Benefits of Hyperthermic Conditioning and Active Thermal Exercise

BENEFIT	RATIONALE	HYPERTHERMIC CONDITIONING (Benefit without exercise)	ACTIVE THERMAL EXERCISE (A) Increases % of Benefit (or) (B) Reduces Time Required or Achieves Benefit % More Quickly
I. CARDIOVASCULAR ADAPTATIONS	Exercise- and heat conditioning- cause the core temperature to increase. To cool the body, blood is sent to the skin to transfer the heat from the core to the skin. Perspiration allows for evaporation from the skin to cool the blood before it is returned to the core.(29) This process is called "thermo-genesis" and results in increased heart rate, stroke volume and cardiac output at any given exercise intensity.(29) In sufficiently hot and/or humid environ-ments, the process occurs even without exercise. If heat is not dissipated, the core temperature will increase and the subject will experience fatigue and exhaustion.(29)	Most healthy people can tolerate body core temperatures up to forty degrees Celsius (when adequately hydrated).(40) Heat exposure increases body temperature and activates a number of beneficial physiological responses, including adaptations that improve performance when the body temperature is elevated (29), including the following: (see a through k below)	Exercise combined with heat exposure increases body temperature more than either one by itself. The combination activates beneficial physiological responses more significantly than either exercise or heat by itself.(31)
a.Increased blood plasma volume	Increased plasma and blood flow results in reduced cardiovascular strain and	One study found a 7.1% increase in plasma volume after a 30-minute heat	

	lowers the heart rate for the same given workload.(1)	session twice a week for three weeks.(1)	
b.Increased stroke volume	The amount of blood pumped by the left ventricle of the heart in a single contraction. Increased stroke volume results in decreased heart rate during sustained exercise.(29)	Heat exposure acclimation increases stroke volume resulting in decreased heart rates during sustained exercise.(2, 3, 4)	Exercising in heat causes acclimation and increases stroke volume more than just exercise or heat exposure alone.(32)
c. Increased cardiac output	Cardiac output is measured in liters per minute.(29)	Studies have shown significantly increased maximal cardiac output resulting from hyperthermic conditioning.(5)	Exercising in heat causes acclimation and increases cardiac output more than just exercise or heat exposure alone.(32)
d. Increased sweat rate	The rate of sweating is increased with both exercise and heat exposure. Heat acclimation also increases the size of the eccrine sweat glands (and larger glands produce more sweat).(41)	Thermal exposure results in increased sweating and lowers the threshold for the onset of sweating to avoid increased core temperature. (6)	Thermal exposure combined with exercise results in even greater increases in sweating than passive heat exposure alone.(32) Exercising in heat can trigger a sweat rate of 2 liters per hour.(29)
e. Increased sweat sensitivity	A rise in core temperature triggers the body's temperature regulating center for heat dissipation. Sweat sensitivity determines the body's potential for evaporative cooling.(6)	Studies have shown that heat acclimation results in increased sweat sensitivity and a lower threshold for the onset of sweating.(6)	Sweat sensitivity increases during both heat acclimation and exercise conditioning.(32)
f. Increased blood flow to the skeletal muscle	Increased blood flow to the muscles keeps them filled with glucose, fatty acids and oxygen (while removing metabolic byproducts such as lactic acid). This reduces the muscles' reliance on glycogen stores.(29)	Heat acclimation increases blood flow to the muscles. (2,7) Increased delivery of nutrients to muscles reduces their dependence on glycogen stores.(7)	Thermal exposure combined with exercise results in even greater increases in blood flow to the skeletal than passive heat exposure alone.(32)

g. Increased efficiency of oxygen transport to muscle	The enzymes the body needs to burn fat require a great deal of oxygen. The aerobic energy cycle also requires a great deal of oxygen.(29)	Heat acclimation improves the efficiency of oxygen transport to the muscle cells.(1)	Published studies have found that the capacity of rats subjected to a program of strenuous aerobic exercise to oxidize pyruvate doubled. The same study determined that the exercise program brought about a significant increase in the ability of the involved muscles to oxidize pyruvate, and that the activities of the enzymes in the mitochondrial electron transport chain doubled.(26)
h. Increased red blood cell count	Increased numbers of red blood cells allows for increased oxygen delivery to the working muscles.(29)	One study found a 3.5% increase in red blood cell count after a 30-minute heat session twice a week for three weeks.(1)	
i.Lower heart rate	Both exercise and heat acclimation cause adaptations which result in lower heart rates.(29)	Heat exposure acclimation increases stroke volume resulting in decreased heart rates during sustained exercise.(2,3,4)	Both exercise and heat acclimation result in a lower heart rate as the body adapts to the stress imposed.(29)
j.Lower core body temperature	Both exercise and heat acclimation result in lower core temperatures as the body adapts to the stresses imposed.(29)	Both exercise and heat acclimation result in lower core temperatures as the body adapts to the stress imposed.(2)	Both exercise and heat acclimation result in lower core temperatures as the body adapts to the stress imposed.(35)
k.Increased metabolic rate	Exercising in hot conditions cause higher oxygen consumption than in cooler conditions resulting in a higher resting metabolic rate.(29)	The thermogenic effect of an elevated core temperature with the additional energy required for sweat gland activity and altered circulatory dynamics increases rate of metabolism.(29) The resting	Metabolism can rise 20 to 25 times above resting level to about 20 kCal per minute during intense aerobic exercise (which can raise core temperature by 1 degree C. every 6 minutes).(29)

		metabolism of people in tropical climates is generally 5 to 20% higher than people living in temperate areas.(29)	
II.BIOCHEMICAL ADAPTATIONS			
a.Reduced rate of glycogen depletion	Glycogen is the storage form of glucose and carbo-hydrates. About 80% of total carbohydrate is stored in skeletal muscle (about 14% is stored in the liver and about 6% in the blood in the form of glucose).(29) Glycogen is very important but humans have a limited capacity to store it.(29) Muscle glycogen is crucial for ATP re-synthesis during exercise.(29) When glycogen levels are low, muscles use protein and amino acids to produce glucose.(29) Protein and amino acids are the building blocks of muscle.(29) With shortages of glycogen, muscle starts using vital protein and amino acids for energy purposes.(29) This can lead to muscle damage and chronic overtraining (it has been shown that muscle damage limits and interferes with glycogen storage and	Studies show that heat acclimation can reduce muscle glycogen use by 40 to 50%. Reduced rate of glycogen depletion due to improved muscle perfusion.(7,8)	Studies show that exercising in hot environments reduces muscle glycogen use by 40 to 50% and show reduced rates of glycogen depletion due to improved muscle perfusion.(7,8). Additional studies show that heat acclimation leads to sparing of muscle glycogen associated with enhanced ability to perform highly intense exercise following prolonged exertion in the heat.(7)

	synthesis). (29)		
b. Increased production of glucose-burning enzymes	Increased capacity of muscle cells to oxidize pyruvate and form ATP is important for increasing the ability of muscles to perform aerobic work.(29) The rate of aerobic metabolism of pyruvate in the muscles is limited not by the supply of oxygen but rather by the capacity of the mitochondria for pyruvate oxidation.(29)	Heat acclimation improves the efficiency of oxygen transport to the muscle cells necessary for glucose-burning.(1)	Studies have shown found that the capacity of rats subjected to a program of strenuous aerobic exercise to oxidize pyruvate doubled.(26) The study also determined that the exercise program increased the ability of the involved muscles to oxidize pyruvate, and that activities of the enzymes in the mitochondrial electron transport chain also doubled.(26)
c. Increased production of fat-burning enzymes	De-conditioned individuals have a shortage of fat burning enzymes. This severely limits the ability to use fats for energy and causes reliance on glucose burning only.	Heat adaptation can increase the concentrations of fat-burning enzymes inside the mitochondria. Research has shown that heat exposure causes heat shock and oxidative stress (generation of O_2^- and H_2O_2). Heat adaptations promote mitochondrial biogenesis (2–3-fold increases in muscle mitochondria).(9)	Exercise can increase the concentrations of fat-burning enzymes inside the mitochondria. Research has shown that exercise can cause heat shock and oxidative stress (generation of O_2^- and H_2O_2). It can also promote mitochondrial biogenesis (2–3-fold increases in muscle mitochondria).
d.Lowered insulin levels	Insulin stimulates cells to open certain pores to allow the entrance of glucose into the cell. Deconditioned individuals often lose the ability to respond to insulin.	Animal studies have found that 30 minutes heat exposure three times per week for a period of 12 weeks can result in a 31 percent decrease in insulin levels.(10)	
e.Lower blood sugar levels	It is believed that blood sugar levels are reduced because of increased blood	Animal studies have found that 30 minutes of heat exposure three times per	

	flow to the muscles. Lower blood sugar levels have important implications for the maintenance of healthy muscle tissue as well as for combating chronic diseases that are related to insulin resistance such as type two diabetes, metabolic syndrome, and many others.	week for a period of 12 weeks can result in a significant reduction in blood sugar levels.(10) Published studies have also shown that heat acclimation can reduce muscle glycogen use by 40 to 50% compared to before heat acclimation.(7,8)	
f. Increased no. of Calories burned daily	Exercising in hot conditions causes higher oxygen consumption than exercising in cooler conditions resulting in a higher resting metabolic rate resulting in increased Calorie burning.(29)	The thermogenic effect of an elevated core temperature with the additional energy required for sweat gland activity and altered circulatory dynamics increases rates of metabolism and Calorie burning.(29)	Metabolism can rise 20 to 25 times above resting level to about 20 kCal per minute during intense aerobic exercise (which can raise core temperature by 1 degree C. every 6 minutes) resulting in increased Caloric consumption.(29)
g. Increased release of HGH	HGH is a vital hormone that affects the muscle loss and atrophy that typically occurs with aging.(12,13) The higher your levels of HGH, the healthier and stronger you will be. For most people, at about the age of 30 a stage called “somatopause” is reached. When this point is reached, HGH levels begin to drop off dramatically. This decline in HGH levels contributes to the aging process, so the maintenance of high HGH levels is increasingly	The atrophy of the lean body mass and its component organs and the enlargement of the mass of adipose tissue characteristic of the elderly result at least in part from diminished secretion of growth hormone. If so, the age-related changes in body composition should be correctable in part by the administration of human growth hormone.(43)	A number of studies have documented that active thermal exercise can significantly induce the release of human growth hormone (HGH). One study showed a **doubling** of HGH levels with only two 20-minute heat sessions at 176 degrees F.(11,12) A second study showed that HGH levels can be ***increased fivefold*** with only two 15-minute heat-conditioning sessions.(11,12) A third study showed that two one hour heat sessions each day at 176 degrees F. for one

	important as we age.(43)		week increased HGH levels by **sixteen times** on the third day.(13)
h. Improved insulin sensitivity	In overweight individuals, insulin levels are elevated because the tissues do not respond properly to insulin. This is called “insulin insensitivity”. This condition impedes the ability of glucose to enter muscle cells, causes high blood sugar levels and increases in the amount of glucose entering **fat cells**.(10,29)	Animal studies have found that 30 minutes heat exposure three times per week for a period of 12 weeks can result in a 31 percent decrease in insulin levels.(10) Lower insulin levels help maintain higher sensitivity to insulin and promote the entry of glucose into muscle cells.(10,29)	Both exercise and heat conditioning elevate core body temperature and are known to improve insulin sensitivity.(10)
i. Increased protein synthesis	Stimulation of the uptake of amino acids into muscle cells increases protein synthesis.	Hyperthermic conditioning contributes to improved protein synthesis.(11,14,15)	Exercise in heat contributes to improved protein synthesis.(11,14,15)
j.Inhibited cellular protein degradation (and enzymes responsible for same)	Hyperthermic conditioning contributes to improved regulation of protein metabolism.(18)	Heat acclimation reduces the amount of protein degrada-tion that occurs in the muscles. Heat exposure has been shown to trigger the release of heat shock proteins (HSPs) and reduce the amount of protein degradation that naturally occurs during both muscle use and disuse.(14,15,18)	
k.Reduced blood lactate levels (resulting from incomplete glucose burning because the cardiovascular system cannot furnish enough oxygen to break	Increased levels of lactate in muscles causes fatigue during exercise. Reduced lactate production can increase the capacity for prolonged physical activity (it	Heat acclimation has been shown to reduce blood lactate levels. The lactate threshold in a cool environment has also been increased with heat acclimation.(16)	Exercise performed in a hot environment has been shown to reduce blood lactate levels.(16)

down pyruvic acid). Pyruvic acid is converted to lactic acid. (29)	is believed that this is because of the increased blood flow to the muscles). (29)		
l.Increased concentrations of heat shock and oxidative stress proteins	Heat shock proteins (HSPs) reduce the amount of protein degradation that naturally occurs during both muscle use and disuse. Reduced protein degradation increases the net protein synthesis in the muscles and therefore promotes muscle growth.	The concentrations of at least 15 possible heat shock or oxidative stress proteins (including one with a molecular weight of 70 kDa) have been shown to increase, in skeletal muscle, heart, and liver, with increasing temperatures.(9)	Exercise has been demonstrated to induce HSPs.(17)
III.BENEFITS FOR THE BRAIN			
a. Increased levels of nor-epinephrine	Norepinephrine is an important hormone involved in the stress response that increases focus and attention	One study showed that norepinephrine levels increased by 310% in subjects who underwent heat conditioning at 176 degrees F. (11,12) Another study showed an 86% increase with two 20 minute sessions a week.(19)	
b. Increased levels of prolactin	Prolactin is an indirect marker of central fatigue. It is also important for the promotion of myelin growth, which helps the brain function faster and repair nerve cell damage	One study showed that prolactin levels increased **tenfold** in subjects who underwent heat conditioning at 176 degrees F.(11,12) Another study showed a 510% increase in prolactin with two 20 minute sessions a week.(19)	One study compared the prolactin responses of subjects reaching exhaustion via cycling to subjects heated to the same core temperature passively. It was found that with both forms of heating the prolactin response was the same. The conclusion is that core temperature is the key stimulus for prolactin

			release.(20)
c. Increased endorphin levels	The so-called “runner’s high” which can result from a boost in our endorphin levels, and the sense of well-being associated with intensive endurance athletics, can also be achieved with thermal conditioning and ATE.	Heat stress from heat exposure has been shown to increase beta-endorphiin levels, even more than exercise by itself.(11,12)	The boost in endorphin levels associated with running is believed to be related to heat stress. Animal studies have found that heat stress from thermal exposure can significantly increase endorphin levels.(22)
d. Increased BDNF	Brain-derived neurotrophic factor activates brain stem cells to produce new neurons and triggers other important chemicals. In-creased neurogenesis is believed to enhance learning.(22)	Studies have shown that ATE increases BDNF more than exercise done at lower temperatures, adding support for the position that heat stress is beneficial for the brain.(21)	
IV.BENEFITS FOR THE MUSCLES	In the muscles there is always a balance between new protein synthesis and the degradation of existing proteins.		
a. Increased muscle mass	Heat acclimation increases net protein synthesis and muscle growth. Increased production of heat shock proteins (HSPs) and HGH promotes muscle growth and reduces protein degradation. Protein degradation occurs naturally during both muscle use and disuse. Reduced protein degradation increases the net protein synthesis in the muscles and	Heat exposure increases the concentrations of metabolizing enzymes inside the mitochondria. Animal studies have shown that muscle atrophy can be arrested during periods of disuse by over 30 percent (rats exposed to intermittent hyperthermic exposure experienced significant increases of heat shock proteins associated with a 30	Research has shown that both exercise and heat exposure cause heat shock and oxidative stress (generation of O_2^- and H_2O_2). Both exercise and ATE training promote mitochondrial biogenesis (2–3-fold increases in muscle mitochondria).(23,24,25) The administration of HGH to a group of men from 61 to 81 years old for six months

	promotes muscle growth. HSPs help to both prevent and repair damaged proteins and are used by the cells to counteract potentially harmful stimulus.	percent improvement in muscle regrowth compared to a control group. The increased HSPs persisted for up to 48 hours after the heat exposure).(14)	resulted in an 8.8% increase in lean body mass and a 14.4 percent decrease in adipose tissue mass.(27)
b. Increased blood flow to muscles (blood perfusion)	Increased blood flow to the muscles keeps them filled with glucose, fatty acids and oxygen (while removing metabolic byproducts such as lactic acid). This reduces the muscles' reliance on glycogen stores.(7)	Hyperthermic conditioning increases blood flow to the muscles.(7)	
c. Increased efficiency of oxygen transport to muscles	The enzymes the body needs to burn fat require a great deal of oxygen. The aerobic energy cycle also requires a great deal of oxygen.	Heat acclimation improves the efficiency of oxygen transport to the muscle cells.(1)	Published studies have shown that the capacity of rats subjected to a program of strenuous aerobic exercise to oxidize pyruvate doubled. The study determined that exercise increased the ability of the involved muscles to oxidize pyruvate, and that the activities of the enzymes in the mitochondrial electron transport chain doubled.(26)
d.Increased production of muscle proteins		The concentrations of at least 15 possible heat shock or oxidative stress proteins (including one with a molecular weight of 70 kDa) have been shown to increase, in skeletal muscle, heart, and liver, with aerobic exercise and ATE.(9)	
d.Reduced protein	Muscle growth can be	Heat acclimation reduces the	

degradation	promoted by triggering the release of heat shock proteins (HSPs) which reduce the amount of protein degradation that naturally occurs during both muscle use and disuse. Human growth hormone (HGH) also decreases protein degradation. Reduced protein degradation increases the net protein synthesis in the muscles and therefore promotes muscle growth.	amount of protein degrada-tion that occurs in the muscles. Heat exposure has been shown to trigger the release of heat shock proteins (HSPs) reduces the amount of protein degradation that naturally occurs during both muscle use and disuse.(14,15) The administration of HGH to endurance athletes for four weeks was shown to decrease muscle protein oxidation and degradation by 50%.(28)	
e.Protection against degenerative muscle tissue conditions	HSPs help repair damaged proteins and help maintain proper protein structure and function. HSPs also help protect against degenerative muscle tissue conditions. (14,15)	HSPs are induced by intermittent exposure to heat. HSPs help prevent damage by directly scavenging free radicals and by supporting cellular antioxidant capacity by helping to maintain glutathione levels.(14,15)	
f.Reverses age-related muscle atrophy (sarcopenia)			
g.Reduces levels of lactic acid in the blood	Increased levels of lactate in muscles causes fatigue during exercise. Reduced lactate production can increase the capacity for prolonged physical activity (it is believed that this is because of the increased blood flow to the muscles).	Heat acclimation has been shown to reduce blood lactate levels. The lactate threshold in a cool environment has also been increased with heat acclimation.(16)	Exercise performed in a hot environment has been shown to reduce blood lactate levels.(16)

h.Reduced muscle glycogen use.	It is believed that this is because of the increased blood flow to the muscles.	Published studies have shown that heat acclimation can reduce muscle glycogen use by 40 to 50% compared to before heat acclimation. (7,8)	Studies show that exercising in hot environments reduces muscle glycogen use by 40 to 50% and show reduced rates of glycogen depletion due to improved muscle perfusion. (7,8). Additional studies show that heat acclimation leads to sparing of muscle glycogen associated with enhanced ability to perform highly intense exercise following prolonged exertion in the heat.(7)
h.Increases lactate threshold	Increased levels of lactate in muscles causes fatigue during exercise. Reduced lactate production can increase the capacity for prolonged physical activity (it is believed that this is because of the increased blood flow to the muscles).	Heat acclimation has been shown to reduce blood lactate levels. The lactate threshold in a cool environment has also been increased with heat acclimation.(16)	Exercise performed in a hot environment has been shown to reduce blood lactate levels.(16)
i.Increased muscle mitochondria and enzymes.	Increased muscle mitochondria results in increased muscle endurance.		Repeated muscle contraction results in increased muscle mitochondria and mitochondrial enzymes.
j.Lower insulin levels	Lower insulin and blood sugar levels have important implications for the maintenance of healthy muscle tissue. Insulin promotes the uptake of glucose into the muscle and regulates protein metabolism.	Animal studies have found that 30 minutes heat exposure three times per week for a period of 12 weeks can result in a 31 percent decrease in insulin levels. Hyperthermic conditioning improves insulin sensitivity and decreases muscle	

		protein catabolism.(10)	
k.Lower blood sugar levels	Lower blood sugar levels have important implications for the maintenance of healthy muscle tissue.	Animal studies have found that 30 minutes of heat exposure three times per week for a period of 12 weeks can result in a significant reduction in blood sugar levels.(10)	
l.Improved recovery from muscle injury	To return to a healthy condition after injury, muscle regrowth must occur. Muscle regrowth after immobilization occurs as a result of elevated heat shock protein levels. Brain-derived neurotrophic factor (BDNF) is also secreted by muscle cells and plays an important role in muscle repair and growth. (30)	A 30 minute heat session has been shown to increase muscle regrowth by 30% after reloading as compared to a control group in animal studies.(14)	
m.Reduced neuro-motor degradation	Brain-derived neurotrophic factor (BDNF) also protects neuro-motors—which are the most critical elements in the muscles-- from degradation.	Studies have shown that BDNF is increased with heat exposure.(21)	Studies have shown that BDNF is increased with heat exposure more than with exercise alone when done in conjunction with exercise.(21)
V.IMPROVED BODY COMPOSITION			
a. Increased metabolic rate burns more Calories each day	Metabolic increases are due to physiological responses to heat exposure known as “thermogenesis.” ATE causes increases in heart rate, stroke volume, plasma and other physical and chemical processes in our cells.(29)	A regular and consistent program of heat exposure increases metabolic rate and helps increase lean tissue (muscle) mass which consumes increased amounts of Calories.(29)	A regular and consistent program of exercise in heat increases the metabolic rate and helps increase lean tissue (muscle) mass (which consumes increased amounts of Calories).

b.Avoids problems characteristic of traditional “diets”	i.e., reduced lean muscle tissue, yo-yo dieting, etc.		
VI.GREATER LONGEVITY			
a.Increased life span and anti-aging benefits		Thermal conditioning has been shown to increase life span by up to 15% in studies with lower organisms	
b. Increased HSP70 genes	Heat shock proteins (HSPs) have been associated with increased longevity. (36,37,38,39)	Studies have shown that HSPs are induced by intermittent exposure to heat.(14,15)	
VII.HEAT ACCLIMATION	Acclimatization is the process by which the human body makes physiologic adaptations to reduce the stress of an environment. (31) Studies have shown that ATE results in improved responses to exercise in both hot and temperate conditions that are similar to the improvements observed with strenuous training regimens.(33)	Studies have shown that heat acclimation is more important than either VO2 max (aerobic conditioning level) or surface-to-mass ratio in regulating core temperature level in temperate conditions.(35) A 9 or 10 day period is generally sufficient to attain most of the physiologic adaptations associated with acclimation. (31)	
a. Improved thermo-regulatory control	Via activation of sympathetic nervous system.(29)		Acclimatization to work in the heat brings an earlier onset of sweating, increase in sweat rate and evaporative cooling that reduces heart rate in

			proportion to decreased core temperature.(45)
b.Heat exposure triggers thermogenesis	Heat exposure causes a cascade of cardiovascular adaptations to heat.(33)		
c.Dissipates excessive body heat and lowers core temperature	ATE lengthens time before core temperature reaches 40 degrees C.(1)		
d.Prolongs ability to continue exercising before exhaustion	Trained athletes generally reach the point of exhaustion when core temperatures reach 39 degrees Celsius.(34)	One study has shown that a 30-minute ATE session two times per week for three weeks increased the time it took for participants to reach exhaustion by **over 30%** compared to baseline.(1)	
VIII.RELAXATION	Low heat, massage and meditation are helpful in triggering the "Relaxation Response" which can result in decreased muscle tension, heart rate, breathing rate and blood pressure. The Relaxation Response also appears to change brain plasticity or cellular connections in areas of the brain associated with stress response.		
IX.PAIN RELIEF	The therapeutic effects of topical heat treatment are mediated via neurologic, vascular, and biopsycho-social mechanisms. Topical heat inhibits nociceptive signals in the spinal cord and increases proprioception.	A carpal tunnel syndrome study found that continuous low-level heat wrap therapy provided relief of pain and improved overall functionality as compared with subjects treated with oral placebo. (44) The benefits of the heat wrap	Studies have found functional improvement for heat therapy combined with exercise to be greater than either modality used separately. It has also been shown that heat combined with exercise can reduce pain and increase

	Heat therapy stimulates various regions of the brain.(44) Heat also increases the extensibility of collagen tissue. When heated to therapeutic levels, the viscous flow in the tissue becomes predominant and tension relaxes considerably.	were more pronounced in subjects with CTS than in the SS/T/OA subjects. Several possible reasons to explain this finding with the heat wrap include the incremental effects on tissue temperature, improved blood flow, and the effect of heat on improving nerve conduction velocity.(44) Studies have also shown the benefits of heat for treating acute low back pain. Improvement has been shown both immediately and seven days after treatment.	range of motion.