Kinesiology of Exercise

Based on the Work of Dr. Michael Yessis

Training Factors

KinX Learning

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There are many factors involved in exercise execution that can affect the results that you get from your exercise program. You may not be able to change or do much about some of them but if you are at least cognizant of them, you can take steps to minimize any potentially negative effects. Some of the more important aspects are as follows:

The Biomechanics of Exercise Machines

Most exercise machines are made to fit the theoretical average person. If you are of average build, positioning on most machines should allow you to do the exercise in a relatively safe manner. But, for short and tall people, the exercise machines may be ineffective and some cases, dangerous.

Adjustability

One of the most important features that an exercise machine should have is adjustable positioning. This is especially important in exercises in which you must move limbs in a manner safe to the joints and to target particular muscles. For example, in the **pec deck** and **reverse fly** exercises the seat should be adjusted so that the arms can be situated in line with the shoulders and travel in a horizontal pathway during execution.

If you are seated too low you will be pushing upward in the action, which will develop different musculature. The same applies if the seat is too high which forces you to push downward. In some cases the exact pathway may be injurious to the joints if freedom of movement is restricted in any way or if you move the arms at an angle which is detrimental to the joint.

Adjustability is important in exercises such as the **lat pull-down** so that you can reach an overhead bar without having to rise up to grasp it and then sit down and pull the bar down as you sit down and secure the legs. It is especially difficult to correctly position yourself while holding a bar with great tension on it.

An analogous situation exists with the **seated cable row** machine. If you have to reach too far forward to grasp the handles when you are in a seated position, you will have a rounded back which creates tremendous compression forces on the discs when you begin to pull the handle back. Keep in mind that a rounded spine with great loads on it, is one of the most frequent causes of low back injury.

Adjustments on the **seated calf** machine are needed so that you can get into a position where your knees are at a 90 degree angle and there is a corresponding 90 degree angle in the hip joint. In this way you can sit upright while doing the exercise. If your knees are too far forward or backward, you will have difficulty executing the exercise through the full ROM.

Overhead press machines should be adjustable so that you can sit directly under the handles that you push up. In addition, the handles should go straight up so that you do not end up pushing forward or backward near the end of the range of motion. When you find yourself pushing in a direction other than directly upward it may create low back or shoulder problems.

In fact, almost all seated exercises in which you handle considerable weights above the head, compress the spinal discs (especially in the lumbar area) more so than if you were in a standing position using free weights. When you are seated you are unable to use your legs as absorbers of force and there is a strong tendency to round the lower spine. This is why the standing position is usually preferred.

The **four-way hip** machines also require precise adjustments. There should be an adjustable platform to raise or lower the body to adjust height. This is needed to bring the hip joint in line with the axis of the resistance lever. If the axis of the machine and the hip joint are not lined up, compression and shearing forces may be developed in the hips and lower back during execution of the exercises.

Adjustability is also critical to doing safe and effective exercises for the lower back as found on the **Yessis Glute-Ham-Back** machine. If the machine is not adjustable, even a difference of a couple of inches in regard to the axis of rotation can make a major difference in the muscles and actions involved and most importantly, in regard to safety.

Often overlooked is the need for adjustability to get the exact muscular development desired. In addition, adjustability on some machines is conducive to producing the exact type of movement needed to duplicate a sports skill. For example, the adjustable pull-up and dip machines allow for a wide range of muscular development.

These are the only machines that are available in which you can adjust the width of the grip together with the type of grip. This includes the neutral, supinated, pronated, 45° angle level grip and 45° downward angled grip. Such adjustability allows for a very wide range of development.

ROM adjustments should be available on exercise machines. **Multi-hip** and **leg extension** machines should be adjustable so that the leg can be placed in the proper position at the beginning of the exercise and be able to move to a safe ending position. For example, most knee joint extension machines start with the shin underneath the thigh. In this position the knee is at an unfavorable angle and there are tremendous forces acting in the knee joint. If the resistance is sufficiently great, the forces can literally pull the knee apart when you start. For maximum safety you should start with a 90 degree or less angle (closer to the horizontal) in the knee joint.

All **pec deck** machines should be adjustable so that you can assume a seated position and place your arms against the resistance pads with the arms in line with the shoulders. If instead you begin with your arms as far behind the body as possible the initial stress on the shoulders is very high when initiating the forward pushing action. This in turn can create stretch marks and injure the shoulder joint.

In the reverse pec-deck the key to safe and effective execution is to make sure that your seat is adjusted properly so that when you grasp the handles and pull back, the arms are in line with the shoulders. You should be able to pull well behind the level of the back with slightly bent or straight arms.

Hamstring machines can be potentially dangerous when a flat bench is used. In this case as the knee joint flexion occurs the pelvic girdle rises to raise the origin of the hamstrings to provide for a stronger contraction. This action may create excessive arching in the spine, which can be injurious if there is any twisting of the hips. More effective is an angled bench so that the pelvic girdle is positioned high, i. e., in hip joint flexion. The seated knee curl machine does this as it automatically places the upper end of the hamstrings on stretch. As a result, it is more effective for developing hamstring strength.

For safety and effectiveness in using a **calf (heel) raise** machine, the shoulder pads must be sufficiently high. This is needed so you do not have to round the back to get into position to push the resistance pads up high enough before you can assume an erect position. (This also applies to a **squat** machine.) The foot platform should be situated

directly under the pads so that the trunk can be erect and not inclined forward or backward when doing the exercise. In addition, there should be hand grips for better balance and stability.

In the **seated leg press** it is important that the feet be placed flush against the resistance platform. Area of placement is also important. If the feet are placed in line with the hips there is more equal distribution of effort between the knee and hip joints. This positioning is usually difficult to attain on most machines. When the feet are placed high and the knees come closer to the chest, there is more involvement of the hip extensor muscles. Also, when the knees come very close to the chest, there is rounding of the spine, which can be injurious to the spine.

Leg press machines should also have ROM adjustments to prevent the knee from collapsing against the chest or coming too close to the chest during execution of the exercise. Not only are such extreme movements dangerous to the lower back but also to the knees. Improper exercise technique on these machines has resulted in many low back injuries.

When doing **the Hack** or **Smith machine squat** it is important that the feet be placed approximately 12-15 inches in front of your line of gravity. This is needed to allow the spine to stay in its normal anatomical position as you make the descent and ascent. If you place the feet directly under the shoulders, as you do in the barbell squat exercise, there will be great stress thrown on the knees and a greater tendency to round the lower back.

In the squat, hack squat and leg press, it is usually best that the angle in the knee not reach much less than 90 degrees (measured behind the leg) before executing the up or press portion of the exercise. When coupled with breath holding the exercise becomes much safer.

To use most **hip abduction** and **adduction** machines you must assume a seated position with the legs almost perpendicular to the trunk. From this position you push the legs out (abduction) or in (adduction) sideways against resistance. Because the hip joint is basically at a 90 degree angle of flexion, you can get irritation of the tendons and muscles in the hip joint when you execute the movements. Also, they become more susceptible to injury if you push vigorously.

More effective and safer is to have a straight body position when you execute the hip abduction and adduction movement. If you must use the seated version, you should

not use extremely heavy weights, which can exacerbate the problem. This is why the preferable method for strengthening the muscles is by using Active Cords to execute hip abduction and adduction as well as flexion and extension.

When using most of the common **biceps** machines to isolate the elbow flexor muscles, you place the upper arms against a support pad when you do the exercise. In so doing, the elbow pushes against the pad as you curl the resistance upward. This can place stress on the elbow. Whenever possible, have the elbow free of support when you execute the exercise.

In such cases be sure that you do not hyperextend the elbows especially when using heavy weights. In addition, you should not lean too far forward when placing your arms against the pad. This gives the upper bicep muscle and tendons greater slack, which results in less muscle tension and a greater possibility of hyperextending the arms.

On most **triceps** machines the backs of the arms are placed against a support pad to stabilize the arm and isolate the elbow extension movement. It is important that the elbow be free of support, so that you do not push into the pad with the elbow during the movement. This can place great stress on the olecranon process, an extension of the upper arm bone. Also the axis of the machine should line up with the axis of the elbow.

When using the **lateral arm raise** machine, you are limited to only half the range of motion. You typically begin with the elbows close to the sides of the body and raise them until the upper arms are level. This does not work the deltoid muscle through its full range of motion, as does the overhead press.

Back extension machines should be used mainly for stabilization of the spine. The machines should have adjustable seats so that the resistance pad is in the middle of the upper back. With the axis in the hip joint you push back in hip joint extension while you keep the back stabilized. If you flex and hyperextend the back as you do the exercise it can be injurious because of the compression and shearing forces. Much more effective to strengthen the erectors is to lower the trunk from a prone horizontal position with the axis in the waist as is possible on the Yessis Glute-Ham-Back machine. In this way you have full flexion of the spine in the initial position. When you raise the trunk, it is against the force of gravity up to and above the horizontal position.

This exercise, known as the **back raise** is best done on the Yessis Glute-Ham-Back Machine. Because of its adjustability it can fit all different body lengths (from persons four feet tall to persons over seven feet tall) and provide safe and effective strengthening of the erector spinae through a full ROM.

Care must be taken when using abdominal machines. Some of them are limited to flexion of the upper (thoracic) spine in a crunching action, which is effective for development of the upper abdominals. Although you get effective contraction of the upper abdominals keep in mind that if you do not return to the normal spine position, you may end up tightening the abdominal muscles to create a permanently rounded upper back, also known as the hunchback condition.

To prevent this from happening you must return to the normal spine position before doing the next repetition or to stretch the upper spine after completing the set. This can easily be done by hanging from a high bar or using the back stretch strap and holding the down position with the head in place for 10 to 20 seconds on each repetition.

Some abdominal machines have the axis in the hip joint rather than in the waist. In such cases the abdominals undergo isometric contraction to stabilize the midsection while you perform hip flexion (analogous to what occurs with most low back machines). However, in almost all machines going through the full ROM involves both dynamic and static contractions of the abdominals through a considerable portion of the ROM.

And, there is involvement of the hip flexors to create a full ROM. This is why it is often recommended that you do full range abdominal muscle exercises on the Yessis Glute-Ham-Back machine on which it is much safer and the strengthening more precise.

However, for some individuals these exercises may be too advanced. If you are not correctly positioned when using the **abdominal rotational machines**, you may be working the erector spinae instead of the abdominal rotational muscles. Very important is to determine if the forces generated by you are going to rotate you forward or backward as you do the exercise. In general, if the abdominals are involved, as you rotate forward you will also experience a tendency toward slight flexion of the spine near the end of the full ROM.

If you feel the lower back muscles contracting, you are rotating to the rear which leads to slight hyperextension near the end of the full ROM. Because of this you should be cognizant of which muscles are undergoing contraction when you do rotational exercises. If not, it can lead to injury if you are striving to contract one set of muscles when the opposite muscles are in action.

Some of the newer machines available today such as the free motion machines are more advantageous for duplicating free movement as done with dumbbells. They also have great adjustability so that you can get the height and width needed to move the arms in any particular direction that is desired.

These machines can be used for many different exercises as for example, pull downs, presses and crossovers. The key to their successful and effective utilization is to not use excessive weights and to be very specific in your duplication of a particular pathway.

Balance

A major negative criticism of exercise machines is in the lack of balance when doing the exercise. Many people consider this a positive factor for safety. But, because balance plays such an important role in everyday activities as well as in sports, it is a factor that should not be ignored.

If you cannot balance yourself when doing a free weight exercise with light weights, then you are in serious trouble and need specialized rehabilitation to improve your balance capabilities. Undertaking a strength training program will then be much safer regardless of the equipment you use. Keep in mind that you must still stabilize the joints to allow the muscles to contract properly.

By doing free weight exercises you will develop great balance capabilities and you will not have to rely on doing supplementary balance exercises. For example, very trendy today is the use of large inflated balls, also known as stability balls, Swiss balls and physio-balls, along with balance boards, and semicircular boards and half balls for balance training.

This equipment can be used effectively but care must be taken when using the stability balls and other equipment with elderly people, or other people who do not have good balance. Exercises on the balls develop balance because they require high levels of balance to do the exercise. For some reason these exercises are deemed to be perfectly safe, but exercises done with free weights are now considered to be dangerous.

In reality it is just the opposite because you start with a stable position in a free weight strength exercise and are forced to maintain it while executing the exercise. With the balance equipment you are placed an unstable position and then expected to maintain balance while you execute the exercise with good form.

But in this balance training you can never use as much weight or execute the exercise in the same manner. You are also more susceptible to injury and there have been many serious injuries from use of this equipment. They require much greater supervision in comparison to what is required for most free weight exercises.

You should understand that all exercises can be dangerous if you are not prepared to do the exercise the way it should be done. When you have the capabilities and understand

how the exercise should be executed, the exercise becomes very safe. If you do not have the physical abilities to do the exercise correctly, then it can be very dangerous.

In general, doing exercises on large balls is not a wise recommendation. Too many people are injured on a regular basis and often very severely. More importantly, you should realize that you do not get any great advantage in relation to your muscular and balance development in comparison to what you can get with much safer execution of free weight exercises.

Even a “simple exercise” such as the squat is very dangerous regardless of whether it is done with free weights or machine weights. If you do not have the strength to hold the natural curvature of the spine, the exercise will be dangerous. In addition, you must have ample flexibility in the hip joint to enable you to make the descent safely without the knees protruding beyond the toes or your base of support when in the down position.

Thus you should not automatically assume that one type of exercise is safe and another isn’t. All exercises can be safe and they can be dangerous. The key to whether the exercise will be safe or dangerous lies in how it is executed. This is why exercise execution is so important in addition to the development that you receive.

Breathing in Exercise

Breathing plays an important role not only in exercise, but in relaxation. When your respiratory muscles are strong, you are capable of taking in and processing more air per breath. As a result, you can get greater amounts of oxygen, which the body needs not only for the production of energy but to help in your recovery. The stronger your respiratory muscles are, the more effective is your cardiovascular endurance. By improving the strength of the muscles involved in breathing, you will be able to prevent not only the onset of fatigue but to recover faster. Keep in mind that respiratory fatigue occurs before cardiovascular fatigue. Thus your breathing is directly related to your endurance as well as to your lifting. When you do your strength exercises, how you breathe is very important. Because of this, you should develop proper breathing patterns from the start. This also applies to execution of your sports skills. In this book the instructions for the exercises tell you to inhale and hold your breath on exertion - that is, on the hardest part of the exercise when you are overcoming resistance. You then exhale on the return, staying in control of the movements.

But don't be surprised if you read or hear the opposite from other sources—that you should exhale on exertion and inhale on the return. But this widely used recommendation to exhale on exertion is based on theory, not research or actual practice. In addition, it applies mainly to people with heart and circulatory system problems.

For example, if you hold your breath too long in a maximal resistance exercise (up to eight seconds) you could pass out. This is because the internal pressure in the chest and abdomen increases when you hold your breath on exertion. If it increases greatly, it squeezes down on the blood vessels shuttling blood and oxygen to and from the heart. When this happens, you may black out (but rarely, and only on maximum exertion with the breath held too long.

If you are without cardiovascular problems and you do not hold your breath for more than a few seconds as needed in the recommended exercises, the breath-holding on exertion is perfectly safe. It makes the exercises safer and more effective. If you have high blood pressure or other circulatory system or heart problems, avoid heavy resistance training and breath-holding. In fact, you probably should not participate in a strength or explosive sport which requires not only great physical exertion but intense breath holding.

Inhaling and holding the breath briefly on exertion—any exertion, in execution of a strength exercise or in sports, comes naturally. Many studies have shown that whenever athletic skills are executed properly, athletes hold their breath on the exertion—during the power phase when maximum force is generated. The breathholding is important for generating greater force, having more accuracy and control and for the prevention of injury.

For example, Inhaling and holding the breath on exertion provides up to 20 percent greater force, stabilizes the spine, and helps prevents lower back injuries. It transforms the trunk (and sometimes the whole body) into a stable unit against which your hips, shoulders, and arms can move more effectively.

Breathing exercises can also help you relax. For example, it is not uncommon to read that you should inhale and then exhale before starting a race, game or skill execution. This is a good technique to help you relax. But before starting, it is important that the muscles have some tension—not excessive tension, but sufficient tension to take-off with power. This is why you should never completely exhale before starting. Hold slightly more than your usual breath.

Thus, inhalation and breath-holding are needed immediately before and during execution of the key actions. Studies done with devices to monitor breathing patterns have proven this beyond any doubt. To execute a powerful lift or execute a powerful sports skill, you must hold your breath during execution.

In effective breathing, do not take a maximal breath and then hold it. Holding a maximal breath can make you very uncomfortable. Just take a slightly greater than usual breath and then hold it to experience the positive benefits. This is especially important for stabilizing the body, holding the spine in position, and getting greater power in execution of the skill. The breath holding time is very short. Thus, you should have no fear of holding the breath too long or of overexerting yourself.

Exhalation, especially after a deep breath, is very beneficial for relaxation. Thus, anytime you exhale during execution of a maximal lift, you are telling the muscles to relax rather than to remain under contraction to accomplish the work that has to be done. The exhalation weakens your body greatly and can lead to injury.

Some exhalation during a lift can be of benefit. For example, if you are doing a very heavy squat, or handling great weight in a squat, and you are coming up out of the

down position very slowly, the amount of pressure being built up is quite great. To relieve some of this pressure, exhale slightly through pursed lips to relieve some of the pressure.

However, do not let all the air out until you have passed the sticking point, or most difficult part of the up phase. Exhaling after you have passed the most difficult part of the lift is also very important for relieving the built up thoracic and abdominal pressure. The key is to be sure that you exhale after passing the sticking point, not before.

Too often exhalation at this time is taken to indicate exhalation on exertion, but it is after the exertion, not during. Keep in mind that proper breathing is essential to successful execution of strength exercises, especially when handling heavy weights. Breath holding on exertion is a natural consequence. If no one told you how to breathe, you would automatically hold your breath when lifting a heavy weight. You also hold your breath when receiving an object coming at you, as for example when someone is throwing a medicine ball or even a punch. You need the breath-holding to stabilize the body, to better withstand the force or the blow that you are about to receive. If you still believe that you should exhale on the exertion, then you can prove to yourself that this does not happen naturally. Watch a person lifting maximal weights or what an athlete does when he catches a medicine ball thrown to him. You will see that he or she automatically inhales and holds the breath as they prepare for the lift or the catch.

Also, try to find a research study that can substantiate your belief that exhalation occurs on exertion. I assure you that you will not find any. You may see authors theorize that this should occur but they never actually prove it. When you do find literature or studies recommending exhalation on exertion, you'll see that they deal with people who have heart or circulatory problems. You will not find any dealing with healthy individuals, especially athletes.

Thus, you should not be duped by this myth that has been perpetuated in the fitness and sports fields. Be more in tune with nature and do what your body does naturally. Your workouts will be much more effective and safer.

Workout Clothing

When most people think about what clothing they should wear when exercising, they usually think in terms of what looks good as opposed to what will be most functional. Fashion plays a big role today in regard to how one looks and feels. This applies not only to going out on a date or attending an important meeting or function, but also how one looks and feels when working out. Keep in mind that how one looks is often strongly related to how one feels. This in turn can play a major role in how effective your workout can be.

Athletes are typically given workout gear that are more functional or wear clothing with the team logo. Gym-goers seeking fitness typically wear more fashionable clothing but this can vary greatly especially in regard to functionality. Regardless of the clothing, there is a wide range of materials in regard to what the clothing is made of, as well as how fashionable or functional the clothing may be. But yet, the type of clothing worn can play a major role in how effective your workout can be.

If you look closely at what most clothing is made of you'll see that the materials are quite diverse. In past decades polyesters were most used not only for fashion, but ease of care. Then more natural fibers became more in vogue with cotton becoming most popular. It still remains one of the most popular fabrics used in most workout clothing with spandex coming in close behind.

One fabric that may soon combine forces with these two fabrics or compete independently with them is bamboo. For those who like to go green or to use fabrics that are more natural, bamboo may become the wave of the futures. In recent years a range of technologies have been developed allowing bamboo fiber to be used in a wide range of textile and fashion applications.

Today bamboo clothing is clothing made from either 100% bamboo yarn or a blend of bamboo and cotton yarn. The bamboo yarn can also be blended with other textile fibers such as hemp or even spandex. In addition, bamboo appears to have additional properties that are the fabrics do not have.

For example, according to some studies, bamboo clothing was found to have antibacterial and antifungal properties. This can be very important when working out in a gym that may not always be as clean as possible. These properties may also be very important for people with health issues who must avoid contact with bacteria or

fungus. Studies have also shown that bamboo absorbs and wicks water 3 to 4 times better than cotton. Bamboo fabric is a natural moisture wicking agent and because of this, can help keep you dry and thus reduce body odor.

In addition, it has been found that bamboo fabric protects skin from ultraviolet rays more effectively than other fabrics. The bamboo fabrics ability to block ultraviolet rays is reported to be several hundred times greater than cotton fabric.

Another plus factor is that bamboo is safer and kinder to the environment. As a natural cellulose fiber, bamboo is 100% biodegradable and does not cause any pollution to the environment. Bamboo has favorable growth properties as it can grow more than three feet in one day. It also has a relatively short harvesting cycle of 2 to 3 years, and does not require deforestation as occurs when trees are cut for the production of paper.

Weight Training and Flexibility

Weight training can result in an increase in joint flexibility or it can have the opposite effect – a decrease in flexibility. It depends not only on how the exercise is done, but on how much weight is used and the range of motion over which the weight is moved. Also, adaptations to weight training with beginners are different from the level or kind of adaptation by more experienced trainees.

If you use relatively light weights so that you go through a full ROM, you will be able to increase your flexibility. In exercises such as lateral arm raises when you go through a full ROM so that the arms end up directly overhead you can increase shoulder flexibility. You can do the same in front arm raises, lateral prone raises, back raises, etc.

Exercises such as reverse trunk twists are excellent for increasing rotational flexibility of the spine, as well as strengthening the internal and external obliques. To increase the ROM in supination and pronation, use a Strength Bar at full length. There are many other exercises -- if not most -- that can be done through a maximum ROM that will result in an increase in flexibility or maintenance, once an optimal range of motion is established.

As you increase repetitions, sets and/or use greater resistance, your weight training will result in a loss of flexibility. There are several reasons for this:

1. The greater the number of repetitions and/or sets, the greater is the tendency to shorten the ROM.
2. The greater the total number of repetitions the greater is the tendency for the muscle to tighten up and shorten after the work.
3. When you handle very heavy weights you rarely fully extend the limbs because of the loss in mechanical advantage of the muscles.
4. The use of heavy weights brings about residual tonus in the muscles, which, when sufficiently strong, keeps the muscles in a shortened state after the workout.

When you use a greater number of repetitions and/or sets, you will invariably find that as you approach the last repetitions or sets, ROM will be decreased. This typically occurs when fatigue begins to set in or when the muscles begin to tighten from the amount of work being done. The more work you do, the greater will be the likelihood of a decrease in flexibility in the joints affected.

Because of this, all heavy or intense weight training programs should be supplemented with stretching, preferably after the workout and that the stretching is active in nature. This is especially important when the spine is involved in weight bearing and may become compacted, as for example, when holding weights on the shoulders or overhead. Active stretching at this time can be done to regain the normal ROM in the involved joints.

For example, if you do multiple sets of the biceps curl, you can do a straight arm hang on a high bar to regain the straight arm position. For the lower back, hanging is also very beneficial, whether it be on a high bar to get a full stretch of the spinal vertebrae, or on the Yessis Glute-Ham-Back Machine in which you hang down from the hips with the trunk vertical (inversion).

Keep in mind that the stretching at this time is not for an increase in flexibility; it is merely to regain the normal ROM in the joints that you had prior to the exercise. Stretching after the workout is also effective for the prevention of muscle soreness or to decrease the severity of muscle soreness.

Dangerous Stretches

It is important to understand that some stretching exercises such as the straight leg toe touch can severely weaken the spine. When you bend over maximally from the waist (and hip) you stretch mostly the ligaments of the spine, not the muscles or connective tissue. Thus, most of the stretching in straight leg toe touches is of the spinal ligaments, not the hamstrings.

This can easily be proven. Maintain the spine in an arched position and then bend over from the hips. Most often you men will not be able to reach the horizontal trunk position because of tight hamstrings. Now do the toe touch exercise with rounding of the back. You'll see that your hands now go approximate twelve or more inches lower than when you had an arched back. This indicates the amount of stretching that took place in the lower back.

The same applies to the seated toe touch and the hurdler stretch in which there is excessive stretching of the spinal ligaments and not very much of the hamstrings. The exception to this is when you keep the spine locked in an arched position when your bend forward. In this case the total ROM is limited. This is another example of why every exercise should be executed in the most effective manner for the results desired.

Adequate strength in extreme joint positions is necessary to prevent structural damage by outside forces. Keep in mind that in active movements it is muscle strength that moves the limb through the necessary range of motion. Passive flexibility has very little correlation to your active range of motion.

Thus, the greater your active flexibility, the better able you are to perform the necessary actions but only when you have adequate levels of strength through the entire ROM. Also, as you increase your ROM it is important to develop adequate strength in the new found range of motion. Flexibility without strength can be dangerous. ROM may be limited by four factors:

1. Connective tissue restrictions;
2. Bony configurations at the joint;
3. Contact of muscle masses of adjacent segments; and
4. Strength of the muscles over the full ROM.

Physical contact between the muscles of adjacent limbs cannot be changed (unless there is also unnecessary fat). The same is true when you have contact of the bones that form the joint.

When you do not use the total ROM at a particular joint for a long time, the connective tissues crossing the joint become shortened and adapt to the usual ROM. If an exercise demands a large ROM at one or more joints and you do it regularly, the tissues become lengthened and you maintain the needed flexibility. The areas of the body which receive little movement show the greatest decrease in ROM.

Passive and Active Flexibility

Passive flexibility refers to the ROM available when an outside force (i.e., gravity, momentum, another body part or another person) is the causative force. Active (dynamic) flexibility is the ROM produced when muscle force (or gravity) creates the movement range. If the muscles are weak, the ROM will be less than it should be. A passive range of motion shows little correlation to an active ROM. Because you exhibit a great ROM in a static position, it does not mean that it relates to what you do when performing actively. The two are not related! If you desire an active range of motion, you must do active stretching. If you desire a static or passive range of motion, then you should do static stretching.

In active stretching, the muscles that are actively involved do so primarily in the eccentric contraction. For example, when you raise your arms overhead as in the lateral arm raise, you are eccentrically stretching the latissimus dorsi and teres major. These muscles undergo an eccentric contraction as you raise the arms to not only control the movement but also to stop the arms from going beyond the capability of the joint.

Another example is to lie on your back and then raise one leg as high as possible. Then lower and raise the other leg and repeat in an alternating manner. Every time you raise the leg, you are using the hip flexor muscles to eccentrically stretch the hamstrings and increase the range of motion in every repetition. You can also use gravity as the force to produce active stretching. For example, if you do a good morning exercise keeping the lower back in its normal slightly arched position as you bend over from the hips, you will elicit an eccentric contraction in the hamstrings. Gravity is responsible for pulling the trunk down and the hamstring muscles need the eccentric contraction to control the down movement.

When you rise up and each time you go down, you should experience a slightly greater ROM. But you do not force an increase in the range of motion. It happens due to the muscle or gravity pulling. Note that these stretches are more natural since they duplicate what occurs in everyday and sports activities.

Posture

When I was in school, from the elementary grades through college, analysis of posture and exercises to correct posture were strongly emphasized. Since that time, posture appears to be mostly ignored. To make matters worse, in the last few decades it has become popular to assume poor posture positions to “relax” or to look “cool”.

For example, it is not uncommon to find female models who tilt the pelvis backward to create a flat back. Other postures have the pelvis tilted the opposite way to create a slinky appearance, and so on. These postures are then copied by many youngsters especially by the girls to look “in sync”.

As a result, it is not uncommon to find many individuals with poor posture. This includes forward head, round shoulders, sloping shoulders, excessively rounded upper backs, hyperextension of the lower spine (sway back), hyperextended knees, toes pointed excessively outward or inward, thighs rotated excessively inward or outward and so on.

When you have good posture your muscles are basically in balance, and your body is symmetrical. When there is a deviation in posture, it is usually due to a lack of strength of particular muscles to hold the body in the needed position. For example, weak erector spinae muscles of the lower back are the main culprit in not being able to maintain an erect trunk in standing and walking or have proper back posture when lifting weights.

Benefits of Good Posture

Most people are usually unaware that they have poor posture. More startling is that they show little concern about having good posture. However, for athletes and fitness-minded individuals, posture should be of great concern. The reason for this is quite simple: posture can determine the outcome of your performance and well-being. Before relating how this can happen, it is necessary to first examine some of the benefits of good posture.

1. Good posture is esthetically pleasing. When you observe an individual who stands tall with the shoulders back, chest out, body erect without a protruding abdomen or rounded back, it gives the appearance of a healthy, vigorous individual. Physically fit individuals should be especially aware of this since other people are attracted to you by your physical appearance before facial looks or personality come into play.

2. Posture is indicative of body language. How you carry yourself (dynamic posture) tells others what you think of yourself. If you slink and round your shoulders you appear to be embarrassed of your body. Such postures can easily develop negative attitudes. Most people are attracted to individuals who give off good vibrations from the way they look and use their bodies.

3. Good posture is important to health. It is needed to keep the organs in place and to allow them to work efficiently and effectively. For example, if you have sway back, the intestines, instead of being held in place, press against the floor of the abdominal cavity, which interferes with their normal work.

If you have rounded shoulders and an excessively rounded upper back, there is constriction in the chest cage. Because of this, it becomes impossible to get full filling of the lungs with air which is vital in athletic performance and fitness activities.

4. Posture affects how you walk, run, jump, lift weights, and execute other skills. For example, if you have rounded shoulders, your arms, instead of hanging alongside your body, may be slightly in front of your body. As a result, you may find that instead of lifting the arms sideways directly overhead, you are lifting them up and in front of the body. This changes the muscular movement and the movement pathway.

5. If you cannot hold your trunk erect during running, you will be unable to have an effective push-off or knee drive for a long stride length. Even in walking, if your feet or thighs are rotated outward excessively, greater stress will be placed on the hip and knee joints. If walking in this manner is carried on for a long period of time, injuries to these joints can occur.

6. Posture plays an important role in the prevention and rehabilitation of back problems. For example, if you have tight hip flexors they may keep your pelvis tilted forward, causing swayback. If they are too weak and the abdominals are strong, it may cause flattening of the spine. If the hamstrings and their upper tendons are too tight, they do not allow you to hold the arch in your lower back when doing exercises such as the squat or when bending over to lift something.

7. When your abdominals are too tight they flatten the spine, which places excessive pressure on the anterior aspects of the spinal discs. If they are too weak, they may be responsible for swayback. If you're pectoral muscles are too tight they may be responsible for pulling your shoulders forward and creating a rounded back position.

8. By strengthening and stretching the necessary muscles to create good posture, you not only prevent injuries but also rehabilitate them. Merely correcting posture is often all that is needed to relieve back pain. For example, pulling the head back into proper alignment is often sufficient to produce the normal curvature of the vertebral column. By lifting the head and looking forward you can activate the lower back muscles to hold the spine in place and as a result, alleviate the problem.

9. Good posture makes you feel good. Because of its many benefits, such as ease of movement, good balance of muscle strength and flexibility, proper positioning of the spine and proper functioning of the internal organs, your body “feels” good and as a result you feel good. You feel alive, ready to perform and are proud of yourself. Thus posture should be of prime focus in all fitness activities.

Posture is dynamic. It is not merely maintaining the military “at attention” type of posture. Good posture is relatively easy to attain and maintain. Part of it is learning new habits of sitting, standing, walking. But the major factor is developing strength of the key muscles to hold you in the proper posture.

Self-Check

To find out if you have good posture, stand with your back against a wall. Your heels, backs of the calves, buttocks, upper back and head should comfortably touch the wall. If you must strain to make all points of contact, then you probably have some deviations.

Also effective is to secure a string to the ceiling and hang a light weight at the end of the string. Stand so that the string is lined up with your nose and then have a front view picture taken or look in the mirror. Note if your shoulders are leaning to one side or another or if more of your body is one side of the line. In good posture you should be symmetrical on both sides of the string.

Lining up the string at the side of the body so that it is in the middle of your shoulder is also effective. It gives you a graphic representation of how your weight is distributed in front and behind you. It will also show if you have any major deviations in spinal curvature or anterior/posterior positioning of the hips.

Postural Deviations

Postural deviations play a very important role in how well you can perform or execute athletic skills. Because of this, if you wish to be a successful athlete, you must be sure

that you do not have any deviations that may be affecting your performance. Some of the more important ones relate to the relative strength and flexibility of the spinal muscles as they play a role in the alignment of the trunk and pelvis. When there are imbalances, three abnormal conditions result: lordosis, scoliosis and kyphosis. In **lordosis** the superior iliac crests of the pelvis move forward and downward from the normal anatomical position. This is known as **anterior tilt** of the pelvis. In most cases the hip joint flexor muscles are shortened and the abdominal muscles are lengthened or severely relaxed.

The opposite of anterior pelvic tilt is **posterior pelvic tilt** in which the hip flexor and the low back muscles are usually stretched while the abdominal and hamstring muscles are shortened. Posterior tilt is not as common as anterior tilt and is rarely brought about by lack of muscular strength. Both anterior and posterior pelvic tilt place the lumbar vertebrae in potentially dangerous positions because of increased disc pressure and a change in the line of gravity of the trunk.

In **scoliosis** there is excessive lateral curvature of the spinal column. If the curvature is relatively minor you can do exercises to stretch the concave side and strengthen and shorten the convex side of the curve. This usually brings about straightening of the spine. If there is also rotation of the vertebral column, the affected abdominal oblique or erector spinae muscles must be strengthened.

Kyphosis is an exaggerated anterior-posterior curvature of the upper spinal column. It occurs most frequently as excessive forward bending of the thoracic area and is seen most often in older adults. It is usually associated with osteoporosis and osteoarthritis and can result in the hunchback position. It also appears to be occurring more often with younger adults as a result of poor posture and doing excessive amounts of crunches through a shortened range of motion.

The term **flat-back** is used frequently in conjunction with a kyphotic condition since the exaggerated curvature of the thoracic spine creates a reduction in the natural lumbar curvature. The flattening that occurs creates a posterior tilt condition of the pelvis.

This posture is also being seen more frequently in people who do excessive amounts of short range crunches or other abdominal exercises and who also have poor posture. The flat back may also be due to personal trainers who constantly tell their clients to maintain a flat back.

Round shoulders is a condition sometimes associated with kyphosis of the thoracic vertebrae, but it is not the same condition. A round shoulder condition is technically abduction or protraction of the scapula. This creates a “hollow” chest condition. You can have abducted scapulae without having a kyphotic condition or you can have both conditions.

Role of Posture in Athletic Performance

Because little attention is given in the early years to determine what effect physical activity will have on an athlete’s joints, growth cartilages and their component structures, most people have some deviation in their body alignment. As a result, the body doesn’t work at maximum efficiency.

It is analogous to a machine. When a machine is properly aligned, the working parts act efficiently, and with care it will last much longer than one that is out of alignment. In a misaligned machine, wear and tear on the bearings increases, and stress and strain on the working parts produce general depreciation. Since our bodies are like machines, when an excellent performance is desired it is essential that you pay attention to the alignment of your body parts. Proper maintenance of alignment is effected by the balance of all the muscles acting on any joint or body part.

When there is faulty posture, it indicates a shift of a body segment in relation to the other segments. In addition, there is a shift in alignment in relation to the normal gravitational line in which all body segments are lined up properly so that undue stress does not fall on any one particular joint.

When there is misalignment, stress is placed on specific joints. For example, if your shoulders drop forward, your head goes back and your pelvis rotates to the rear. If you constantly lean to one side, your spine curves and your pelvis tilts sideways and your spine curves to the opposite side, and gives the appearance of a low shoulder. Thus, if you assume and maintain an out-of-line position, it will require that your body undergo compensatory adjustments in the controlling ligaments and muscles. In other words, by having one body part out of alignment, another body part must likewise get out of alignment to balance it.

Keep in mind that to maintain a stable position for good body function, approximately 75-80% of the work of the muscles is involved just to attain and maintain joint stability. This is indicative of the importance of maintaining good posture for good body function.

A high development of the agonist-antagonist function is essential to the development of coordinated, skilled movement. The agonist may be responsible for initiating and continuing a movement but an antagonist controls the speed, range and force of the action of the agonist.

This is true of the main muscles involved and of all the muscles acting as stabilizers of the joints. Included here are the muscles that stabilize or hold the joint of the non-movement part in place to allow for movement at the other end of the muscle. There must be a good balance between the opposing muscles.

When you have faulty posture, the normal length of the opposing muscles is changed so that if one is shortened, its opponent must be stretched or lengthened. Therefore, any skill that you execute is affected by the performance of these muscles. When there is faulty posture, it will not be a normal movement.

For example, if you have round shoulders, you may have adaptive shortening of the pectoralis major and the serratus anterior and tight anterior shoulder joint ligaments. The opposing muscles, the mid-lower trapezius and rhomboids are overstretched. Thus the scapulae not only swing apart, but rotate, lowering the tips of the shoulders. Consequently, the more muscle mass that is developed, the greater is the force applied to the joint. Because of this, the stress on the joint increases and the imbalance is increased even more.

There are two factors that operate in round shoulders. The first is that your arm weight and head weight fall forward of the line of gravity. Therefore, they must be compensated for by an increase in the dorsal curve of the spine. This in turn must be balanced by a forward position of the pelvis and increased lumbar lordosis (arching). Such a shift of body weight onto the forefoot tends to increase pronation and foot arch depression.

Second, all arm work, as for example, in the shot put, discus, javelin, baseball pitching, golf swing or when executing an exercise such as the bench press or dumbbell fly, will show decreased efficiency because the weakened rhomboids have become long and the pectorals short. As a result, your arm cannot be moved back through the maximum shoulder joint range since the contractile length of the pectoralis major will not allow it.

Deficiencies can also be seen in the shoulder girdle rotation as for example, when twisting with a barbell on the shoulders. The reason for this is that the spinal column cannot rotate most effectively on a “straight” axis because the spine is now bent. Thus

more attention should be given to the antagonist musculature instead of only trying to develop the agonist. You must restore the muscle balance. This is essential to arm and shoulder girdle performance.

In the lumbar area, you must strengthen the abdominals, especially the internal and external obliques, which are mainly responsible for shoulder rotation forward and flattening the abdominal wall. In addition, you must stretch and strengthen the erector spinae by doing back raises to a position above level.

You can also do the reverse sit-up and reverse trunk twist to stretch the erectors even more and at the same time strengthen the abdominals. Other muscle group pairs should be corrected in a like manner if there is any imbalance.

The key to having a well aligned and balanced body is to have the muscles (agonists) on one side of the joint developed in proportion to the muscles on the other side of the joint (antagonists). Only in this way will the muscles keep your joints in their natural state and not allow any deviations to occur. Not only will you feel better when you have this development, but you will also look better and perform more efficiently.

Tonus

Tonus typically refers to hardness or softness of the muscles. A person with good tonus typically has what can be considered “solid “ muscles. This means that when you touch or palpate a muscle or put your hand around someone's muscle you can feel substance to it. A person with little to no tonus typically shows a lack of any muscle density. When you put your hand around a muscle you hardly feel the muscle and you can often feel the bone under the muscle.

Muscular tonus is associated with blood circulation and economy in movement. When there is improper alignment, it results in additional muscular effort and strain, especially since it creates rotary movements at the various joints. If excess muscular effort is sufficient to produce fatigue, it can eventually affect your health. In more severe cases the strain on the joints can be sufficient to alter structure. There is also evidence to indicate that chronic strain contributes to the development of arthritic types of ailments in later life. Such alterations mean limited use of body parts and continued fatigue and strain.

The Spine

The spine is the keystone of body structure. It must support the weight of the head, trunk and upper extremities. In addition, it is the solid point of attachment for most of the muscles, anchoring and controlling the pectoral-shoulder girdle as well as the latissimus dorsi and other muscles of the back that move the arm. These functions require a strong, well-supported spinal unit.

In addition, the spine encloses and protects the spinal cord and the nerves which lead to and from it. Because of this, the spine should be firm, carefully articulated and not too flexible. You should be able to maintain the four natural curves of the spine at all times during exercise and when not exercising.

The ROM in the spine will vary from person to person, but there should be approximately 30-40 degrees of spinal flexion forward and 15-20 degrees of spinal extension to the rear. Going beyond these limits is usually indicative of excessive flexibility, which leads to additional spinal problems unless you maintain good strength of the erector spinae muscles.

Note that when you go beyond these limits the pelvic girdle must also be involved. The combination of pelvic girdle rotation and spinal flexion, extension or lateral flexion can produce a very wide range of motion. This in turn begins to involve other muscles and control features regarding coordination and timing.

The Feet

Seemingly small, insignificant deviations in the feet can lead to major changes in the entire body. For example, if your feet are not sufficiently strong to keep your body equally balanced and your shins in line with the feet, it can change the positioning of the knees, which, in turn, affect the hips, which, in turn, affect the spine, which can then affect head position.

Each joint will then be limited in the actions that it is capable of, especially when the deviation is coupled with tight muscles on one side and weak muscles on the other. This is a very important point that must be taken into consideration at all times. It often explains why someone is not capable of doing a particular movement or executing a particular sport skill.

Even being able to balance your weight has a very profound bearing on the feet. How the feet and legs are used in activities such as running is directly related to the influence of the joints, ligaments and muscles in the limbs above it. Thus, if there are any problems in the lower body it will affect the upper body and vice versa.

For example, many athletes, including bodybuilders, have a lateral tilt of the pelvic girdle. This usually occurs to compensate for deviations above or below the pelvis. Studies have shown that up to 50% of individuals can have a lateral tilt of the pelvis of one-fourth inch or more. It can be caused by having one arch of the foot lower than the other, greater angulation of the knee on one side, an increase or decrease in the angle on the neck of the femur, (the angle that the bone runs from the hip to the knee in a normal standing position).

It may also be due to rotation of the femoral shaft, which can have the knee pointed outward or inward and the size and shape of one ilium, (the bone on the sides of the hips) as compared with the opposite one. Wearing special insoles and doing specialized strength exercises for the feet, can go a long way to correcting foot deficiencies and producing more effective functioning of the lower body. Asymmetry and tilting of the pelvis will result from asymmetrical muscle lengths and a tilt in both hip axes, which produce an eccentric action between the two joints. The transmission of weight and forces acting on the legs and feet will be different. Consequently, the wear and tear on the ligaments and joints will be different.

The Pelvis

Even more common among bodybuilders and athletes is a forward tilt of the pelvis, i.e., when the upper pelvis drops forward, resulting in excessive arching of the lower back. If this is coupled with a slight lateral tilt of the pelvis, there is torsional force from the twisting of the spinal column. When this occurs, one hip socket as well as one side of the hip will be further forward than the other. In this case, the hip joint flexor muscles will be shortened and the lower back muscles will be tightened.

Excessive arch in the lower back can be the result of low back problems or the result of deviations of the pelvic girdle. The pelvis and spine are so inter-related that it is almost impossible to say which is primarily at fault in causing any particular problem. However, note that the vertebral column is flexible and often compensates for any pelvic faults by changing position in corresponding planes so that in a well-muscled person these changes can be easily overlooked.

An increase in the forward tilt of the pelvis in relation to the adaptive shortening of the hip flexors and the lower trunk extensor muscles, upsets the normal antagonism in the forward and backward direction. But this antagonism must be brought into a balanced action for the best performance when lifting weights.

In this case, shortening the abdominals in front and the gluteals in back are essential to attaining the best position of the pelvis in relation to the trunk. Also, stretching the hip flexors by doing the lunge exercise as previously described, assists greatly in correcting pelvis position.

In addition, the hip lifting action of the quadratus lumborum and latissimus dorsi hold the leg on the same side up during the swing phase in walking and running. At the same time the rotational action of the internal and external obliques brings that side of the hip forward.

Not only must the one side be pulled forward but the alternating action of the opposite oblique muscle must relax enough to allow the serratus anterior and the shoulder girdle to be rotated backward. The balance of these trunk muscles is a vital element in all motor movements.

When there is any pelvic asymmetry structurally, there cannot be a symmetrical action of the lower trunk muscles because of the torque in the pelvis and the compensatory curvature and torque of the spinal column. The latissimus dorsi, quadratus lumborum, iliopsoas and abdominal obliques are all affected, and there will be an imbalance in the length and strength of the contralateral muscles.

Explosive and Plyometric Exercises

Explosive and plyometric exercises have been gaining in popularity in recent years. However, how these exercises should be executed and the reasons for their inclusion in the strength training program vary tremendously and are often misleading. For example, it is not uncommon to hear that one should use explosive or plyometric training to:

1. Get more variety in a strength training program,

2. Increase your levels of strength,

3. Develop greater power, and

4. Become faster and more explosive in your movements.

With so many "benefits", it is not surprising to see more and more people using so-called explosive exercises. However, close examination of what constitutes a plyometric or explosive exercise will tell you that doing such exercises does not increase strength.

Plyometric exercises do, however, increase power and you can get faster and quicker from doing plyometric and explosive exercises. But to gain these benefits, the plyometric or explosive exercises must be done after you have gained a sufficient level of strength. For more information on such exercises see *Explosive Plyometrics*. If you carefully observe how plyometric and explosive exercises are done you will see that there are major differences between them and strength exercises. Some variants produce positive results and some negative results. There has also been an increase in the number of injuries experienced by participants some types of plyometric training because of the way the exercises are done.

Understand that plyometric and explosive exercises are not simple exercises that can easily be incorporated into a strength training program. They require very precise instruction and must be executed within certain parameters. For example, most plyometric exercises involve jumping. As a result, many people do jump exercises but call the exercises plyometrics.

However, even though plyometrics usually involves jump exercises, not all jumps are plyometric. There are major differences between these two types of training! Jump exercises are a very specific type of exercise just as are plyometric or explosive exercises.

Even the terms explosive training or explosive exercise does not appear to have one meaning. For example, many trainers equate power training (which is used synonymously with explosive training) with the lifting of a maximum weight very slowly. Others use power training to mean the lifting of a sub-maximal weight with great speed. Thus we see the same terms used for diametrically opposed weight lifting exercises.

In some magazines and web forums you can read how an exercise can be done explosively when handling a very heavy weight. In these cases the term “explosive” is used to mean contracting the muscle as quickly and as forcefully as possible, i.e., you literally explode as you lift the weight. But, because the weight is so heavy, the movement is very slow.

On the other hand, some trainers use explosiveness to mean maximum quickness in executing a movement. This term is most commonly used to describe exercises such as the snatch and clean and jerk and the power clean. Explosiveness is also used to describe various jump exercises.

Thus, in the popular literature, it can safely be said that all jump exercises are considered to be plyometric. Explosive training usually relates to overcoming maximally heavy weights very slowly as long as you try to lift as quickly as possible. Power training is used synonymously with explosive training.

Most often power training refers to lifting a maximal weight slowly which is really a pure strength move. Because of this, I now use the term speed-strength or explosive training which is synonymous with power and plyometric exercise but only according to the definitions given below.

If you closely examine the scientific definitions for power, explosiveness, plyometric and speed-strength, you will see that they are all basically the same. Power is the amount of work done per unit of time. The faster the work is executed the greater the power. This is also the key to explosive training, i.e., development of maximal power in the shortest amount of time, or the greatest amount of force developed in the shortest amount of time.

True plyometrics is also known as the shock method as originally created by Dr. Yuri Verkhoshansky of the former Soviet Union. According to Dr. Verkhoshansky, when a jump is executed it must be executed in .20 seconds or less. This means that the landing and take-off must be extremely fast, similar to the technical definitions of

power and explosive training. Thus power, explosive and plyometric training require a combination of strength and speed. For more information on this topic read my book *Explosive Plyometrics.*

In the fitness field, however, it appears that many writers in the popular literature think up their own terms for the particular type of training that they are espousing. They use terms that sound impressive as opposed to using the definitions that have already been established in science and are well recognized. Staying with well-established terms and definitions would avoid a great deal of confusion.

Instead, however, as more articles are written, there is a greater amount of confusion created. This is seen not only in the use of the terms power, explosive, and plyometric but also the names of particular exercises, as for example, car crash, weighted cork screw and toe pulls. With every author creating his own terms it will soon be impossible to agree on not only how an exercise should be done, but which exercise is being discussed and how it should be executed.

Physiological and Biomechanical Factors

Power, explosive, plyometric or speed-strength exercises (according to their scientific definitions) involve some or all of the same biomechanical and physiological mechanisms. For example, in jumping, the magnitude of the forces generated on the landing from a jump up in the air depends on the distance you travel before touchdown. In this case gravity is the force that accelerates you toward the ground.

When receiving a moving object, as, for example, a medicine ball, the magnitude of the force when you first make contact with the ball depends upon the velocity of the ball (speed with which the ball is traveling). In this case since the ball is moving faster horizontally than downward, gravity is not a major force with which you must contend.

When catching a medicine ball you must be able to handle the force generated by the velocity of the ball or momentum if you also consider the weight of the ball. The greater its initial acceleration and the less the distance that the ball must travel the greater is the force you experience at contact. The further the ball travels the more gravity pulls down on it and the greater the air resistance. As a result the ball slows down before reaching you.

In jumping, the ground reaction forces as well as the amount of time it takes in the transition from the down to the up phase (landing and take-off) varies greatly among the different types of jumps. In general, the faster the transition, the higher will be the jump. This is the main reason for including true plyometric jumps in training for explosiveness.

In a simple, relatively easy lead-up type plyometric jump you generate the least amount of force and muscle loading on landing; examples of this are easy hops, skips and jumps as seen in children's games. These jumps have the lowest height of drop down and the height attained after take-off is low. In addition, landing and take-off time is much longer than in an explosive jump in which the transition time is very short. When receiving a moving object, the reaction forces of your body and arms depend upon the eccentric strength of your muscles to stop the moving ball and to repel it. It is the same as in a landing from a height. The amount of time it takes to transition from receiving to throwing the ball will vary depending upon how fast the ball was traveling, how heavy the ball is, and how capable you are of receiving and returning the ball.

In addition, you will need high levels of neuromuscular coordination to catch and throw the ball back as quickly and as forcefully as possible. Recall that all skills have a neuromuscular base. To improve them takes more than just improving the physical qualities.

The Stretch Reflex

The elasticity of the muscles and tendons is used to a great extent in athletics and in strength training to handle more weight and to enhance fast and explosive movements. For example, when doing the bench press as the weight is being lowered the muscles involved undergo a strong stretch (eccentric contraction). The muscles become greatly tensed as they are stretched in the contraction.

As a result, when the bottom position is reached, there is a great amount of energy stored. To utilize it you must quickly reverse directions and push the barbell back up in the concentric mode. If you stop in the bottom position, the tension (energy) in the muscle decreases (turns to heat) and you then have to develop much more muscle force to push the weight upward.

Making a quick reversal in the bottom position (without bouncing) is indicative of the resiliency of the muscle, which is the key to explosive movements. It is related to the stretch reflex. Resiliency can be thought of as the ability of the muscle to stretch and contract in a smooth and coordinated manner .

However, the amount of stretch is not the critical factor. Most important is the amount of forced tension developed, how quickly it is developed in the stretching action and how quickly you change directions. To better understand this concept of what happens, following is a sequential description of the muscle and joint actions that are involved in jumping.

When you are airborne and dropping down toward the ground, your body has kinetic energy i.e., a force created by gravity pulling you downward. The higher the height from which you start, the faster your speed and force generated on contact with the ground. Keep in mind that your body is accelerating as it drops toward the ground. On touchdown, which should be ball-heel almost immediately, there is some absorption of the landing forces to cushion the landing. But most of the forces experienced must be withstood and returned in order to jump back up. In other words, the accumulated force attained at touchdown is used in for another jump upward. Upon landing the joints undergo flexion and the muscles involved lengthen they develop tension in the eccentric contraction. When the tension becomes sufficiently great, downward movement stops. The muscles switch to a momentary isometric contraction and then to the concentric contraction to propel you up in the air. The tendons play a very important role in this, especially the Achilles tendon of the shin and the tendons on the

bottom of the foot. They are very resilient structures that can withstand and accumulate great amounts of tension when they are forcefully stretched. The energy given back in the take-off can be as high as 60-70% of the landing forces.

When a jump landing and take-off is executed quickly the muscles do not have time to experience a volitional contraction to generate the force for takeoff. The volitional contraction time takes up to 0.6 to 0.8 sec while an explosive, true plyometric jump takes place in 0.15 sec or less! This occurs mainly because of the pretension of the muscles in the eccentric contraction. Without this prior pretension, it would be impossible for you to execute a quick (explosive) jump.

In the landing there is forced loading of the muscles. This happens automatically. To help prepare for the forces generated on landing, you should engage the brain prior to touchdown. In essence, you alert the muscles to prepare for the landing. The brain sends signals to the corresponding muscles and joints so that as soon as touchdown occurs, the muscles, which are already pretensed, can begin to handle the landing forces to prevent you from "sinking" or lowering the body too much.

Keep in mind that the lower the body goes on landing, the longer it takes for the body to come up and the longer it takes for the jump to be executed. In essence, the less the body is lowered the greater is the accumulation of energy and the faster the landing and take-off are executed. This is an explosive or true plyometric jump. Weight exercises can be used in combination with jump exercises or in series with them. They can be used for different purposes and for different emphases on different body areas. For example, the exercises can be used to help improve quick starting actions or to develop explosive strength of the arms, legs or midsection. Explosive or plyometric exercises are not used to develop more strength or muscle mass. In fact, when done correctly true plyometric or explosive exercises will result in less mass but more defined musculature.

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