Making the client bulletproof

By Leith Darkin September 2006

This article is a compilation of three articles that I have written
1) The key ingredients (May 2003) Published in "Strength & Conditioning Coach" Volume 11 (3) 2003
2) A Balanced upper body routine (December 2003) Published in "Strength & Conditioning Coach" Volume 13 (2) 2005
3) A balanced lower body and trunk routine (August 2006)

Abstract

In this article we are going to look at
1) Gravity ane human evolution.
2) Gravity and resistance training.

We are then going to use this information to put together
1) Balanced and functional training routines for the upper body.
2) Balanced and functional training routines for the lower body and trunk.
3) Functional training routines for transversus abdominis.

Gravity and human evolution

"Gravity" a very important contributing factor when it comes to life on Earth. We all know gravity exists, we've all heard the story of the apple that fell from the tree that Isaac Newton was sitting under, but do we really understand or appreciate how important gravity is, how it influences everything we do and how our whole evolutionary process was shaped by gravity.

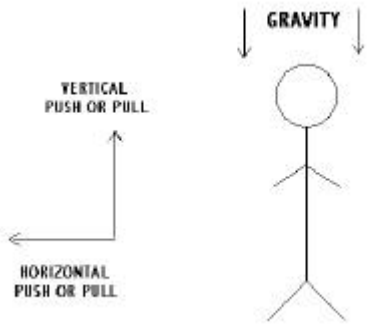
One could say that gravity is the architect of human design, it specifically designed our body so that we could coexist together. Our bones are our bodies main support structure along with transversus abdoninus, this enables us to stand upright, resisting the compressive force of gravity. Our muscles connect to our bones to form a lever system, this allows us to move around freely in the presence of gravity. Our heart is designed to pump blood in an upward direction to the brain resisting gravity, while the veins in our legs have one way valves which are designed to open when our leg muscles contract then close to stop the blood flowing downwards in the direction of gravity. The way in which we consume food and pass waste products is solely reliant on gravity. The position of a fetus in relation to the birth cannel and the actual birthing process are all reliant on gravity. The position of a woman's breasts, the way in which a baby suckles milk from its mother and the direction in which the milk flows are all reliant on gravity.

Another way of examining how important gravity is to human evolution is to examine what happens to humans when gravity is removed.

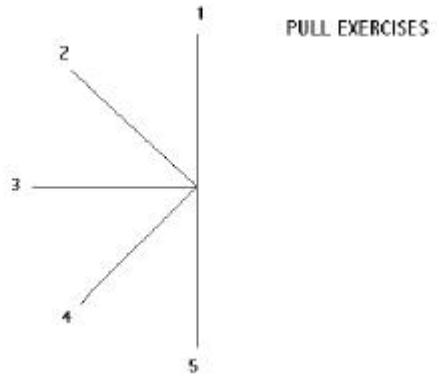
Studies on astronauts in space have revealed that gravity is more than a force, it is also a signal that tells the body how to act. For one thing, it tells muscles and bones how strong they must be. In zero gravity, bones loose density at the rate of 1% a month. Muscles atrophy quickly, because the body perceives it does not need them. Muscle mass can vanish at a rate as high as 5% a week. When astronauts return from long-term stints in space, they sometimes need to be carried away on stretchers as the atrophy of their muscles and loss of strength makes it too hard for them to stand upright in the presence of gravity.
(Gravity hurts by Karen Miller)
Other factors of zero gravity include increased blood pressure in the brain, this results in a 22% reduction in blood volume in the first 2-3 days of zero gravity. With a reduction in blood volume the heart doesn't have to work as hard and results in atrophy of the heart.
(Dr. Victor Schneider, research medical officer for NASA).

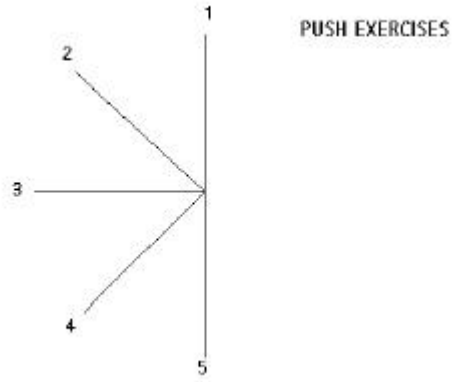
Gravity and resistance training

What is the key ingredient to resistance training? "Gravity" without gravity you could pick up a 100-lb dumbell and throw it around like a tennis ball (astronauts move satellites weighing several tun with one hand). If for some reason gravity's force were to increase then that 100-lb dumbell would weigh considerably more. The next important consideration when it comes to resistance training is "alignment with gravity". When standing in an upright position our alignment is perfect for a superior vertical push (eg. military press) and a superior vertical pull (eg. chin up) however our alignment with gravity is incorrect for a horizontal push (bench press) and a horizontal pull (bench pull). To correct our alignment for our bench press we need to lie supine (horizontal, face up) and for our bench pull lie prone (horizontal, face down).



When looking at compound exercises for the upper body you'll find we have our "superior and inferior vertical push & vertical pull"(1&5), our "horizontal push & pull"(3) and our 45degree variations (2&4). Our 45degree variations amount to cross training between our vertical and horizontal joint angles. In total this gives us five "Push" and five "Pull" exercises.





1) Superior vertical push
2) Incline push
3) Horizontal push
4) Decline push
5) Inferior vertical push

1) Superior vertical pull
2) Incline pull
3) Horizontal pull
4) Decline pull
5) Inferior vertical pull

1) Superior vertical push- shoulder press
2) Incline push- incline bench press
3) Horizontal push- bench press
4) Decline push- decline bench press
5) Inferior vertical push- dips
1) Superior vertical pull- chin-up/lat pulldown
2) Incline pull- incline lat pulldown
3) Horizontal pull- seated row/bench pull
4) Decline pull- 45-degree bent over row/45-degree one arm DB row
5) Inferior vertical pull- upright row

When training the upper body, our five "push" and five "pull" exercises are the nucleus of functional strength training and all other compound exercises for the upper body are variations of our five "push" and "pull" exercises.

When training the lower body and trunk, your functional strength exercises are.

1) The "sit-up" and its variations (To resist gravity and get from a lying position to a seated position we have a sit-up).

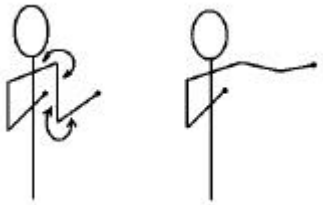
2) The "squat" and its variations (To resist gravity and get from a seated position/squatting position to a standing position we have a squat).

3) The "deadlift" and its variations (To resist gravity from a standing position and bend over to pick up an object off the ground, we have a deadlift).

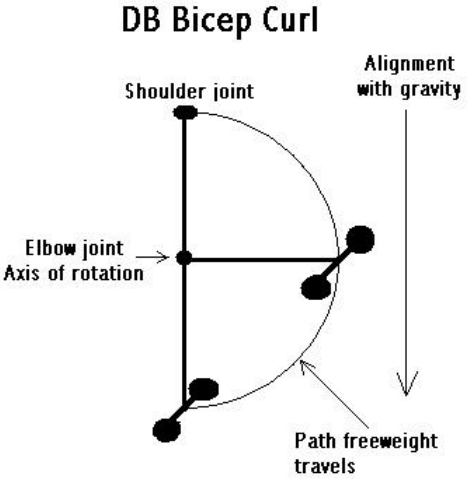
4) The "lunge" and its variations (To resist gravity and walk around in its presence we have the lunge).

What is the difference between compound and isolation and why do we call compound movement "Functional" movement?

There are two types of motion the human body is capable of producing from our lever system.
1) "Angular motion" which is motion that rotates around an axis. An axis in the human body can be a joint between two bones, in which case the movement around an axis is created by the pull from the muscles attached to the bones either side of the joint (the term isolation means movement at one joint).
2) "Linear motion" is motion in a straight line created by compound (multi joint) movement. When looking at the joint mechanics to produce motion in a straight line, you'll find that the individual joint movements are actually created by angular motion (rotation around an axis), however when these individual joint movements are activated in the right sequence, you have movement in a straight line



The above picture is of a person throwing a punch, the punch moves in a straight line (linear motion) however it is created from rotation at the shoulder and elbow joint.
We tend to call compound movement functional movement for the same reason that when we talk about functional strength we prescribe compound exercises. With compound or functional movement we have movement across several joints, producing movement in a straight line. Producing movement in a straight line is what's required to keep alignment with gravity (eg. our five "Push" & "Pull" exercises). With isolation exercises we have movement at one joint, this means that there are stages during the exercise where we lose our alignment with gravity, the problem is, when we lose our alignment with gravity, there is an increase in the amount of sheering force that gravity places on our joints.



The above figure represents a DB bicep curl, you'll notice that the path the DB travels is different to the alignment with gravity. Ideally an upright row would be a more functional movement to raise an external load from the hip to the shoulder, which would maintain alignment with gravity and in turn alleviate the sheering force gravity has placed on the elbow joint.
Compound exercises generally allow the human body to move an external load in alignment with gravity, which in turn alleviates allot of the sheering force that gravity places on our joints, where isolation exercises tend to increase the amount of sheering force that gravity places on our joints.

A balanced upper body routine

When writing and implementing a resistance training program for the upper body, it is important that all muscles are treated with equal importance and that an attempt is made to balance all opposing muscles/muscle groups that surround joints.
From my experience of working in gyms over the years, watching individuals implement their own training routines, looking at programs that other trainers have written, even reading through programs that appear in magazines and books, the majority of focus is placed upon the muscles that are either aesthetically pleasing to individuals, or muscles that

1) Vertically flex and extend the shoulder.
2) Horizontally flex and extend the shoulder.
3) Abduct and adduct the shoulder.
4) Flex and extend the elbow.

(Anterior deltoid, posterior deltoid, middle deltoid, pectoralis major, latissimus dorsi, biceps & triceps)
Generally not enough emphasis is placed upon balancing the muscles that surround and stabilise the scapula (trapezius, levator scap, rhomboids & serratus anterior) and more often than not, additional rotator cuff strengthening is only implemented after a rotator cuff injury.

The Scapula

Over recent times it has been brought to the attention of trainers, coaches and individuals in the medical profession the importance of strengthening "tranversus abdominus" (our trunks main support structure) for individuals with back problems and also as a preventive measure for individuals without back problems (this is largely due to the recent introduction of "Swiss Balls" and the reintroduction of "Joseph Pilates" theories). When looking at the shoulder, it is just as important to strengthen all the muscles that surround the scapula as a preventive measure to help reduce the possibilities of future shoulder injuries, maintain upper body posture or help correct upper body postural problems such as "thoracic kyphosis".
If you were to build a house you would first address the stumps and footings (foundations), if the stumps and footings aren't right then everything from that point onwards will be out. The muscles that surround the scapula are the foundations for shoulder movement; if they are strengthened with a "balanced" program, the humerus then has a firm and stable base to work off of.

There are 6 movements involving the scapula you need to consider when writing and implementing an upper body routine.

SCAPULA MOVEMENT	MUSCLES INVOLVED
Protraction	Serratus anterior
Retraction	Rhomboids & middle trapezius
Upward rotation	Upper trapezius
Downward rotation	Lower trapezius
Elevation	Levator scapulae & upper trapezius
Depression	Lower trapezius

An exercise to produce “elevation” at the scapula would be a “vertical shoulder shrug” however elevation is rarely used in isolation, it is usually incorporated with “upward rotation” likewise an exercise to produce “depression” of the scapula would be a “straight arm dip” (dips done on parallel bars, producing vertical movement of the body at the shoulder joint with arms locked straight at the elbow joint) however “depression” is rarely used in isolation it is usually incorporated with downward rotation.
As “elevation” is more often than not incorporated in “upward rotation” and “depression” is more often than not incorporated in “downward rotation” when writing a balanced upper body routine there are 4 main movements at the scapula to consider
1) Protraction
2) Retraction
3) Upward rotation in conjunction with elevation
4) Downward rotation in conjunction with depression
(1&2 are opposite joint actions and 3&4 are opposite joint actions).

The rotator cuff

The shoulder joint is a shallow “ball and socket” joint, with the head of the humerus (ball) being more than twice the size of the glenoid cavity (socket), being a shallow “ball and socket” joint allows the shoulder to go through more variety of movements than any other joint in the human body, unfortunately being able to go through a large variety of movements compromises its stability.

The head of the humerus is held in place by 4 muscles that surround the head of the humerus attaching it to the scapula, these 4 muscles are known as the “rotator cuff”. These muscles consist of

1) Teres minor
2) Infraspinatus
3) Supraspinatus
4) Subscapularis

When writing and implementing an upper body routine it is also important that the “rotator cuff” muscles are also strengthened equally, as they are responsible for holding the humeral head in place.

MUSCLE	ORIGIN OF MUSCLE	INSERTION OF MUSCLE	MOVEMENT IN ISOLATION	FUNCTIONAL MOVEMENT
Teres minor	Posteriorly on the upper and middle aspect of the lateral border of the scapula	Posteriorly on the greater tubercle of the humerus	External rotation	Horizontal extension & extension
Infraspinatus	Medial aspect of the infraspinatus fossa just below the spine of the scapula	Posteriorly on the greater tubercle of the humerus	External rotation	Horizontal extension & extension
Supraspinatus	Medial two-thirds of the supraspinatus fossa	Superiorly of the greater tubercle of the humerus	Abduction	Abduction
Subscapularis	Entire anterior surface of the subscapular fossa	Lesser tubercle of the humerus	Internal rotation	Adduction & extension

If the sport you are involved in,
1) Relies on complex movements at the shoulder joint such as throwing.
2) Relies on powerful and/or repetitious striking with a bat or racket.
3) Is a contact sport where movement at the shoulder is used to fend off other players or strike opponents.
4) Is a team sport, where at times you have to compete against other players to retrieve a ball from overhead with a straight arm (eg. basketball).
5) Is a contact sport where there is a chance of falling to the ground or being pushed or thrown to the ground.
6) Involves high intensity resistance training for the upper body.
Then additional isolation resistance training, specifically designed to strengthen the rotator cuff should be considered.

Isolation exercises to strengthen the external rotators (teres minor and infraspinatus).
Progression 1 External rotation from adduction where the humerus is braced firmly against the body (with the use of either rubber tubing, cables or dumbbells).
Progression 2 External rotation from 45 degree abduction (with the use of either rubber tubing or cables). As the humerus is no longer braced against the body a stability component for the shoulder is now added to the exercise.
Progression 3 External rotation from 90 degree abduction (with the use of either rubber tubing or cables). As the humerus moves further away from the body an even greater stability component for the shoulder is added to the exercise.

Isolation exercises to strengthen the internal rotators (subscapularis).
Progression 1 Internal rotation from adduction where the humerus is braced firmly against the body (with the use of either rubber tubing, cables or dumbbells).
Progression 2 Internal rotation from 45 degree abduction (with the use of either rubber tubing or cables). As the humerus is no longer braced against the body a stability component for the shoulder is now added to the exercise
Progression 3 Internal rotation from 90 degree abduction (with the use of either rubber tubing or cables). As the humerus moves further away from the body an even greater stability component for the shoulder is added to the exercise.

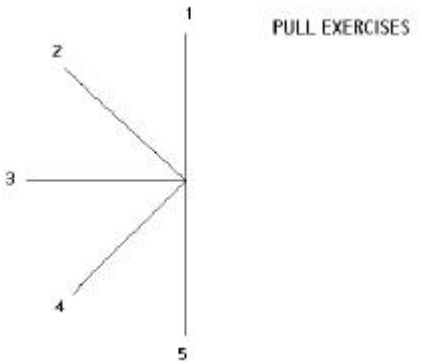
The isolation exercise used to strengthen supraspinatus is scaption; this exercise is best performed with dumbbells.

Scapulohumeral rhythm

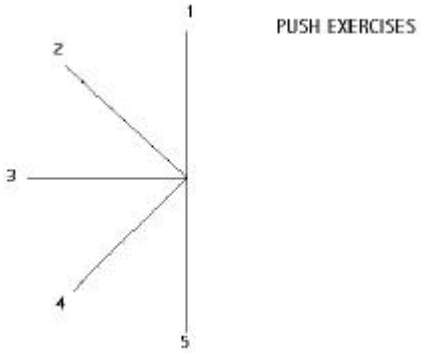
The scapula and the humerus are an inseparable team, working together to produce set movement patterns at the shoulder (scapulohumeral rhythm)
Ie. if the humerus is in horizontally flexed, the scapula is protracted or if the humerus is horizontally extended the scapula is retracted etc.
The next 2 table's lists our five push exercises and our five pull exercises along with the movement patterns of the scapula, the movement patterns of the humerus and the muscles involved in producing scapulohumeral rhythm

Pull	Exercise	Movement of Humerus	Muscles	Movement of Scapula	Muscles
1	chin up	adduction	latissimus dorsi & posterior deltoid	downward rotation & depression	lower trapezius
2	incline lat pulldown	adduction & horizontal extension	latissimus dorsi, posterior deltoid & middle deltoid	downward rotation, depression & retraction	lower trapezius, middle trapezius & rhomboids
3	seated row	horizontal extension	latissimus dorsi, posterior deltoid, middle deltooid, teres minor & Infraspinatus	retraction	middle trapezius & rhomboids
4	bent over row	abduction & horizontal extension	anterior deltoid, posterior deltoid, middle deltoid, supraspinatus, latissimus dorsi, teres minor & infraspinatus	upward rotation, elevation & retraction	middle trapezius, upper trapezius & rhomboids
5	upright row	abduction	anterior deltoid, posterior deltoid, middle deltoid & supraspinatus	upward rotation & elevation	upper trapezius

5 PULL EXERCISES



5 PUSH EXERCISES



Push	Exercise	Movement of humerus	Muscles	Movement of scapula	Muscles
1	over head press	abduction	anterior deltoid, posterior deltoid, middle deltoid & Supraspinatus	upward rotation & elevation	upper trapezius
2	incline bench press	abduction & horizontal flexion	anterior deltoid, posterior deltoid, middle deltoid , supraspinatus & pectoralis major	upward rotation, elevation & protraction	upper trapezius & serratus anterior
3	bench press	horizontal flexion	anterior deltoid & pectoralis major	protraction	serratus anterior
4	decline bench press	adduction & horizontal flexion	anterior deltoid & pectoralis major	downward rotation, depression & protraction	serratus anterior & lower trapizius
5	dips	adduction	anterior deltoid & pectoralis major	downward rotation & depression	lower trapezius

Writing a balanced program

Now we have a better understanding of “scapulohumeral rhythm”, the importance of strengthening all the muscles that surround the scapula, as well as a better understanding of the “rotator cuff” and how it attaches the humerus to the scapula, writing a balanced upper body routine is as easy as combining (1&3 push and 1&3 pull) or (3&5 push and 3&5 pull) or (2&4 push and 2&4 pull). Using the above three variations balances all the muscles that surround the scapula, balances all the rotator cuff muscles and balances all the muscles that flex and extend the elbow joint. When looking at the main muscles that move the humerus (not including the rotator cuff) you’ll find that when using (1&3 push and 1&3 pull) there is slightly more emphasis on muscles posterior to the shoulder (posterior deltoid & latissimus dorsi) and using (3&5 push and 3&5 pull) there is slightly more emphasis on muscles anterior to the shoulder (eg. anterior deltoid & pectoralis major), however the slight discrepancies can be over come by cycling your training. (2&4 push and 2&4 pull) balances all the main muscles that move the humerus.

Suggestions for cycling your program

Variation 1

Macro cycle 1 consisting of 4-8 weeks 1&3 push and 1&3 pull
Macro cycle 2 consisting of 4-8 weeks 2&4 push and 2&4 pull
Macro cycle 3 consisting of 4-8 weeks 3&5 push and 3&5 pull

By the end of the third macro cycle, most slight discrepancies in the muscles that move the humerus will be balanced up.

Variation 2

Macro cycle 1 consisting of 4-8 weeks 2&4 push and 2&4 pull
Macro cycle 2 consisting of 4-8 weeks 1&3 push and 1&3 pull
Macro cycle 3 consisting of 4-8 weeks 2&4 push and 2&4 pull
Macro cycle 4 consisting of 4-8 weeks 3&5 push and 3&5 pull

In variation 2 we use (2&4 push and 2&4 pull) as the nucleus of our training as there are no discrepancies in the balance of the main muscles that move the humerus and we alternate between (1&3 push and 1&3 pull) and (3&5 push and 3&5 pull). Once again by the end of the fourth macro cycle, most slight discrepancies in the muscles that move the humerus will be balanced up.

Variation 3

If you were to incorporate a split routine into your training, you again use 2&4 push and 2&4 pull as the nucleus for your program and combine it with our other 2 variations.

Macro cycle 1 consisting of 4-8 weeks (2&4)&(1&3) push for workout A and (2&4)&(1&3) pull for workout B.
Macro cycle 2 consisting of 4-8 weeks (2&4)&(3&5) push for workout A and (2&4)&(3&5) pull for workout B.
Once again by the end of the second macro cycle, most slight discrepancies in the muscles that move the humerus will be balanced up

Technique

When looking at our 5 push exercises you'll find that generally there is little or no problem with technique. Push exercises 2, 3 & 4 are performed on a bench which holds the body in the correct position while we push an external load away from our body, keeping alignment with gravity. The further we push the external load away from our body the weaker we become, this in turn places greater emphasis on technique to maintain correct alignment with gravity (for push exercise 2 & 4 the bench should be set at 45 degrees). With push exercise 1 the body is in the vertical position while pushing an external load over head (this can be done either standing or in the seated position), once again the further the external load is pushed away from the body the greater the emphasis is on technique or the individual will lose control of the weight or fall over. With push exercise 5, the body needs to be vertically aligned with gravity, however this exercise is often performed with the body leaning forward and therefor should be corrected.
When looking at our 5 pull exercises you'll find that there is a greater likelihood of problems with technique, there are 2 main reasons for this.
1) More often than not exercises are performed without a bench or chest support to hold body in a fixed position, the emphasis is then on the individual to maintain correct body alignment and to keep the external load aligned with gravity.
2) The closer we pull an external load to the body the stronger we become, this means that when finishing our concentric contraction we can slightly change our alignment with gravity and or get some active trunk movement to assist in getting out those last few reps.

Pull exercise 1) Keep body vertical at all times with no swinging of the torso (if performing chip-ups), make sure the movement at the scapula is downward rotation and depression with no retraction.

Pull exercise 2) Keep upper body alignment at 45 degrees at hips and maintain neutral curvature of the spine (the curvature of the spine should be the same as in the standing position).

Pull exercise 3) Keep upper body vertical at all times through out movement (if performing a seated row) and make sure the movement at the scapula is retraction with no elevation.

Pull exercise 4) Keep upper body alignment 45 degrees at hips and maintain neutral curvature of the spine (the curvature of the spine should be the same as in the standing position). If the load you are attempting to lift is too heavy for you to maintain the correct body posture, you should consider one of the alternative exercises in the next section "EXERCISE VARIATIONS"

Pull exercise 5) Keep body vertical at all times, no hyperextension of the trunk at end of concentric contraction.

Exercise variations

1 - PUSH standing military press, behind neck press, DB shoulder press.
2 - PUSH incline BB bench press, incline DB bench press.
3 - PUSH flat BB bench press, flat DB bench press.
4 - PUSH decline BB bench press, decline DB bench press.
5 - PUSH dips, bench dips.

1- PULL chin up, lat pulldown.
2 - PULL 45 degree lat pulldown, 45 degree chin up (feet flat on ground, body completely straight on 45 degree angle while maintaining neutral curvature of the spine).
3 - PULL seated row (unsupported), seated row (with chest support), bench pull.
4 - PULL BB bent over row (upper body 45 degrees at hips), 45-degree supported t-bar row, t-bar row (upper body 45 degrees at hips), 1 arm DB row (upper body 45 degrees at hips).
5 - PULL BB upright row, DB upright row.

Three common misconceptions

"Dips" are a triceps exercise. Yes dips involve the triceps, however, lets say you used 1&3 push and 1&3 pull as your compound upper body routine, then you add an additional isolation exercise for your biceps and "dips" for your triceps. As you have added an isolation exercise for your biceps you should add an isolation exercise for your triceps, using "dips" for your triceps means that there is now additional use of your lower trapezius, pectoralis major and anterior deltoid which has now unbalance your routine.

Because “seated row” and “chin ups” involve the back (latissimus dorsi), I can “bench press” 6 sets, “chin” 3 sets and “row” 3 sets.
Yes “seated row” and “chin ups” involve the back (latissimus dorsi) however if you have 6 sets of protraction (bench press) you need 6 sets of retraction (seated row).

“Shrugs” are great for building your traps. Partly true, however there is more emphasis on levator scap than your upper trapezius, your upper trapezius is more of an upward rotator rather than an elevator. If you are going to incorporate vertical shrugs (elevation) into your training you will need to add a straight arm “chins” or “dips”(depression) into your training to balance your opposing muscle groups.

A balanced lower body and trunk routine

I found that identifying the five push and five pull movement patterns, then using them to put together a balanced upper body routine was quite simple, but to be honest, when I initially took on the task of attempting to do the same for the lower body and trunk I nearly gave up due to the complexity of some of the muscle groups.
Most of the hamstring muscle group crosses two joints and therefore is responsible for two movements, the primary function of the hamstrings is to flex the knee joint, where the secondary function of the hamstrings is to extend the hip joint. The lower portion of semitendinosus, semimembranosus and one head of biceps femoris is responsible for flexion of the knee, while the upper portion of semitendinosus, semimembranosus and one head of biceps femoris is responsible for extension of the hip, but only when the knee joint is nearly straight to straight eg jumping, hopping, running, approaching the lockout phase of a squat or regular deadlift, or throughout the full phase of a stiff legged deadlift. Even though the upper portion of the hamstrings is attributed with extension of the hip and the lower portion of the hamstrings is attributed with flexion of the knee, there must be some degree of tension on both ends of the muscles for the muscles to be able to apply force. Most of the quadriceps muscle group only crosses the knee joint and is therefore responsible for knee extension, however rectus femoris has two heads, one of which crosses the hip joint, making it responsible for flexion of the hip.
To make things even more complicated, the quadriceps and hamstrings are opposing muscle groups where the agonists and antagonists actually work together simultaneously to apply force (extension of the knee & extension of the hip). Due to the complexity of these two muscle groups, I decided that the best way to go about this was to go back to basics and have a look at the movement patterns that gravity has bestowed upon us so we could coexist together. In the end I decided on the following four movement patterns as they each play an important role in our every day life as far as functional movement goes and all compound exercises for the lower body and trunk seem to fit into one of the following four movement patterns

1) To resist gravity and get from a lying position to a seated position, we have the sit-up.
2) To resist gravity and get from a seated position/squatting position to a standing position, we have the squat.
3) To resist gravity from a standing position and bend over to pick up an object off the ground, we have the deadlift.
4) To resist gravity and walk around in its presence, we have the lunge.

I next decided to look at all the muscle groups that were responsible for each of the individual joint actions in each of these four movement patterns/exercises, I then put the results into a table where I could analyse what was going on.

Exercise	Muscle groups involved at the trunk	Muscle groups involved at the ankle	Muscle groups involved at the knee	Muscle groups involved at the hip
Sit-up	rectus abdominis & obliques			
Squat	erector spinae & multifidus	calves and other plantar flexors	quadriceps	glute max & hamstrings
Deadlift	erector spinae & multifidus	calves and other plantar flexors	quadriceps	glute max & hamstrings
Lunge		calves and other plantar flexors	quadriceps	glute max & hamstrings

When I first looked at this table a pattern started to emerge, out of these four movement patterns/exercises we had.
1) Calves and other planter flexors (PF) utilised three times.
2) Quadriceps utilised three times.
3) Glute max & the hamstrings utilised three times.

The problem was that the hip flexors didn't come into the equation at all, rectus abdominis (RA) and the obliques were only in the table once and erector spinae and multifidus were only mentioned twice.
I first looked at the hip flexor problem and realised that the only logical way to involve the hip flexors was to incorporate them into the sit-ups, which if you think about it, it makes sense. Over the years I've prescribed the majority of abdominal exercises as isolation exercises to really target RA, which when looking back now, doesn't make sense. RA and the obliques work in conjunction with our hip flexors as a compound exercise (flexion of the trunk & flexion of the hip) enabling us to sit upright, try to sit upright by isolating RA, you cant! It also came to my attention that when performing sit-ups with your feet anchored, not only do you bring your hip flexors into the equation, you also bring your dorsi flexors (the forgotten muscle group) into the equation as well.
If we look at performing 1 set of squats, 1 set of deadlifts, 1 set of lunges and 3 sets of sit-ups with our feet anchored, our table now looks like this.

Exercise	Muscle groups involved at the trunk	Muscle groups involved at the ankle	Muscle groups involved at the knee	Muscle groups involved at the hip
Sit-up	RA & obliques Times 3	dorsi flexors times 3		hip flexors times 3
Squat	erector spinae & multifidus	calves & other PF	quadriceps	glute max & hamstrings
Deadlift	erector spinae & multifidus	calves & other PF	quadriceps	glute max & hamstrings
Lunge		calves & other PF	quadriceps	glute max & hamstrings

Now when we look at the table we have.

1) Dorsi flexors utilised three times.
2) Calves and other PF utilised three times.
3) Quadriceps utilised three times.
4) Hamstrings utilised three times.
5) Glute max utilised three times.
6) Hip flexors utilised three times.
7) RA & obliques utilised three times.

The only problem now is the erector spinae and multifidus are only used twice, initially I thought of throwing in an isolation exercise to solve the problem, however that didn't sit well with me. My belief is, if you are building a functionally strong body you generally don't need to use isolation exercises (though in some instances it may be deemed necessary to introduce your injury preventative isolation exercises into your functional strength training). Once you have built a functionally strong body and you wish to move onto your sport specific training, you then maintain your functional strength and introduce your compound or isolation injury preventive/sport specific exercises. It took me a while before I realised that the missing erector spinae and multifidus movement was in our five pull exercises, exercise number 3 "seated row" or exercise 4 the "bent over row". When combining our upper body training, our lower body training and our sit-ups, everything evens out. To make sure I was on the right path I got out my anatomy books and double-checked all the main muscles that were involved in each of our four movement patterns and found that there are 34 muscles involved in our sit-ups, squats, deadlifts and lunges.

Sartorius, iliopsoas, rectus femoris, tensor fasciae latae, gluteus maximus, gluteus medius, gluteus minimus, biceps femoris, semitendinosus, semimembranosus, vastus lateralis, vastus medialis, vastus intermedius, adductor longus, adductor magnus, adductor pectineus, adductor brevis, adductor gracilis, gastrocnemius, soleus, tibialis posterior, flexor digitorum longus, flexor hallucis longus, peroneus longus, peroneus previs, peroneus tertius, tibialis anterior, extensor digitorum longus, extensor hallucis longus, rectus abdominis, external obliques, internal obliques, multifidus and the erector spinae.

If you were to do 3 sets of sit-ups, 1 set of squats, 1 set of deadlifts and 1 set of lunges, you would find that all these individual muscles are utilised three times. There are 2 additional muscles (gluteus minimus & gluteus medius) that don't fit into my equation and one muscle (biceps femoris) which is only partly utilised. Gluteus minimus and gluteus medius are only utilised once (in our lunges), there role is to stabilise the hip when performing single leg movements/exercises such as walking, running, lunges and single leg squats. Biceps femoris is only partly utilised as it has two heads, one of which crosses the knee and hip joint which is utilised in hip extension and one which only crosses the knee joint which is only utilised in knee flexion, which isn't featured in these exercises. In total there are 36 main muscles listed of which 34 (or 94.5%) of these are utilised evenly over these four movements. Now this method isn't 100% accurate when attempting to write a balanced program for the lower body and trunk, however this method is simplistic and I feel that it is accurate enough for prescribing effective, and functional lower body and trunk routines.

Exercises and their variations

In this section we are going to look at

1) Sit-ups, squats, deadlifts, lunges and their variations.
2) How the variations effect joint angles, alignment with gravity and involvement of muscles.

The joint angles listed in these exercises will vary slightly from individual to individual due to technique variations, exercise range of motions and differences in individual body structures, the point of listing joint angles is to demonstrate how the same muscles are utilised differently in the squat and its variations, the deadlift and its variations and the lunge and its variations.

Squats, deadlifts and lunges

Front squat- In this particular squat the weight is sits anterior to the body, this means the body must stay fairly vertical throughout the exercise to keep the weight over the base of support. This results in

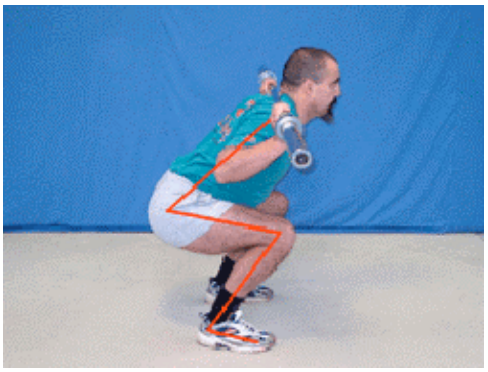
1) A slightly lesser degree of movement at the hip joint compared to a back squat, which results in a lesser contribution from glute max, hamstrings, erector spinae and multifidus.
2) The movement at the knee joint and the involvement of the quadriceps is pretty much the same for all your squatting variations.
3) The movement at the ankle joint and the involvement of the calves and other PF is pretty much the same for all your squat variations.



Ankle joint 64-degrees.
Knee joint 63-degrees.
Hip joint 70-degrees.

Back squat- In this particular squat the weight sits posteriorly to the body which means the participant has to lean further forwards to keep the weight over the base of support (leaning further forwards means that the alignment with gravity is such that there is an increase in stress on the hip extensors and trunk extensors), this results in a

1) A greater degree of movement at the hip joint compared to a front squat, resulting in a greater contribution from glute max and the hamstrings to extend the hip.
2) A greater contribution from the erector spinae and multifidus compared to a front squat, to keep the spine in the neutral position throughout the exercise.
3) The movement at the knee joint and the involvement of the quadriceps is pretty much the same for all your squatting variations.
4) The movement at the ankle joint and the involvement of the calves and other PF is pretty much the same for all your squat variations.



Ankle joint 67-degrees.
Knee joint 65-degrees.
Hip joint 53-degrees

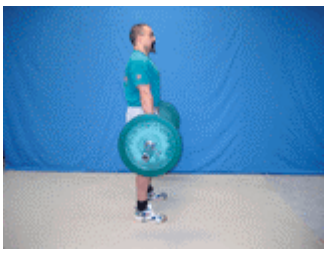
Single leg platform squat- In this particular squat the angles at the ankle joint and knee joint are the same as the joint angles in a front and back squat, where the angle at the hip joint is the same as the joint angle in a back squat, when weight is added the body position remains relatively unchanged so the participant can keep balance and keep the weight over their base of support. As the joint angles in this exercise are pretty much the same as the joint angles in a back squat, the contribution from each of the muscle groups will be much the same except for the erector spinae and multifidus who only contribute minimally until weight is added, even then their contribution will be considerably less than their contribution in a back squat due to the decrease in load that is needed for a single leg exercise. In this exercise there is a huge stability component (which will further increase the intensity) for the calves and other PF, quadriceps, glute max and hamstrings, this single leg stability component also places allot of stress on gluteus minimus and gluteus medius which come into play to stabilise the hip joint.
Key points to the single leg platform squat.

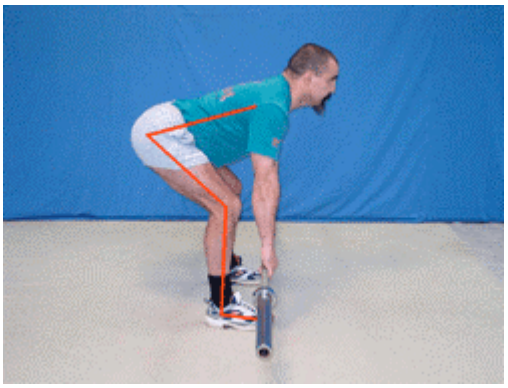
1) Platform squat can be performed on a bench of suitable height or you can make a platform for your power rack. Platform is made from a piece of timber 150-ml wide x 50-ml thick, the length of which is the width of your power rack. Platform is secured with bolts onto 2 pieces of tube or bar, the diameter of which is such that the tube/bar will go through the holes in your power rack where they are fastened to the power rack with locking pins.
2) Height of the platform/bench is the height of your kneecap when your foot is flat on the ground.
3) Lowering the foot to the ground is done in a controlled manner, you only briefly touch the tip of your toe on the ground (your foot does not support your body weight) before you start the concentric phase of the exercise.



Ankle joint 65-degrees.
Knee joint 65-degrees.
Hip joint 55-degrees.

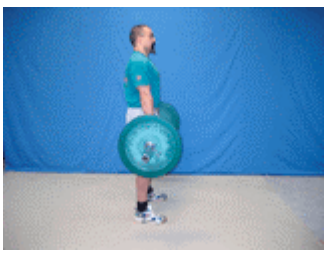
Regular deadlift- In this particular deadlift there is a lesser degree of movement at the knee joint compared to all your squat variations resulting in a lesser contribution from the quadriceps. At the ankle joint there is minimal movement, however there is quite a substantial isometric contraction from the calves and other PF to stop you from falling forwards (as the weight in this exercise is positioned anteriorly to the body). At the hip joint there is slightly more movement than a front squat and slightly less movement than a back squat, however, the upper body positioning at the end of the eccentric phase is almost perpendicular to gravity, in this position the alignment with gravity increases the stress on glute max and the hamstrings to extend the hips and places a considerable amount of stress on the erector spinae and multifidus to keep the spine in the neutral position throughout the exercise.

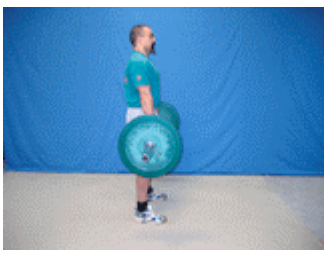


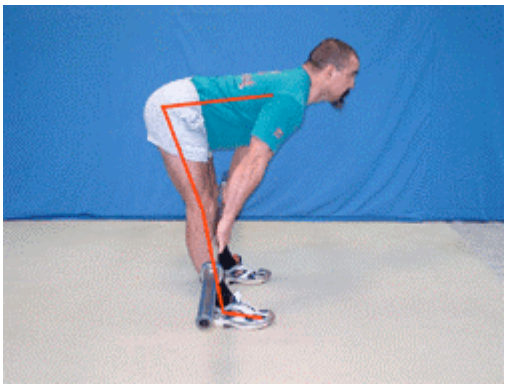


Ankle joint 90-degrees.
Knee joint 130-degrees.
Hip joint 55-degrees.

Stiff-legged deadlift- During a regular deadlift and squat, as you descend, the bending of the knees distributes part of your body weight posteriorly to your bodies centre line of gravity, while the bending of the hips distributes part of your body weight anteriorly to your bodies centre line of gravity, this ensures that your body weight is distributed evenly over your base of support. In a stiff-legged deadlift, the mechanics of distributing your body weight is different as there is no movement at the knee joint, resulting in no contribution from the quadriceps. As you descend into the lift, the bar runs down the thighs (this helps to alleviate some of the shearing force on the spine) as the calves and other PF contract isometrically to stop you from falling forwards, when the bar approaches the knees there needs to be a shift in body weight, as at this point there is too much weight anteriorly to your bodies centre line of gravity, to counter this, the movement at the ankle joint goes beyond 90-degrees to around 110-degrees which now brings your dorsi flexors into play (at this point your bodyweight is over your heels). As you ascend, your dorsi flexors initially contract until there is around 90-degrees at the ankle joint (at this point the bar is around knee height), then your calves and other PF come back into play to stop you from falling forwards as you ascend back to the start position. At the hip joint there is lesser degree of movement compared to a regular deadlift (though this can vary depending on your flexibility and your ability to keep the spine in the neutral position), however as there is no contribution from the quadriceps, glute max and hamstrings do all the work. The body positioning at the end of the eccentric phase is perpendicular to gravity, in this position the alignment with gravity increases the stress on glute max and hamstrings to extend the hips and increases the stress on the erector spinae and multifidus to keep the

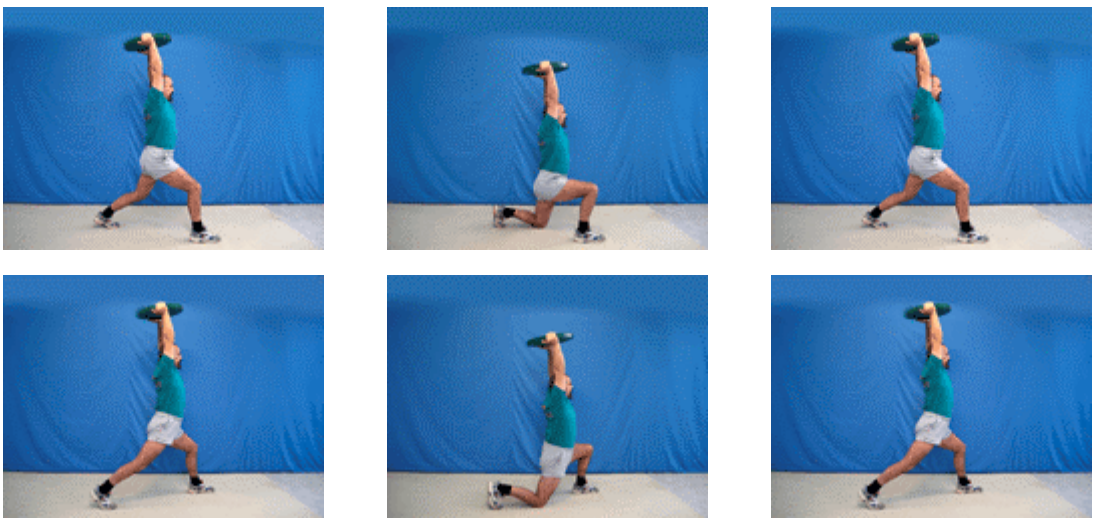






Ankle joint 110-degrees.
Knee joint 188-degrees.
Hip joint 80-degrees

Walking lunge- In this particular lunge there are two noticeable contractions at the ankle joints, an approximate 20-degree contraction at the ankle joint of the front leg, which de accelerates the body through the eccentric phase of the exercise and approximate 30-degree concentric contraction at the ankle joint of the rear leg, which assists in driving your body forwards. The degree of movement at the knee joint and hip joint is approximately the same as all your squat variations, though this can vary depending on how deep you lunge. There are phases in this exercise where only one foot is in contact with the ground, which means gluteus minimus and gluteus medius come into play to stabilise the hip joint. In this exercise there is no load on the erector spinae until you add weight either in the form of a BB placed on the shoulders, DB's held in each hand or a weight disc held over head (these load variations can be applied to all lunge variations), even then the stress on the erector spinae and multifidus is minimal compared to your regular squats and deadlifts as the upper body remains vertical throughout the exercise, aligned with gravity.

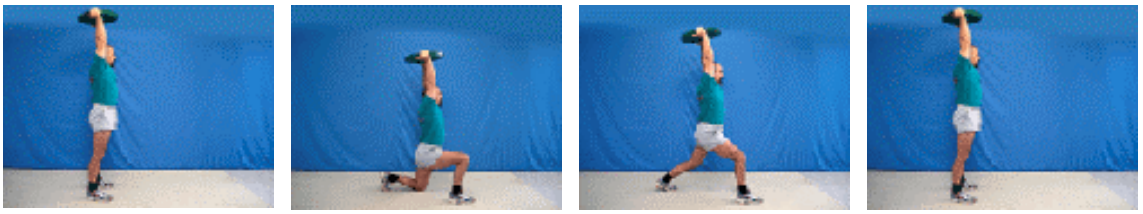


Alternate lunges- In this particular lunge you alternate your feet with each repetition, the joint angles at the knee and hip are the same as your walking lunge providing the depth of your lunge stays the same, this will result in the same contribution from your quadriceps, glute max and hamstrings. The movement at the ankle joint of the front leg goes from around 85-degrees at the end of the eccentric contraction to around 120-degrees at the end of the concentric contraction (around 35-degrees in movement) to assist in driving the body back to the start position.

Other differences between a walking lunge and an alternate lunge are.

1) When you perform an alternate lunge, your planter flexion, knee extension and hip extension in the initial part of the concentric phase, must be performed in a slightly more explosive manner to return your body back to the start position.
2) When you perform walking lunges, the distance you stride is twice that of an alternate lunge, which means a greater contribution from gluteus minimus and gluteus medius to stabilise the hip.
3) A walking lunge better replicates the movement patterns of walking and running.

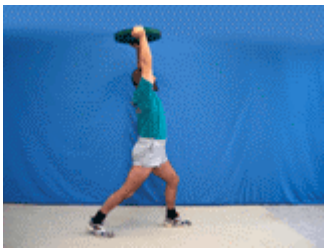
When performing a walking or an alternate lunge, you'll find that the angles at the knee joint and the hip joint will vary considerably depending on the depth of your lunge. The deeper you lunge the greater the stress on glute max, the shallower you lunge the greater the stress on the quadriceps.

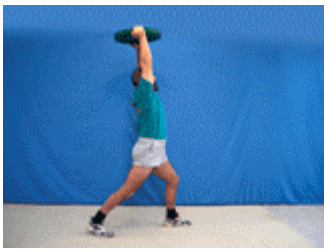


Ankle joint 85-degrees.
Knee joint 82-degrees.
Hip joint 85-degrees

Rear leg lunge- In this particular lunge we are targeting the rear leg, so it is important that you position your body weight directly over the rear leg, to minimise the stress on the front leg. There is approximately 20-degrees of movement at the ankle joint in this exercise which is similar to that of your squats. Ideally there is no the movement at the hip joint on the rear leg, which means there is no contribution from the glute max and hamstrings. At the knee joint of the rear leg there is a considerable amount of movement (more than any other squat or lunge), resulting in a huge contribution from the quadriceps. Like all lunges there is no load on the erector spinae and multifidus until you add weight, even then the stress on the erector spinae and multifidus is minimal compared to your squats and deadlifts as the upper body remains vertical throughout the exercise, aligned with gravity.
Key points to the rear leg lunge

1) Initially you measure the depth of your lunge by aligning the knee of the rear leg with the heel of the front leg.
2) You slightly lean backwards keeping your body weight directly over the rear leg, ensuring that there is a straight line from the wrists (if holding weight over head), through the shoulders, through the hips and down through the knee of the rear leg.
3) This particular lunge is a static lunge; you only work on one leg at a time until you complete your reps, then you swap legs.






Ankle joint 100-degrees.
Knee joint 70-degrees.
Hip joint 180-degrees.

Lunge alternatives- Dragging a sled and using a weighted wheelbarrow are a couple of excellent lunge alternatives, both of these exercises utilise walking and/or running with load. The length of your stride is somewhat shorter that your “walking lunge” and “alternate lunge” (unless you are running), which means reduced joint angles all around. As there are phases in these exercises where only one foot is in contact with the ground, gluteus minimus and gluteus medius come into play to stabilise the hip joint

Summarising the squat, deadlift and lunge

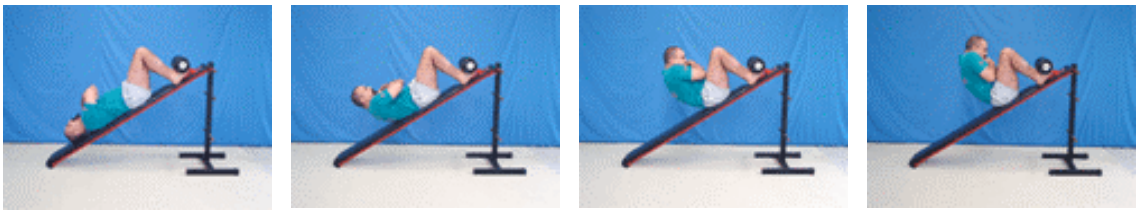
Squat- (Static exercise where the body moves vertically) The movement pattern of the squat replicates being able to stand upright along with jumping vertically. The squat places more stress on the quadriceps than the deadlift and lunge (with exception of the rear leg lunge) and places more stress on the erector spinae and multifidus than the lunge.
Lunges- (Dynamic exercise where the body moves horizontally) The alternate lunge and walking lunge replicates the movement patterns of walking, running and jumping horizontally (when taking off on one leg). The planter flexion at the ankle joint is performed explosively compared to your squats and deadlifts, the single leg stability component brings the hip stabilises (gluteus minimus and gluteus medius) into the equation which aren’t utilised in your regular squats and deadlifts.
Deadlift- (Static exercise where the upper body moves back and forth from vertical to horizontal) The movement pattern of a deadlift replicates lifting. The alignment with gravity at the end of the eccentric phase of the exercise places more stress on glute max the hamstrings, erector spinae and multifidus, than the squat or lunge.
I like to think of the front squat as the most functional squat, the walking lunge as the most functional lunge, the regular deadlift as the most functional deadlift and all other squats, lunges, and deadlifts are variations of these three movements, which can be utilised for variety.

Sit-ups

Sit-ups- In this exercise we are going to use an incline bench and perform sit-ups in either the supine position (bench lying flat on the ground) or in the decline position for those who are more advanced. Using an incline bench brings gravity into to equation, this inturn increases the stress on your hip flexors, RA, obliques and dorsi flexors, the greater the degree of incline the greater the stress on these muscles. Once you reach maximal height on your incline bench, your next progression is to hold a weight to your chest, which will further increase the stress on your hip flexors, RA, obliques and dorsi flexors.

Method 1- Working RA and the obliques isometrically by keeping the spine in the neutral position throughout the exercise, in the same manner that the erector spinae and multifidus are utilised when performing squats, deadlifts and bent over rows.

Method 2- Working RA and the Obliques concentrically and eccentrically by bringing the ribcage towards the pelvis (shortening RA & the obliques) through the concentric phase of the exercise, then moving the ribcage away from the pelvis (lengthening RA & the Obliques) through the eccentric phase of the exercise.



There are literally dozens of different ways to perform sit-ups and other abdominal exercises, this variation of the sit-up where the knees are bent at 45-degrees while the feet are anchored has been around forever and utilises important muscle groups that often don't get utilised in other exercises.

Analysing these four exercises and putting together effective training routines.

Upon first looking at these four movement patterns/exercises it appears that the joint actions and muscle groups involved in the squat, deadlift and lunge are almost identical and the joint actions and muscle groups involved for our sit-ups are complete opposites. This may lead to the belief that you don't need to perform a squat, a deadlift and a lunge in a set training routine/training phase. My belief is if you are building a functionally strong body, or looking at maintaining a functionally strong body, then you need to utilise each of these three movement patterns. Each of these three movement patterns are individual and specific movements that contribute to humans being able to coexist with gravity and although each of these three movement patterns utilise the same muscles.

1) The contribution from each muscle group is different in each of these three movement patterns.
2) The neural patterns that activate these muscle groups are all individually different.
3) Each of these three movement patterns is specific to a different evolutionary task.

When putting together effective routines, you can include.
2 sets of squats, 2 sets of lunges, 2 sets of deadlifts & 6 sets of sit-ups.
Or.
3 sets of squats, 3 sets of lunges, 3 sets of deadlifts & 9 sets of sit-ups.
Or
4 sets of squats, 4 sets of lunges, 4 sets of deadlifts & 12 sets of sit-ups.
If you wish to incorporate either a rear leg lunge or a stiff-legged deadlift into your training, then I would recommend that you put both of these exercises into the same training routine as the rear leg lunge has no movement at the hip joint, where the stiff legged deadlift has no movement at the knee joint. When putting these two exercises into a routine, you would include
2 sets of squats, 2 sets of rear leg lunges, 2 sets of stiff-legged deadlifts &
4 sets of sit-ups.
Or.
3 sets of squats, 3 sets of rear leg lunges, 3 sets of stiff-legged deadlifts &
6 sets of sit-ups.
ETC.

Injury preventative exercises

In our lunge, squats, and deadlifts our hip adductors and hamstrings are both utilised in there secondary role, if you are involved in sports where injuries to the hip adductors and or the hamstrings are common, then you should consider additional isolation exercises to specifically strengthen these muscles in their primary role. These exercises can be introduced in a “general preparatory training phase” and or a “specific preparatory phase” depending on how you rate their relevance.

Knee flexion- Acute, moderate or severe hamstring strains are common injuries among sprinters, hurdlers and long jumpers. They also occur in other sports involving sprinting, especially football and field hockey.
P Coburn (2002).
The involvement of the hamstrings in our functional training is to extend the hips, which primarily involves the upper portion of semitendinosus, the upper portion of semimembranosus and the portion of biceps femoris that crosses the knee and hip joint (even though there is some degree of tension at both ends of the muscle) this means that the lower portion of semitendinosus and the lower portion of semimembranosus doesn’t get utilised as much as the upper portions and the portion of biceps femoris that only crosses the knee joint doesn’t get utilised at all. As the majority of hamstring injuries occur in sports that involve medium to high intensity efforts of sprinting, I would recommend that all individuals who participate in these types of sports to consider incorporating hamstring curls into their resistance training programming.

Hip Adduction- Adductor muscle strains are a common injury in sports that involve sudden changes of direction.
C. Bradshaw (2002).
Concentric and eccentric hip adduction should be considered for participants of sports that involve twisting, turning and rapid changes of direction, although all five hip adductors are utilised evenly in our functional training, they are utilised isometrically in a secondary role of hip flexion, although this contraction can be quite substantial, additional concentric and eccentric training that is more specific to their primary role of hip adduction should be considered.

Gluteus minimus & gluteus medius- Throughout our lower body and trunk training, gluteus minimus & gluteus medius are only utilised in single leg exercises such as walking lunges, alternate lunges, lunge alternatives and single leg squats, this means that these muscles are under utilised compared to the other 34 muscles that contribute to our lower body and trunk training. This deficit can be made up by performing exercises for the upper body while standing on one leg, exercises must be gauged as to their suitability and posture must be maintained throughout the exercises (especially hip alignment). Rotator cuff exercises with thera-bands are an excellent exercise to perform standing on one leg, at the end of the concentric phase, the tension on the thera-band is pulling your body towards the origin of the thera band, this results in a huge stability component for the ankle joint, knee joint, hip joint and transversus abdominis to stabilise the body throughout the exercise. Other isolation exercises for the upper body are also suitable to perform while standing on one leg due to the decrease in load that is needed to perform isolation exercises.

Transversus Abdominus

Over recent years there's been allot of discussion about Transversus Abdominus (TA), in particular, effective ways to strengthen TA. When looking at exercise prescription for TA, we first need to look at how TA works and what TA is designed to do.
TA is the main support system for our trunk, allowing us to stand upright where it resists gravity as a compressive force. TA wraps around our trunk like a corset, attaching either side of our spinal column with the upper portion attaching to the ribs where it works in conjunction with the diaphragm and the lower portion attaching to the pelvis where it works in conjunction with the pelvic floor muscles. As TA contracts, it pushes our intestines and internal organs in an upward direction against our diaphragm and in a downward direction against our pelvic floor muscles which in turn increases our inter abdominal pressure (our core area is now acting like an air shock absorber). The amount of pressure we can build up in our core area is relative to the strength of TA, the greater the strength of TA the greater the intra abdominal pressure that can be built up and just like our car shock absorber, the more air we pump into it, the greater the load that can be placed in the back of the car or in the trailer.

Pilates, swiss balls & freeweights

Although it has been proven that Pilates and Swiss Balls are effective tools for strengthening TA, especially in dysfunctional individuals (individuals with postural problems or injuries), my question is “are these forms of training the most effective way to strengthen TA?” In my opinion “no”. As humans we didn’t evolve over millions of years sitting and lying on Swiss Balls and Pilate machines. Another problem with Swiss Ball exercises, Pilates machines and Pilate floor exercises, is the majority of these exercises are performed in the prone or supine position, this means that the emphases on strengthening TA is to resist gravity as a sheering force to our spine (which would be fine if we walked on four legs). If we take into consideration our principle of training “Specificity”, it would be far more preferable and beneficial to strengthen TA to resist gravity as a compressive force to the spine, seeing humans have evolved to be upright beings. Although another important principle of training “Variety” would deem that a portion of our training to strengthen TA could or should be done in the prone or supine position, the nucleus of strength training for TA should be done standing upright, resisting gravity as a compressive force.
Your more effective and functional exercises for strengthening TA are the overhead presses, upright rows, BB bent over rows, squats, deadlifts, lunges, cleans and snatches, when performing lunges and squats, weight can be held over head to further increase the stress on TA to stabilise the trunk.
Exercises such as dragging a heavy sled and pushing a weighted wheelbarrow are beneficial in developing TA in a dynamic environment, (which is important for contact sports) rather than working TA while standing still.

When not to use a balanced routine

There are going to be instances where clients have a postural problems, or the sports you or your clients are involved in, will predominantly use one type of movement (eg. base ball pitcher), if this is the case, a balanced routine may not be appropriate, in which case a sports physiotherapist will be of help in getting the right balance of exercises.

Conclusion

The objective of this article was to highlight the importance of gravity and how gravity has shaped our evolutionary process, understanding these key points will create a better understanding of what your evolutionary process has bestowed upon us as far as “functional movement”, once we have a better understanding of functional movement, the next step is to put functional movement patterns into a balanced resistance training program that focuses on strength.
A periodised and balanced resistance training program that focuses on functional strength is without a doubt the best way to prepare your body to cope with the stresses of every day life as well as the stresses of your work environment, it also creates a needed base for your sport specific training as well as assisting your body to cope with the stresses of competitive sport.

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