GLOBAL NEUROMUSCULAR ACTIVATION TECHNOLOGY (G-NAT) EQUIPMENT AND EFFECTIVENESS REVIEW

Jeff Collins, M.S., Scott Forman, M.D., MSc., Petras Avizonis, Ph.D.

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1 Introduction

Exercise is an ever increasing area of interest in the medical and health fields with increasing numbers of studies on a yearly basis evaluating new modes of exercise and how to structure exercise to achieve optimum benefits. Maximizing an appropriate training response with minimum amount of recovery is the key to improved performance and reduced risk of injury and overtraining, along the entire continuum of physical conditioning for athletes and non-athletes.

The purpose of this article is to review existing research, as well as, the research conducted at the Welltec Human Performance Lab in Albuquerque, N.M. to test and analyze the effectiveness of Global Neuromuscular Activation Technology™ (G-NAT™) equipment and training.

Four areas were specifically studied: Central Nervous System (CNS) response, balance and stability, metabolic response, orthopedics and joint impact.

1.1 CNS Response Summary

The central nervous system (CNS) is activated when the body is subjected to emotional or physical stress. Looking at heart rate variability, the postural threat position of G-NAT™ exercises (torso off vertical center requiring hand(s) to cling to the device) was found to lead to a sympathetic response. This, in turn, causes increased parasympathetic tone which can reduce the stress response (cortisol secretion)[16] in future similar situations. This similarity to fear of falling (FOF) may also have neuromuscular benefits such as anticipatory postural control (APC)[4,8] which may reduce musculoskeletal injuries and improve athletic performance.

1.2 Balance and Stability Summary

G-NAT™ programming includes movement patterns that significantly increase balance and stability which have been shown to improve athletic performance, including strength, speed and vertical jump, as well as, reduce injury rates for the hips, knees, ankles and low back.[14,21,24,25]

Performing G-NAT Life Movements™: one or both of the feet must be engaged and at least one hand required to grasp the device and hold the body in position. By design the foot support on the G-NAT™ device cannot accommodate the entire foot and the body's center of gravity is kept outside its base of support, creating a postural threat that can be physically confirmed by the CNS. The vertical and angular leverage causes a multitude of constant forces from the feet to the hands, in planes, because the torso cannot be over or pass over the feet and establish equilibrium at any time during a specific movement/exercise.

These G-NAT™ movement patterns are more effective than conventional techniques in eliciting balance and stabilization because of the direction of forces, resulting in improved athletic performance and injury prevention. The fact that the movement patterns are performed in a vertical position that mimics many "real world" activities enhances postural stabilization and proprioception.

1.3 Metabolic Response Summary

A G-NAT™ workout was found to burn an unusually high number of calories during a 6-minute continuous or 24-minute interval exercise session because of the vertical position and the high number of muscles recruited, high intensity interval training and the use of heart rate for work/recovery optimization. Resting metabolic rate increased 57% and 24% 1 hour and 24 hours, respectively, after a G-NAT™ session.

This higher excess post-exercise oxygen consumption or "afterburn" is attributed to the vertical training mode of exercise, program design and intensity levels.

1.4 Orthopedics & Joint Impact Summary

G-NAT™ movements have been shown to reduce knee, low back, elbow, shoulder and ankle pain.[8,11,12,19] These low impact, unloading, decompressive exercises can reduce recurrence and intensity of chronic joint symptoms. There is also strong evidence that range of motion and flexibility is improved which may result in improved athletic performance.

1.5 General Conclusion

Research and review of G-NAT™ exercises and sessions demonstrated several important benefits not found in other exercise modalities.

Typically, several separate modes of exercise are required to achieve the benefits that result from one all-inclusive G-NAT™ session; such as, enhanced balance and stabilization, higher caloric consumption and increased metabolic rate. A 6 minute continuous or a 24-minute interval G-NAT™ session 3 times per week achieve these results while minimizing risks of injury and overtraining, as a result of the closed chain, low impact movements.

2 CNS Response

The CNS studies were done using a Polar rs800CX, R-R recorder and time domain heart rate variability (HRV) analysis on each subject in the Welltec Human Performance Lab.

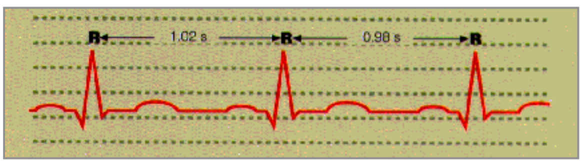

Figure 2.1: HRV diagram, Polar Electro OY 2012

2.1 Overview

The CNS, activated when the body is subjected to emotional or physical stress, is divided into two systems: sympathetic and parasympathetic.

Sympathetic nervous system serves to stimulate body function primarily by systemic means, as in the fight or flight response. An increase in sympathetic stimulation causes an increase in cardiovascular function, including increased heart rate and stroke volume, as well as, systemic vasoconstriction. Sympathetic effects on the heart are carried out systemically by delivery of catacolomines in the blood.

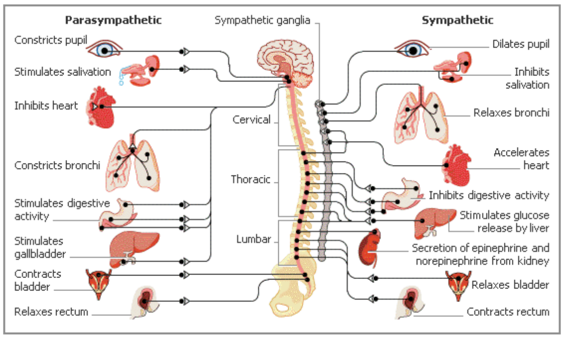

Figure 2.2: Sympathetic and parasympathetic nervous system

Parasympathetic nervous system inhibits or tempers cardiovascular function which presents as a decrease in heart rate, stroke volume and systemic vasodilation. Parasympathetic effects on the heart are carried out locally and almost instantaneously by enervation of the vagus nerve which is in direct contact with the heart.

2.2 Sympathetic, Parasympathetic Activity

Heart Rate Variability (HRV) is a non-invasive and accurate method of measuring sympathetic-parasympathetic activation.[9] HRV indicates the fluctuations of heart rate around its average. If a heart rate is measured at 60 beats per minute (bpm), the times between successive heartbeats is not 1 second but can fluctuate from 0.5 second to even 2.0 seconds and can be analyzed with various algorithms. This study uses the time domain SD1 real time method (RLX).[9]

2.3 Methods

A unique property of G-NAT™ is the ability to stimulate the sympathetic nervous system through a physically confirmed threat, similar to the emotional stress of the fear of falling phenomenon, without a corresponding increase in physical stress. This can occur because the subject is in a vertical position, grasping the handles of the G-NAT™ device with hands and feet forcing the torso in a position that equilibrium can not be achieved.[31] Since equilibrium can not be achieved (postural threat) with one or both feet engaged, one or both hands are required to grasp the device to maintain the body's position. This leverage causes a multitude of constant lines of force from the feet to the hands in vertical and diagonal planes. If one hand or foot is removed from the device during a specific exercise, the diagonal planes change and forces shift. Moving the legs and arms through the exercise's range of motion, tensional lines transition from one to another as fulcrum leverage changes.

G-NAT™ sessions are performed and defined as follows:
6-minute continuous session: An integration of 12 G-NAT Life Movements™ done consecutively with no rest.
24-minute interval session: An interval or 1 minute of each of the 12 G-NAT Life Movements™ with 1 minute of rest between each.

It is well documented that fear of falling (FOF) influences anticipatory postural adjustments (APA) for medio-lateral stability[14] when in postural threat. In previous research the APA was measured using maximal velocity of muscle contraction; the purpose of this study was to measure the entire CNS response to fear of falling using HRV.[9]

2.4 Results

Figure 2.3 shows a sample of an HRV curve during 2 minutes of standing on flat ground; 2 minutes of standing on the G-NAT™ device; 4 minutes recovering standing on flat ground.

Figure 2.3: HRV Response: 2 minute standing on G-NAT

The bracket indicates the RLX response. The lower the RLX, the greater the sympathetic response (depressed parasympathetic response). The decrease in HRV (sympathetic nervous system response) was greatest when the subject was in postural threat on the G-NAT™ device. This occurred during a static, non-exercise state.

This indicates there is a mechanism activating the sympathetic nervous system, causing a response that would not be found with traditional exercise positions. There was no increase in pulse rate, indicating a specificity in sympathetic response.

2.5 CNS Conclusion

This study found that a two, three or four-point position (both hands and feet) on a G-NAT™ device caused a strong sympathetic nervous system response, as measured by heart rate variability (HRV). This decrease in HRV indicates a strong CNS response to the vertical G-NAT™ position.

A fear of falling has been shown to be a factor in APA for medio-lateral stability in previous research.[14] Using HRV, this research suggests the CNS stress response does, in fact, happen when in postural threat on the G-NAT™ device.

This sympathetic response explains the high levels of metabolic consumption and increased motor unit recruitment for balance and stability, both during and after a G-NAT™ exercise session.

In addition, it was observed that while G-NAT™ stimulated the sympathetic system, as measured by HRV, the FOF effect did not elicit Cortisol or Alpha Amylase increases that are typically seen in sympathetic responses. It is recommended to be studied further for additional benefits.

3 Balance and Stability

Balance and stability are an essential part of athletic performance and general fitness and are essential for daily tasks. New ways to maximize balance and control is one of the goals of functional training. Benefits include improved athletic performance, reduced injury rate and increased overall strength.

G-NAT™ increases balance and stability through G-NAT™ specific movement patterns and techniques.

3.1 Definitions

Balance is defined as maintaining equilibrium of the body in static and dynamic conditions. During unloaded static activities, balance is maintained when the body's center of gravity is within its base of support, and stability is the state of that equilibrium.[32]

Stability is the sufficient stiffness in surrounding tissues and appropriate motor control around the joint(s) to resist perturbations in maintaining balance.[21]

Functional Training is integrated, multi-dimensional movement that requires acceleration, deceleration and stabilization in all three planes of motion.[26]

3.2 Overview of G-NAT Movement Patterns

G-NAT™ movements use either two, three or four anchor points on the vertical axis which causes activation of the trunk stabilization muscles. See Figures 3.1 and 3.2.

Remaining vertical while performing the G-NAT™ movements allows gravity to act in a different plane than in typical floor stability movements. A stable core enables the effective transfer or forces between the upper and lower body, maximizing transfer of power and protection of joints or limbs. This is a complex contraction pattern that requires coordination between the musculoskeletal system and central nervous system, using feedback and feedforward communication patterns that are improved by G-NAT™ movements. APA's are a feedforward response that happen before anticipated rapid movements and increase stiffness and balance.[6]

Figure 3.1: Hip extension engaging rotary stability (roll component)

Figure 3.2: 4 point anchor and force line

3.3 Strength and Athletic Performance

Six weeks of G-NAT™ neuromuscular (balance) training has been shown to improve measures of strength and lower-extremity biomechanics. Squat strength (strength measure) increased by, as much as, 92%, and knee varus torque, a risk indicator for knee injury (biomechanics measure), decreased by 38%.[24]

Incorporating the balance training into a five-week training program resulted in 33% improvement in static balance and 9% increase in vertical jump height .[18]

Lumbar spine stability increases with increased trunk load magnitude, to the extent that this load brings about an increase in trunk muscle activation. The data from this study suggests that muscle reflex response to sudden loading can augment the lumbar spine stability level achieved immediately prior to the sudden loading event.[1]

3.4 Injury

According to the U.S. CDC, more than 3.5 million children, under age 14, receive medical treatment for sports injuries each year, and one in every three adults, age 65 and older, falls. These falls result in moderate to severe injuries, such as, hip fractures and head injuries and can increase the risk of early death. According to the CDC, falls are most commonly caused by a loss of balance or stability.

A study of 765 high school soccer and basketball players found that the balance training significantly lowered the rate of ankle sprains (6.1%, 1.13 of 1000 exposures vs. 9.9%, 1.87 of 1000 exposures; P = .04). Athletes with a history of an ankle sprain had two-fold increase in the risk of sustaining a sprain compared to those without an ankle sprain history (risk ratio, 2.14); whereas, athletes who performed the balance training intervention decreased their risk of a sprain by one-half compared to those without the intervention (risk ratio, 0.56).[22]

Hip abduction strength and recruitment may improve the ability of female athletes to increase control of lower extremity alignment and decrease knee abduction motion and loads, resulting from increased trunk displacement during sports activities. This results in a significantly lower incident of ACL injury in female athletes.[24]

The specific G-NAT™ motor control training can help restore the deep abdominal muscles that show delayed activation and histological changes, secondary to injury or pain, and has been shown to be beneficial for spondylolisthesis, acute low back pain and pregnancy-related pain.[21]

3.5 Age and Balance

Recent evidence suggests that perturbations with a roll component may be more representative of conditions that induce falls in everyday life. For example, analysis of spontaneous or induced sway in the mediolateral plane appears to correlate better with faller status than anterior-posterior sway. In fact, a large proportion of falls in the elderly has been found to involve lateral motion[17] and are associated with the genesis of hip fractures.

Lateral perturbations may be more destabilizing because they require a more complex coordination of muscle responses on the left and right sides of the body; and therefore, place a greater demand on the processing requirements of the CNS. Furthermore, the coordination of differing pitch and roll trunk dynamics must be achieved.[6] Thus, proprioceptive information elicited by multidirectional stance perturbations may well be more difficult for the elderly to process than that coming from a pure pitch plane perturbation.

Similarly, adequate balance corrections in two planes may be more difficult to generate.[17] The G-NAT™ movement patterns are well suited to mimic these planes and improve balance and stability, and possibly reduce rates of falls and injury.

3.6 Balance and Stabilization Conclusion

Balance and stability require multi-joint coordination and strength and are critical for high-level athletics, as well as, for daily tasks and injury prevention.

G-NAT™ movements rely on two, three or four anchor points on the vertical axis which causes activation of the trunk stabilization muscles. A stable core enables the effective transfer of forces between the upper and lower body. G-NAT™ movement patterns have been shown to significantly increase static and dynamic balance, stability and proprioception which has been shown to improve athletic performance including strength, speed and vertical jump and to reduce injury rates for hips, knees, ankles and low back.

As subjects perform the G-NAT™ movement patterns in a vertical position that mimics many "real world" activities, these movement patterns are more effective in improving balance and stabilization than similar movement patterns in other positions because of the direction of forces. This results in improved athletic performance and injury prevention.

4 Metabolic Response

Caloric consumption is one of the foremost topics of exercise research as athletes strive to burn more calories, and trainers search for exercises that increase caloric burn. The studies mentioned in this article were conducted using O_2 and CO_2 gas analysis equipment, blood lactate measurement devices and heart rate monitors on each subject in the Welltec Human Performance Lab.

4.1 Principles of Caloric Burn

In general, there are two ways to increase the number of calories burned. One is to increase the number of calories used during exercise; the other is to increase the metabolic rate or the number of calories used while not exercising.

4.2 Caloric Burn During G-NAT Session

To maximize the number of calories burned during a short exercise period, it is necessary to optimize the work/recovery period. High Intensity Interval Training (HIIT) workouts that focus on heart rate can allow the body to recover just enough to do high levels of work repeatedly in the shortest amount of time. Recent research on HIIT challenges the belief that long, slow exercise is the only way to increase VO2max,[16] demonstrating that HIIT is a potent, time-efficient strategy to induce numerous metabolic adaptations usually associated with endurance training. In fact, six sessions of G-NAT™ HIIT over two weeks can increase skeletal muscle oxidative capacity, increase endurance performance and alter metabolic control during aerobic-based exercise.[16]

Figure 4.1 is a heart rate curve of a G-NAT™ test measuring heart rate, O_2 and CO_2 which are typically monitored in real time along with the number of calories burned during each G-NAT™ session. The high number of calories burned during a G-NAT™ session is due to G-NAT's large number of muscles recruited and optimized work/recovery methods which also elicit an optimal gain in VO2max.[2,5,16]

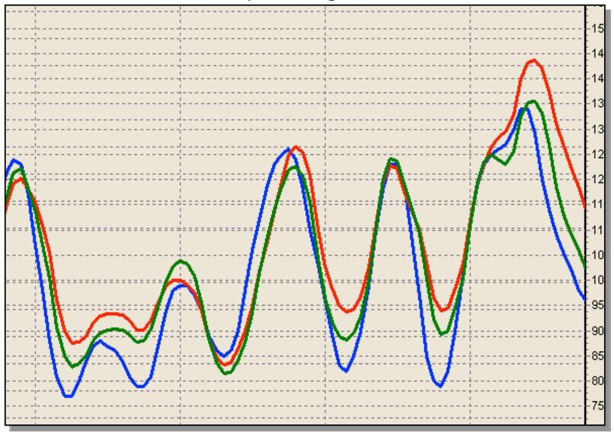

Figure 4.1: Heart Rate (red), O_2 (green), CO_2 (blue) During G-NAT Testing

4.3 EPOC

Excess Post Oxygen Consumption (EPOC) is also known as "after burn." EPOC is the continued consumption of calories after exercise and can last up to 72 hours post exercise. Figure 4.2 illustrates how increased caloric expenditure continues immediately after exercise, diminishing over time. The rate of taper is affected by the type of activity, VO2max, age, gender and weight. Sustained EPOC over weeks or months helps increase resting metabolic rate (RMR).

VO2max is the maximum rate of oxygen consumption as measured during incremental exercise. Maximal oxygen consumption reflects the aerobic physical fitness of the individual and is an important determinant of their endurance capacity during prolonged, sub-maximal exercise. The name is derived from V - volume, O2 - oxygen, max - maximum

High levels of EPOC are generated from G-NAT™ high intensity work.[5,15] Research has shown that repeated intervals based on heart rate and recovery, results in more work over the same period of time when compared to continuous exercise. Part of the reason G-NAT™ results in increased caloric expenditure over a short workout is its large number of muscles recruited and use of G-NAT™ work/recovery ratios and HR monitors in guiding interval training.

4.4 EPOC Results

The average increase in metabolic rate within the first hour following a G-NAT™ session for male subjects was 1,152 kcals, a 57% increase. 24 hours after exercise, male subjects displayed a continued increase in metabolic rate of 489, a 24% increase in kcals expended when compared to their fasting baseline (as measured by gas analysis). In addition, a strong correlation between G-NAT™ V-Factor™ and EPOC has been previously demonstrated as shown in the G-NAT™ RMR Table 1.

Description$_S$	Description$_L$	kcal$_{AVG}$	%Change
RMR$_1$	Fasting, pre-exercise	2009 kcal	baseline
RMR$_2$	Within 1-hour post-Exercise	3161 kcal	57% ↑
RMR$_3$	24 hours post exercise	2498 kcal	24% ↑

Table 1: G-NAT™ Resting Metabolic Rate (RMR) Results

4.5 Confirming Results

Continued research was conducted to determine why such a dramatic increase in EPOC and metabolic rate was found following these short (6 & 24-minute) G-NAT™ sessions. Previous research has shown a predictive association between lactate and EPOC.[16] Thus, lactate measurements were taken immediately post workout in this study. While the anaerobic threshold (AT) for lactate levels averages around 4.0 mmol/l for most individuals, the average lactate levels post G-NAT™ session were 12.9 mmol/l, offering a partial explanation for the very high increase in EPOC.

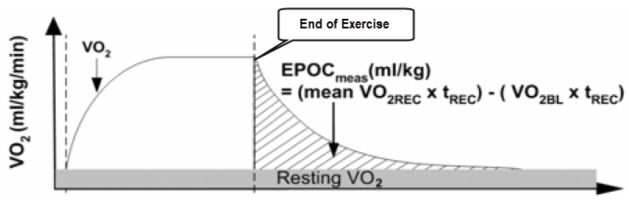

Figure 4.2: EPOC Diagram[3]

4.6 Metabolic Response Conclusion

Caloric consumption is another way to express the amount of work a body does. Using a larger number of muscles leads to more total work being done in a given time period. Our research found G-NAT™ workouts burn an unusually high number of calories during the exercise session which can be explained by the large number of muscles recruited, high intensity interval training method and optimization of work/recovery periods, using G-NAT™ work/recovery ratios and real time heart rate monitoring.

In addition to the number of calories burned during a G-NAT™ session, there continued to be greater than normal caloric expenditure for 24 or more hours following the session. The average increase was 57% within an hour following exercise and 24% on average 24 hours later.

Based on these results, three conservative G-NAT™ sessions per week can burn an additional 3300kcal/week for an average 130 lb. female (1lb fat=3500kcal). Combined with the caloric consumption during the exercise session, this yields a 5100kcal/week deficit.

5 Orthopedics & Joint Impact

The CDC reports the prevalence of arthritis and Chronic Joint Symptoms (CJS) is 1 in 3 among U.S. adults.[7] Based on a review of prior research and testing at the Welltec Performance Lab, G-NAT™ exercises are a unique modality for decompression and relief of CJS.

5.1 Osteoarthritis Overview

Of all the many causes of joint pain, osteoarthritis is the most common. Osteoarthritis results from deterioration or loss of the cartilage that acts as a protective cushion between bones, particularly in weight-bearing joints such as the knees and hips. As the cartilage is worn away, the bone forms spurs, areas of abnormal hardening, and subchondral cysts, fluid-filled pockets in the marrow.

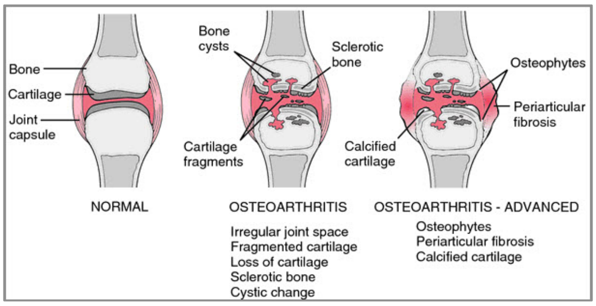

Figure 5.1: Miller-Keane Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health, Seventh Edition.

As the disorder progresses, pain results from deformation of the bones and fluid accumulation in the joints. The pain is relieved by rest and made worse by moving the joint or placing weight on it.[23]

5.2 Closed Chain vs. Open Chain

Closed kinetic chain exercises (CKC) are physical exercises performed where the hand (for arm movement) or foot (for leg movement) is fixed in space and cannot move. The extremity remains in constant contact with an immobile surface, usually the ground or the base of a structure.

The opposite of CKC exercises are open kinetic chain exercises (OKC). Closed chain exercises are typically considered safer and more "functional" than open chain exercises.[8]

Closed chain exercises traditionally focus on upper body or lower body separately for a given exercise. As shown in Figure 5.3, G-NAT™ uses the upper and lower body simultaneously in this CKC exercise.

Figure 5.2: G-NAT™ Open Chain Kinetic Movement

Figure 5.3: G-NAT™ Closed Chain Kinetic Movement

Research on joint pain has shown that high impact, sheering forces and open chain kinetic exercises cause the most pain; while, unloading, low impact, closed chain exercises relieve pain most effectively.

Table 2 lists the 12 Life Movements™ that are part of the G-NAT™ curriculum. Each is rated based on whether it is closed chain and the level of unloading or joint decompression, demonstrating the value of G-NAT™ for such pain relief.

Note: Life Movements™ LM10, LM11 and LM12 demonstrate Excellent levels of unloading on the side of the body with the foot off the device; while, on the side of the body with the respective body weight on that foot, the level of unloading is still Fair or Moderate.

Table 2: G-NAT Life Movements™

Name	**Closed Chain, unloading factor**
LM1-Wide Grip Row &	Excellent
LM2-Close Grip Row	Excellent
LM3-Close Grip Lat/Delt Pull-up	Excellent
LM4-Wide Grip Lat Pull-up	Excellent
LM5-Ab Extensions	Excellent
LM6-Calf Extensions	Excellent
LM7-Knee Extensions	Excellent
LM8-Seated Squats	Excellent
LM9-Open Hip Squat	Excellent
LM10-Single Leg/Glute Extensions	Moderate/Excellant
LM11-Oblique Extensions	Fair/Excellent
LM12-Hip Flexors	Moderate/Excellent

5.3 Low Back, Sacroiliac (SI) Joint

Practicing the active G-NAT™ movements in low, bent-knee positions significantly improves movement range and body posture, as well as, reduces pain in the lower segments of the spine. Such G-NAT™ seated and open form movements also improve functional abilities in everyday activities.[11]

In a prior vertical study, SI joint pain had electromyographic-documented hyperactivity of the ipsilateral gluteus muscles and contralateral latissimus muscle compared with 15 asymptomatic control patients. After a 2-1/2 month exercise program, all five patients achieved a significant reduction in pain.[8] Figure 5.5 shows a G-NAT™ movement focusing on the ipsilateral gluteus and contralateral latissimus muscles shown in Figure 5.4.

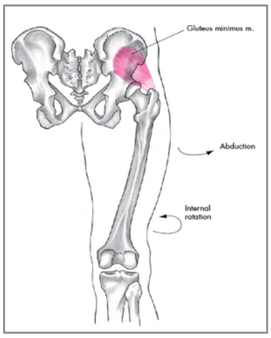

Figure 5.4

Figure 5.5

5.4 Knee

A recent study evaluated a broad range of weight bearing loads during exercise and showed significantly higher tibial tray loads during open chain movements.[20]

Relaxed and closed chain conditions demonstrated improved congruence compared with the open chain condition at 0, 10 and 20 degrees of knee flexion ($p < .0001$).[11]

Many G-NAT™ exercises reduce tibial loads and sheering forces, in addition to, using closed chain movements as discussed in section 5.2.

5.5 Orthopedics & Joint Impact Conclusion

Osteoarthritis is the most common cause of joint pain, and compressive or high impact exercise has been shown to aggravate or worsen the symptoms of osteoarthritis.

The low impact, unloading and decompressive exercises, as seen in G-NAT™ movements, can reduce frequency and intensity of chronic joint symptoms. There is also strong evidence that range of motion and flexibility are improved with the reduction in pain.

Closed Chain Kinetic Exercises (CKC) have been recommended for rehabilitation and joint health, and many G-NAT™ movements involve the upper and lower body concurrently in CKC exercise.

G-NAT™ exercises contain movements that have been shown to reduce knee, low back, elbow, shoulder and ankle pain because they are intrinsically low impact and incorporate CKC movements.[8,11,12,19]

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