificity – the SAID Principle in action

Including specific weight training exercises to enhance sport specific movements offers no value. For example, consider a boxer who punches the air with 5-pound dumbbells in his hands. The important point to remember is that there are no degrees of specificity. Either something is entirely specific or it is not. Either a physical movement is completely specific or it is not. *Specific* means explicit, particular, or definite, not "sort of" or "similar to.” A boxer does not box in the ring with 5-pound dumbbells in his hands, nor do boxing gloves weight that much, so why practice boxing with 5-pound dumbbells. Or consider that throwing a baseball ounces heavier than a ball normally thrown is no longer specific and the different ball weight may hinder pitching accuracy (if continued for too long) before returning to the original ball weight.

By trying to do exercises that are "similar" to sport specific movements, there can be negative (transferring) effects on the nervous system. This happens because the nervous system controls the muscles, and *specific* nervous patterns are produced in accordance to *specific* practiced movements. By altering a movement slightly, with weight training exercises, a person can "mess up" the motor patterns that were established from practicing specific sport movements and skills.

Any positive transfer, i.e., the ability for something "similar" to help something else, is typically small or negligible. If the tasks are similar, the transfer tends to be higher, yet still typically small. An example is a badminton player taking up tennis. Because of this athlete’s past experience, the skills of badminton may help in learning the game of tennis a bit faster. However, a proficient tennis player will not improve in tennis as a result of learning badminton skills. Never has a world-class tennis player become a world-class badminton or table tennis player. The skills may appear similar, but differ greatly as a result of play area, racket weight, air resistance, ball/birdie weight, and movement characteristics such as velocity, delivery, and return of the ball/birdie.

A similar exercise philosophy has been adopted by strength coaches for athletic teams in that some coaches have their athletes move barbells explosively (abruptly and as quickly as possible) in the belief that athletes will become more "explosive" and faster in game play. The skills of throwing a barbell cannot be transferred to the skills of sprinting and dodging in football, or a slap shot in hockey, for example. Muscular strength is general and contributes to any activity. But the applied demonstration of strength is *specific*, and applying strength to any activity, such as football, requires *specific* skill training. And the only way to produce specificity in a sport is by practicing a sport’s skills.

Next, consider that in football there are many positions, including running back, quarterback, and wide receiver. Being good in one position does not make an athlete good in all positions. If that were the case, a running back could take the quarterback's place if the quarterback became injured. It should be obvious that the skills are much different from one position to another. Weight training exercises are not related in any way to football skills, and weight training skills have even less in common than the different skills among different football positions. Because of this, and it should be obvious, weight training exercises do not offer any direct transference of skill to any sport (aside from weight training), although weight training can improve the function of an athlete to perform sport-specific skills better.

Since resistance exercises – even if they look similar to sport movements – are not specific to the velocity, actions and muscular force produced in athletic events, and they are useless for increasing a specific sport skill. Doing similar weight training exercises is also a less effective way to build general strength in the entire body in order to enhance general athletic ability. For example, some sprinters attach parachutes to their bodies in order to create drag during sprinting in the hopes that the ability to sprint faster will improve. This has never been proven to be the case since running with a parachute is non-specific to the velocity, mechanics, and gait of sprinting without a parachute. Those who obtain modest gains from parachute sprinting do so because the overload on the muscles from running with a parachute caused some muscular strength and growth. However, these sprinters could have achieved better results from a sensible, non-specific exercise program that would not mess up the specific skills of their normal running ability. This would mean some squats or leg presses in the gym while practicing non-parachute sprinting on the running track.

Swimmers have also been guilty of applying "strength specific" exercise in their programs. Some have used a dual overhead pulley system, in a bent over position, thrusting the arms forward and back to simulate the action of swimming, but with added resistance. These swimmers believe that by doing this exercise, they will increase "swimming ability". However, this action is non-specific to swimming for the following reasons:

1. The resistance of the machine is greater than the resistance of water
2. The resistance of the machine provides a different feel and dynamics from those of water
3. The style of performance is quite different (a bent over standing position as opposed to being buoyant in a face-down position with legs kicking), and
4. The arc, delivery, and retraction of the arms are entirely non-specific to swimming.

Negative transfer

Attempting to duplicate a sport specific movement, with unaccustomed exercises and loads, results in an athlete learning two methods or styles of performance, and this can cause a *negative transfer*. Multiple "memory patterns" become engrained in our nervous systems, and this can lead to nervous and muscular confusion. Competitive performance will either suffer or not benefit in any manner as a result. Consider this example: it is common for a strength athlete to be very strong in the bench press, yet to be relatively weak in other chest exercises because he or she did not practice the other exercises and has not acquired or learned the motor skills of the other exercises.

Arthur Jones, inventor of Nautilus exercise equipment, relayed an excellent example of how a small pebble or grain of sand in a shoe can *alter* walking gait, to *accommodate* the discomfort.[4] The significant effect that such a small object can impose on our *normal* movement illustrates the potential problems that can occur with our learning curves if we attempt to duplicate *similar* sport specific movements with added resistance.

[4] Jones, Arthur. *Specificity in Strength Training: The Facts and the Fables*. Athletic Journal, May, 1977.

Operating a transport truck will not affect the ability to operate a compact car, since the characteristics of these two vehicles are so far removed. But driving a compact car for several years, then suddenly a Lincoln Continental, results in initial difficulty driving – especially when parallel parking or moving in tight spaces. The close (similar) relationship between the two cars confuses our observation and perception to a greater extent than that vast difference between a small car and a transport truck. Furthermore, as Arthur Jones also observed, piloting a plane and driving a car are even less specific to each other, and neither will have a detrimental effect on the skills of the other.

In sum, it is best for athletes to select common exercises, such as the bench press, squat, chin-up, etc., and leave skill training to the sport in question. This does not mean that athletes should not perform exercises to develop the primary muscles of a sporting event (e.g., squats for sprinters, shoulder work for tennis players), but that they should avoid weight training exercise movements that are very close to specific muscular movements in sports.

Principle of Diminishing Returns

The **Principle of Diminishing Returns** takes into account the relationship of the initial four principles: intensity, volume, frequency, and overload – as governed by the SAID Principle and the Principle of Individualism (discussed next). It states that a prescription of exercise strain that exceeds the *minimum necessary* to produce (a potentially) *optimum response* is pointless as it relates to the best interests of the individual. A person's "best interests" would be the time and effort devoted to exercise relative to the gains produced. Gains could mean fat loss, the building of muscle or strength/lifting skills, enhanced flexibility, improved sporting skill, increased muscular/cardio endurance, or a combination of any of the above. This principle holds true at the other end of the spectrum, that if doing too little, a goal cannot be achieved. And if far too little exercise stimulus occurs, functional ability can be lost and this means wasted effort in the gym.

Of course, this principle must be viewed in its proper context. As stated previously in this chapter, slowing regression may be the only recourse for an aging athlete, or maintaining muscle and strength may be ideal for some trainees with medical complications, who should not exert themselves to their limits all the time. Consequently, an “optimum” response is that which is a best for the individual in question, relative to a person's needs, goals, abilities, limitations, and preferences.

The dilemma, however, is discovering how hard a person should exercise and for how many sets and how frequently. It is unlikely this could ever be resolved because of so many extrinsic and intrinsic factors. Consider someone with a positive mental attitude one workout (who is fully recovered from the last workout), then who experiences a death of a loved one. Obviously the person would not be able to train as hard, and may even push him or herself too much if attempting to do so. This is possible since the total stress factors in our lives affect each workout and the ability to recover at different rates. Further consideration must be given to the characteristics of each muscle, such as whether it is fast twitch or slow twitch. Increasing or decreasing workout demands even slightly can also affect how well we perform or make gains week or months later. Then there is the effect that weather and climate can have on emotions and moods. Rain and lack of sunshine can depress a person, reducing focus and effort and requiring a person to increase set volume in order to produce a similar effect to what could have been achieved with fewer sets and greater intensity of effort.

The list of contributing factors that could arise to affect an ideal amount of exercise, and all the different exercise combinations, is almost endless and constantly altering. The goal, however, is to exercise appropriately, based on comparing past workouts and what was going on in one's life during different workouts.

So far everything should make sense: only do what is required and in the right amount. However, what must be considered are the *psychological perspectives* that influence a person's values and interests, such as social and (possibly) addictive tendencies toward exercise. In other words, some people choose to exercise more than is necessary – even when they realize they are doing so – because they value the social aspect as much as the health benefits. And some people simply prefer to do something every day even if better results could be obtained by exercising less.

Principle of Individualism

This principle states that exercise must be prescribed in accordance with the needs, goals, abilities, limitations, and preferences of an individual. The problem with individual prescription should be obvious: this aspect is quite vast; so vast that it could fill several books on exercise. Consequently, I will limit the discussion to some general areas involving genetics and how we differ from each other. There is more information on genetics beginning on page 94 in Chapter Three.

Genetics forms the basis of individualism. In regard to exercise prescription, it means, despite what may be suitable for the average population or anyone else, the goal is to discover what is ideal for the individual in question, since that person may not be reflected within the average or what may be appropriate from someone else. *Suitability* refers to an appropriate or ideal amount of exercise for a particular person.

Because of the diversity of individual genetics, it should be obvious that no single exercise program or method can be *right* or *optimum* for all of us. It may be true that some basic exercise programs can provide good results generally and for most of us, but such programs should only be implemented as a base from which to develop a unique program, to better reflect *individual* needs.

Understand that the needs, abilities, and limitations of any *body*, and of each *muscle group*, can vary. Some muscle groups may have less ability to tolerate exercise and activity, and show far less potential to increase in strength and muscle mass. Other muscles seem to grow or get stronger with far less effort.

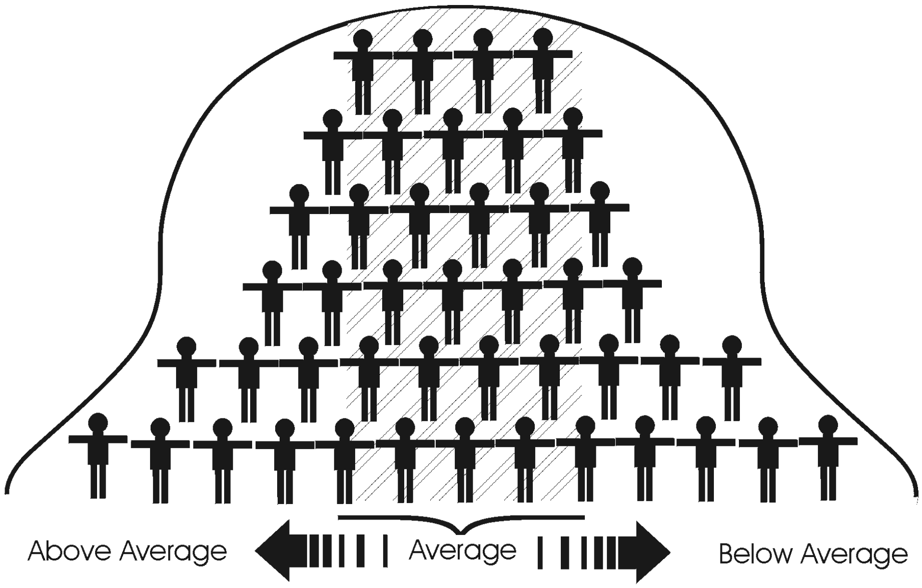
Bell curve distribution

The reason that there needs to be such a wide variety of exercise programs is to fit the needs of a wide variety of people. The needs and tolerances of the elderly are much different from those of the young. Requirements are much different among beginners, intermediates and advanced trainees. Obviously, then, needs are quite diverse if we look at the people who make up the entire human population. The majority of the population constitutes the *average*, and as we look at people who are above or below average, in any aspect, we are looking at "deviations." The further from the “average”, the greater the difference or deviation from average.

This fact has been confirmed and established through what is called *statistical distribution data*, as represented graphically by the *Bell Curve*[5], so named for its shape (see diagram on the next page), and it can be witnessed with any phenomenon. To explain, the majority of the population is found in the middle or *median* of anything that is measurable. But there are people who are above or below average in regard to that measure. The less average an individual is, the more they diverge outside the average population. When presented graphically, this produces a bell shape with those most below or above average on the outermost reaches of the graph, and those who are more average are found toward the middle of the graph.

As one example, the average adult Caucasian male is approximately 5'10" tall, although this could be changing. Within the "average", men might be 5'8" and 6' tall. Therefore, anyone who is between 5'8" and 6' tall is considered within the average. Men who are shorter or taller than this range is either below or above average, respectively. The shorter a man, the more he "deviates" from average; the same is true of a man who is taller, in that he also deviates from average. Now, consider his when it comes to exercise. Some people can develop a lot of muscle, whereas other people have difficulty building muscle. Or we could have a person who finds it easy to develop a lot of muscle in the arms, but difficult to develop muscle in the legs. Consequently, we not only have people who are average, below average or above average, but each person can be average or deviate from average in different respects, such as being good (above average) at endurance activity, but not very good (below average) at developing muscle or strength.

[5] Hernstein, Richard J., and Murray, Charles. *The Bell Curve: Intelligence and Class Structure in American Life*. New York: Free Press, 1994.



Thrives on to-failure training all the time	(Median)	Tolerates to-failure training occasionally
Requires lower volume of exercise	(Median)	Requires higher volume of exercise
Does not tolerate frequent training	(Median)	Tolerates frequent training
High % FT muscles	(Median)	High % ST fibers
Large muscles	(Median)	Small muscles
Very strong; poor endurance	(Median)	Relatively weak; high endurance

Key aspects of individualism

Individual **needs** typically differ from the concept of a "goal" in that needs are things to be acquired in order to achieve a goal. In some respects, a person may "need" to achieve a goal, and the goal then becomes a need. But to differentiate the two terms, consider a bodybuilder whose goal it is to win a competition but who needs to reduce body fat below eight percent. In this respect, his need to drop fat becomes a "sub-goal" to the main goal (objective) of winning the competition. This need could be viewed as a specific (proximal) sub-goal of losing 'x' pounds or percentage of fat weekly or monthly until all necessary body fat has been lost so that this bodybuilder can enter the competition with the desired level of body fat.

In another instance, consider a powerlifter whose goal is to bench press 400 pounds by a specific date in order to quality for the World Championships. He may have a *need* to increase shoulder joint stability by doing more shoulder work. He may further *need* to decrease his exercise frequency slightly in order to handle increasingly heavier weights better so that he can bench press 400 pounds eventually. He may *need* to decrease his weight in order to compete in a specific weight category.

In yet another instance, consider a long distance runner whose goal is to run in the next Boston Marathon, but who recently injured her Achilles tendon (the cord-like tissue at the based of the heel). She now has a *need* to rehabilitate the ankle tissues and to retrain her cardiovascular system (because of the layoff caused by the injury) in order to achieve the objective of running the marathon. This type of need could likewise be viewed as a sub-goal to the main goal.

Goals can be viewed as the ultimate achievement within a given time frame. Of course there are many smaller, proximal goals that make up or lead to the end goal, which can be viewed as “needs”. Consequently, needs and goals are separated relative to how a person views needs and goals. In other words, what the individual wants to achieve inevitably or what must be accomplished in the process to achieve some distant goal makes all the difference. More will be said about goals, and goal setting, in the last section of Chapter Six, *Exercise Elements*.

Abilities and **limitations** have a mutual relationship. “Abilities” refers to what a person is capable of, whereas “limitations” refers to what is stopping an individual from progressing beyond a particular physical or psychological point. For instance, a bodybuilder may have the ability (capability) to acquire a muscular 18-inch arm, but he may be limited as to how hard he can train to achieve that size. Another person may have the psychological ability (motivational drive) to achieve an 18-inch arm, but not the genetics to do so. Or consider a person whose genetic ability includes being a world champion bodybuilder, but he is denied that achievement because he lacks interest to even start exercising.

Abilities and limitations then tie into an individual’s needs and goals. A bodybuilder who may have the *goal* to win a bodybuilding competition, and who may have the psychological *ability* to achieve that goal, may have physical *limitations* to build muscle mass. This produces a *need* for an environmental intervention, i.e., anabolic steroids or growth-producing drugs. Similarly, a bodybuilder may have the physical ability to achieve the goal of winning a competition, but not the ambition and motivation, and so he also requires the need for drugs to help make up for lack of discipline.

In a different vein, an individual may have the goal and need to win a golfing tournament to achieve status, money, and entry to the next level of competition. But he could be limited by low ability (skill acquisition), and the limitation of having lower back pain. His ability will not change beyond what skill training and genetics allow, but rehabilitation and strengthening of the lower back (fulfillment of a need) could reduce the extent of that limitation.

These four factors must then take into account an individual’s “preferences”. It is possible to design a very worthwhile and effective program for an individual based on physiological needs, goals, abilities, and limitations. However, if an individual’s personality is not in sync with his physical aspects, that “perfect” program becomes pointless. If the individual terminates exercise because of a dislike for an exercise program, for whatever reason, then the physical needs and goals can never be realized relative to his or her physical abilities. For example, the squat exercise is one of the most productive, but if a person dislikes the movement, even for the simple and common reason that it is difficult or challenging to perform, that person can create an aversion to exercise on a whole.

Of course personal preferences must be looked at objectively. A person may have a preference for a particular exercise style because that is how "Champion Athlete Mr. X" trains. Also, a person can be influenced by what “seems” reasonable, or because of the charismatic influence of an "expert" who is giving the advice. Hence, it must be discovered why a person has particular preferences or dislikes, and the underlying reasoning or rationalization.

Perhaps the most prevalent example of psychological limitation is in the ability to exercise very hard. Not everyone should train to muscular failure, such as an individual recovering from a heart condition or someone with a mental disability, like Down syndrome. Further, and more noticeably, not everyone *can* train to muscular failure. It is not always a case of being “lazy”, since this same person may very well have excellent work ethics in other areas of life. Rather, the trainee may not view the discomfort and mental motivation required to exercise so hard worth the effort relative to any benefit. Such a person is more likely to sustain an exercise program based on “fairly” hard work (but not as hard as possible) while performing a few more sets or exercising a bit more frequently.

Biological clocks

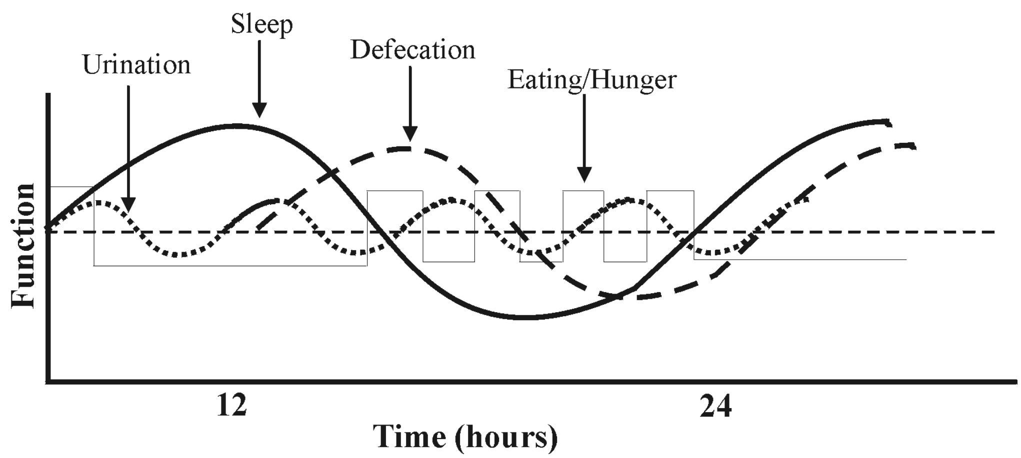
Within our systems are a series of patterns or rhythms that regulate various biological complexities, controlled by chemical activities of the cells. These are referred to as *biological clocks*. The clock mechanisms within our bodies do not measure time, like a typical clock, but is a self sustaining oscillator. Essentially, cells communicate and dictate distinct patterns and rhythms that exist within our bodies, such as:

- The sleep-wake cycle
- Hormone secretion (e.g., testosterone is highest during sleep and drops slowly over the course of the day)
- Blood chemistry
- Red and white blood count ratios
- Blood pressure (highest in early evening and in the month of December)
- Rate of urination production and excretion
- Body temperature (lowest around 3 AM and highest around 7 PM)
- Hunger (highest early afternoon and lowest around 12 midnight)
- Breathing (optimum rate of breathing and peak cardio efficiency is between 6-7 PM)
- Aging

Most of these systems are both active (self-contained) and passive (they can be affected by the environment). For instance, the body automatically maintains blood pressure, but lifestyle, i.e., food intake and activity level, are factors that help determine what that pressure will be. Also, internal body rhythms consist of up and down phases within a "normal" range, and these rhythms govern how well a person can tolerate many things including exercise.

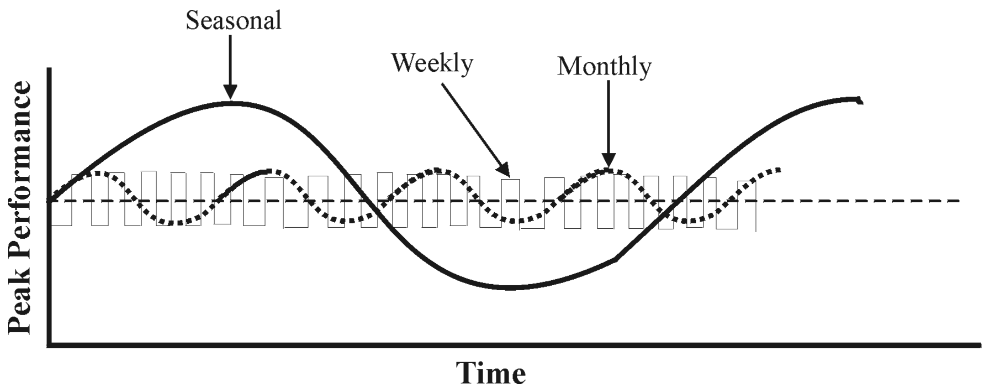
Rhythm examples

Each body rhythm meshes with others, like gears in a machine, each keeping its own individual rhythm within the network of activity:



Similarly, there needs to be a balance between activity and rest. It is not wise to exercise too often because just as the body is in the "upswing" of recovery, another bout of exercise can cause problems or short-circuit the recovery process. Before you know it, you can be overtrained because the internal rhythms were messed up.

Also, consider that there will be times, whether weekly, monthly or seasonally, when exercise progress will be best. Some people can workout harder on Mondays and Fridays, whereas other people prefer the weekends or other weekdays. Monthly downtime is prevalent for women during specific intervals of menstruation (p. 44). Because of shorter days – and the effect light has on our sleep cycles and emotions – seasonal "downtime" typically is during the winter, and it particularly affects with those who live in colder climates (p. 45).



Many habits are also based on timing and rhythms, including when to eat and when to exercise. In effect, habits instill a time reference for the body, and these regulate when it is best to exercise and when eating should take place. It's like programming the information into a computer, then allowing the computer to run the program without having to think about it thereafter. These self-instilled rhythms, as well as those pre-regulated by the body (i.e., sleep), can be upset by illness, or other abnormal stress factors.

Consequently, it is important to look for patterns in our daily lives and that we alter exercise and nutrition prescription to coincide with alterations that occur in normal rhythms as a result of high stress factors, such as illness and exercise overtraining. After all, it only makes sense to avoid exercise or to reduce the intensity of effort when feeling ill or when overtrained from doing too much exercise.

Sleep patterns and optimal performance[6]

The patterns and rhythms of sleep cycles control body temperature, blood pressure and hormone secretions. The rise and fall of these factors always coincide with whether we are asleep or awake. Moreover, and because of the interconnection of quality sleep and normal functioning, lack of sleep or poor sleep patterns increase heart rate, blood pressure, and affect the rise and fall of different hormones. Poor quality sleep also causes memory problems and reduces critical thinking ability, as well as affecting the body's immune response – an important factor in recovery ability. It should be evident that an individual's sleeping patterns/rhythms, and its quality, have a bearing on exercise recovery and productivity.

What is required is sufficient sleep, a *measure* that can be different from person to person, but can be defined as the amount that permits optimal (or at least good) daytime functioning. This can be achieved best by regularizing a sleeping schedule, as well as maintaining a dark, quiet, and cool bedroom; factors necessary for restful sleep.

Another important consideration is to go to bed only when sleepy, and if not having fallen asleep within 30 minutes, to get up and read or do something. Further, lying in bed and forcing a sleep state, or worrying about problems increases frustration and even disrupts later sleep. This occurs since arousal wakens the mind from its intended state of relaxation. Even late at night the body works in cycles, and this is why a person sometimes wakens in the middle of the night, even if only momentarily, or feels very tired then suddenly wakens moments later.

[6] Information on sleep patterns and cycles in the chapter adapted from Smolensky, Michael, Ph.D., and Lamberg, Lynne. *The Body Clock Guide to Better Health*. New York: An Owl Book, 2001.

Sleeping categories

Some people are “early birds”, or those who retire early and rise early (10-15% of the population). Others are “night owls” and late risers (15-20% of the population). The remaining population lie somewhere between. Apparently there is a genetic connection with sleep cycles, and clock mechanism characteristics pass from parent to offspring. This definitely holds true of my family, we are moderately early risers, in that we typically awaken around 7-8 A.M. if not provoked by an alarm clock, or the need to rise earlier. My wife’s family, on the other hand, is more “night owlish” since they go to bed relatively late and awaken mid morning around 9-10 A.M., unless having to rise earlier.

Occasionally I awaken as early at 3-4 A.M., but often this is because of disturbed sleep and anxiousness to do something. Too frequently, failure to relax and obtain sufficient sleep can lead to altered and varying body rhythms, guaranteeing irritability and fatigue.

It is important to note the difference between early birds and night owls, of about a 1-2 hour difference for either. For instance, the early bird will awaken 1-2 hours before most people, whereas the night owl may rise 1-2 hours after most people (at least if given the chance and if work or school did not interfere with natural rhythms). Similarly, if the average person retires around 11 P.M., early birds may retire as early as 9 P.M., whereas night owls may remain awake until midnight or a bit later (particularly on weekends or days off from work/school).

Keeping this in mind, an individual’s best time to exercise can be determined, as well as what skills should be trained if the person is an athlete. This can be done if we are to base exercise and athletic training on sleep patterns and when the person feels most awake and energetic. This process can be enhanced if other influencing factors are observed, such as work or school, eating habits, etc.

Characteristic	Early Bird	Typical	Night Owl
Most Alert; Technical instruction and learning of new exercises.	11 AM – Noon	Noon – 2 PM	5 PM – 6 PM
Ideal Exercise Time	Morning, since body temperature reaches a peak earlier than in the other two categories; low energy in the evening	Noon–2 PM or 5 PM-6 PM	6 PM-9 PM
Peak Heart Rate	Around 11 AM	Early Afternoon	After 5 PM
Personality	May be more introverted	Neutral	May be more extroverted
Eating Habits	Enjoys breakfast (usually favorite meal of the day)	Often has breakfast	Occasionally has breakfast
Work Habits	Most productive early to late morning and prefers day shifts	Most productive late morning, early afternoon	Most productive at night and can tolerate night and rotating shift work better
Muscle Soreness	Greatest if typically exercising in the morning	Average if typically exercising late afternoon)	Lowest if typically exercising in the evening (possibly because of sleep rest only a few hours later)

The above figures are based on generalities and averages. Differences do arise for various reasons. Observation of patterns, habits and requirements are necessary to determine the cycles of each individual.

Monthly cycle

Another significant time period, particularly for females, is the *circa lunar* rhythm or *circatrigintan cycle*, which transpires every 29 days (a monthly cycle). The most recognized cycle during this duration is *menstruation*. The bleeding time of menstruation is known as a ‘period’, which averages every 27-28 days and lasts 3-7 days. The starting and ending date of bleeding, as well as premenstrual syndrome (PMS) varies among females. Events that cause sleep disturbance and other stress factors can affect menstruation regularity.

A week or so before bleeding, women often suffer from the effects of *premenstrual syndrome* (PMS), including[7]:

- Slight increase in body temperature
- Marked changes in appetite, possibly including binge eating or food cravings
- Abdominal bloating
- Irritability
- Cramping
- Breast tenderness
- Fatigue
- Sleeping too much or too little (this can affect fatigue levels)
- Fluctuating emotions (feeling sad, hopeless, tense, anxious, mood swings, suicidal thoughts)
- Difficulty concentrating
- Decreased interest in usual activities
- Depression

Also, on the first day of the menstrual cycle, a woman’s immune system relaxes, making her more prone to allergic reactions and illness, including flu, hives, herpes sores, ulcer attacks and even diabetic coma. Headaches are more common during this time, and asthma attacks (if typical with the woman) seem to be more prevalent shortly before bleeding. It appears that fluctuation in both estrogen and progesterone hormones are responsible for the changes in wellbeing, with estrogen being highest the first half of the cycle and progesterone highest in the latter half of the cycle.

Another important time during the menstrual cycle is days 10-14 (mid-cycle) when the hormone *relaxin* is at its peak. This hormone, also at a high during childbirth, relaxes the soft tissues, and this relaxation reduces stability and strength around joints. The "ACL" is a ligament that runs through the center of the knee and controls pivoting of the joint, and if the knee stretches too far because of the relaxation (such as by planting the foot down and twisting), an injury can occur. Stretching of this ligament is more pronounced, and likely, if the surrounding tissues are not strong enough to maintain joint stability.

Although relaxin could cause problems in the joints with slow and controlled exercises, like deep squats, the ACLs are especially vulnerable during impact activities, like running or sports that require sudden movements. On average, the rate of ACL injury among athletes is much higher in women than in men, and far greater during times of peak relaxin release, such as during days 10-14 of the menstrual cycle.

[7] Beers, Mark H. M.D., and Berkow, Robert, M.D., eds. *The Merck Manual of Diagnosis and Therapy*. New Jersey: Merck Research Laboratories, 1999. 1932-1933.

All symptoms of menstruation and pre-menstruation can affect workout performance and concentration, as well as physical appearance (see below). Consequently, physical peaking and intense exercise periods should be worked around the time of PMS and menstruation, if possible, while expecting lower performance, altered exercise programs and reduced adherence to strict dieting at certain times. Female exercise enthusiasts need to be in tune with their cycles to choose appropriate exercises and to avoid exercises that place a great deal of strain on the joints, such as deadlifts, leg presses, squats, and any impact activity like running and intense sport play.

MENSTRUAL CYCLE CLOCK[8]	
Day	**Characteristics / Symptoms**
1	Bleeding starts
9	Breathing easiest
10-14	Relaxin peaks (avoid heavy lifting, including squats or deadlifts)
14	Vision sharpest (ideal time for female athletes to practice intense hand-eye coordination activities)
15	High self-esteem and confidence because of the hormone estradiol
18	Pain tolerance best (consider scheduling intense leg training on this day)
21	PMS – Moodiness begins, including depression (reduce exercise demands or expectations until day 2 of next cycle). Progesterone highest, prompting food cravings and overeating (slack off on diet accordingly and focus on low-sugar and low-fat desserts)
22	Blood pressure elevates (some caution may be necessary, depending if the female is prone to high blood pressure)
24	Breast tenderness, water retention & weight gain common (these may affect exercise quality, confidence, concentration, etc.)
25	Sleep most restless; if arthritis, asthma, diabetes, digestive tract disorders, hay fever, migraine, seizures or skin conditions exist, they are likely to flare at their greatest between days 25 day 2 of the following cycle.

Circannual cycle

"**Circannual cycle**" refers to a yearly or annual time period. During some months or seasons of the year, there appears to be a greater rate of *seasonal affective disorder* (SAD)[9], when people feel depressed and lethargic. This condition probably occurs because of a disturbance in the biological clock of the brain that regulates hormones for sleep and mood.

In effect, shorter days and less sunlight seem to alter normal rhythms. Reduced light appears to be the reason since people in Alaska (or any location higher in the northern hemisphere) are more apt to suffer from SAD than people in Florida or other sunny areas. Exposure to artificial light seems to help (i.e., light therapy). This treatments consists of a box of fluorescent lights that shines on an individual – who does not look directly into the light – for about 15 minutes to 2-3 hours, twice a day, depending on the severity of SAD.

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[8] Adapted from Smolensky, Michael, Ph.D., and Lamberg, Lynne. *The Body Clock Guide to Better Health*. New York: An Owl Book, 2001. 127.

[9] Adapted from http://fly.hiwaay.net/~garson/terre4.htm (Note: web page is no longer available) and Smolensky, Michael, Ph.D., and Lamberg, Lynne. *The Body Clock Guide to Better Health*. New York: An Owl Book, 2001. 296-300.

Some common side effects of SAD include:

- Extreme fatigue and lack of energy.
- Increased need for sleep and sleeping more than usual.
- Carbohydrate cravings and increased appetite. Carbs increase serotonin levels (a neurotransmitter in the CNS that is important in sleep-waking cycles) in the brain. This is why people sometimes crave carbs – so that they can get more rest. High carb diets, particularly light or small carb snacks a few hours before bed, are ideal for this group. However, be aware that eating too much before bed can disrupt sleep.
- Difficulty controlling food intake and weight (depression can lead to 'comfort' eating).
- Difficulty finishing usual tasks or chores.
- Difficulty in keeping appointments or arriving at work or school on time.
- Difficulty in problem solving, thinking and concentrating.
- Skewed emotions, such as feeling sad, guilty or pessimistic for no reason.
- Negative thoughts during one season but not during other times of the year.

Exercise demands and expectations of goal achievement must take into account the emotions and moods of an individual during 'darker' months. If motivation is not as high, or ability to concentrate is not as acute, then the trainee must be cautious to avoid exercise practices that may increase the risk of injury. This may mean less intense exercise and less intricate sporting skill practicing. Be realistic about what can be achieved during downtimes, and make workouts as "fun" as possible with less emphasis on goal achievement, intensity of effort and stern rules.

Besides SAD, there are other seasonal changes that occur with the human body:

- Testosterone levels are highest in the fall. They are also highest in most men around 7 A.M., but training at this time will not produce any measurable difference in muscle gains. In fact, the stress from exercise may retard or interrupt peak testosterone secretion/production.
- Sperm concentration and activity are highest in winter, with the highest rates of conception occurring during the winter.
- Fatal heart attacks are most common in the winter. Winter season also produces the lowest immune resistance and highest cholesterol levels, which may contribute to the risk of heart attack (regular or daily snow shoveling of poorly conditioned people in the North may contribute to heart attacks as well). Consequently, food choices must be taken more seriously, to avoid fat weight gain and to provide quality nutrients during this time. This should include a reduction in exercise intensity and overall demands so as not to challenge the immune system, advice most important for those over 50 years of age, those who have suffered a heart attack, and those with a history of family heart problems.

The *Principle of Individualism* Governs Exercise Prescription