THE PERCUSSIONIST BODYBUILDER: OPTIMIZING PERFORMANCE THROUGH EXERCISE AND NUTRITION

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ABSTRACT

The Percussionist Bodybuilder: Optimizing Performance Through Exercise and Nutrition

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Do preventive therapies have the potential to help avoid common injuries among percussionists? This document investigates physiological therapy and nutrition in relation to percussion performance. My interest in this subject matter is derived from my personal experiences with injuries related to the performance of percussion. Although I have studied and played percussion professionally for more than a decade, I was unaware of certain methods of rehabilitation that were available to me prior to my injuries. As I learned about the rehabilitation process through first hand experience, I discovered that my injuries were very common among percussionists. This raised the question: Why isn't performing arts medicine incorporated into formal music training? And, if this is a common problem among percussionists, how can we prevent injury? The goal of my research is to develop a comprehensive diet and exercise regime in order to optimize performance and prevent the most common injuries to percussionists.

Acknowledgements

This document publically signifies the completion of my Doctor of Musical Arts Degree from the University of Nevada, Las Vegas. Although I believe this to be a big accomplishment, the true significance of this document signifies the end of a very long chapter of my life in higher education. I would like to thank all of you who have been a part of this wonderful experience and especially thank Kevin Pryor, Brian Hetsko, Frank Kumor, Will Rapp, Tim Jones, Dean Gronemeier, Kurt Rasmussen, Tom Leslie, Ken Hanlon, and Jeff Koep. I am forever grateful for your time, patience, and thoughts.

Dedication

This document is dedicated to my parents, Ed and Elena Merlino. Although my mom isn't able to be here to see me complete my degree, her kind sentiments and endless support are constantly felt. I am forever thankful to my dad for his encouragement, hard work, and dedication to helping me grow as a musician, a percussionist, but most importantly a person. I love you both, and thanks for everything!

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER ONE: INTRODUCTION

Do preventive therapies have the potential to help avoid common injuries among percussionists? The Percussionist Bodybuilder: Optimizing Performance Through Exercise and Nutrition investigates physiological therapy and nutrition in relation to percussion performance**.** Physiological exercises that use certain amounts of resistance coupled with a well-balanced nutritional plan have shown to enhance functional ability in musicians.[1] Resistance training programs are designed for reducing chances of injury risk through increasing strength of bones and muscles, through programs derived from the principle that body muscles can overcome the force of resistance if required. According to *The Resistance Band Workout Book*, whenever we engage in resistance training, body muscles grow stronger.[2] And, due to the ability of bone tissue to remodel and adapt to physical stress imposed on individual areas, resistance training can play a great role in strengthening the musculoskeletal system. Resistance bands (strands of latex that when stretched provide force against the direction of movement) are well suited for training of this nature because they provide progressive resistance throughout the entire range of motion, meaning that the tension increases as you move further away from the point of attachment. This constant tension also means that muscles need to stabilize the weight continuously.[3] Resistance bands can be found at many sporting good stores and come in a wide variety of tensions. Generally, resistance training reduces chances of osteoporosis, fracture, and other ailments related to bones by enhancing bone mass.[4] Enhanced bone

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[1] Susan E. Harman, "The Evolution of Performing Arts Medicine as Seen Through the Literature," in *Textbook of Performing Arts Medicine*, ed. Brandfonbrener Sataloff Lederman (New York: Raven Press, 1991), 1-9.
[2] Ed McNeely and David Sandler, *The Resistance Band Workout Book* (Online: Burford Books, 2006), 192.
[3] Ibid.
[4] Alan Watson, *The Biology of Musical Performance and Performance Related Injury* (Lanham, Md.: Scarecrow Press, 2009), 182 (accessed 4.16.14).

mass has been shown to promote correct posture, which helps prevent the aforementioned injuries but also leads to an increased range of motion. For percussionists an increased range of motion is necessary to perform many strokes and physical gestures, such as performing loud passages on marimba or striking a 32" timpano and a 23" timpano in quick succession. In terms of muscle, a regime of resistance training is of great help to an aging population in reducing musculoskeletal injuries connected to muscle imbalance or bilateral comparison. If certain areas of a percussionist's body are not as well adapted to perform a task, other muscle groups have to overcompensate to achieve the desired result. For example, if a percussionist's wrist is not developed enough to perform repetitive strokes on a snare drum the muscles in the forearm will be activated. This kind of muscular imbalance may significantly contribute to injuries among percussionists such as carpal tunnel syndrome, tendinitis, tendinosis, and bursitis.

My interest in this subject matter is derived from my personal experiences with injuries related to the performance of percussion. In preparation for my senior recital and graduate school auditions I began to develop detrimental practice habits that began to have long term effects on my playing. Long practice sessions, practicing through pain, and a lack of knowledge of ergonomics in performance led to complex injuries. As a result of these poor practice habits, I was diagnosed with repetitive stress injuries starting in my shoulder and migrating down through my wrist, with the primary cause being insufficient conditioning. These series of injuries forced me to stop playing completely for three months, and rehabilitate my injuries for an additional six months. My body was trying to accomplish tasks it was not well equipped to handle, and as a result, carpal tunnel and tendinitis were developing.

Although I have studied and played percussion professionally for more than a decade, I was unaware of appropriate methods of rehabilitation that were available to me prior to my injuries. As I learned about the rehabilitation process, which involved suspension from practice and employed the use of resistance band exercises, I discovered that my injuries were experienced by many other percussionists.[5] This raised the question: Should performing arts medicine be incorporated into formal music training? And, if this is a common problem among percussionists, how can we prevent injury?

Due to the application of sports medicine to the field of music**,** there has been an increased awareness surrounding career-jeopardizing injuries affecting percussionists. According to Alice G. Brandfonbrener, "In studies of musicians of school and college age, the injury figures are comparable to those of professional musicians. Therefore, there must, indeed, be something inherent in being a musician that accounts for these injuries, more than does age."[6] The formation of the Performing Arts Medicine Association is the result of this newfound interest in connecting medicine to the performing arts. This organization is comprised of medical professionals, performing musicians, educators, and administrators who have a goal of improving health care for musicians. The studies that have been conducted by physicians such as Darin Workman, Alan Watson, and Janet Horvath have resulted in extensive development of methods for rehabilitation, but they pay little attention to prevention through diet and physiology. My research shows that injury prevention is more efficient and cost-effective than post injury rehabilitation for maintaining a healthy career as a percussionist. A rehabilitative process only occurs

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[5] Darin Workman, *The Percussionists Guide to Injury Treatment and Prevention: The Answer Guide to Drummers in Pain (*Routledge, 2006), 25-49.
[6] Alice G. Brandfonbrener, "Epidemiology of the Medical Problems of Performing Artists," in *Textbook of Performing Arts Medicine*, ed. Brandfonbrener Sataloff Lederman (New York: Raven Press, 1991), 31.

through heightened attentiveness to physiology after a part of the body fails to work as expected, predominately due to a lack of attention to physical fitness in the educational curriculum for musicians. Furthermore, in the past many percussionists have erroneously rated their practice sessions by how poorly their bodies felt rather than by evaluating musical outcomes. With today's percussionists thinking more about their health, my research and preventative tools offer even greater positive effects when incorporating nutrition and physiological development into practice sessions, performance, and the percussionist's general well-being.

Current methods of rehabilitation include acupuncture, chiropractic therapy, cold or heat therapy, drugs such as ibuprofen, periods of rest, massage, stretching, and methods of re-conditioning an area of the body by working on rudimentary technique. Acupuncture belongs to a family of processes that incorporates stimulation of anatomical locations using various methodologies on the skin. This theory is based on the notion that the energy stream through the body is very crucial for health. Chiropractic therapy is a form of care that manipulates and mobilizes parts of the musculoskeletal system. In this type of therapy, drugs are not used. Instead, therapy, dietary, and rehabilitative exercise and lifestyle counseling are more applicable. Massage is an effort to eliminate pain through rubbing and kneading of the body and joints. Stretching is a form of exercise that improves muscular strength and joint flexibility. Cold therapy typically uses water or ice applied directly to areas of the body that are swollen after a period of physical exercise. By using cold therapy swelling immediately is reduced and lactic acid begins to be flushed from the body, allowing the body to heal more rapidly. Heat therapy has been used in the past in a similar manner to ice therapy, but can only relieve muscle tension or

chronic pain. Finally, drugs such as ibuprofen can provide relief from pain and inflammation after physical exertion, but have also been shown to reduce muscle protein synthesis.[7] The aforementioned methods of rehabilitation serve as effective resources to heal injury and relieve pain, but do not prevent injury from occurring. Re-conditioning the body to develop techniques that help prevent injury serves as the only method of prevention currently available, however, repetitive and extreme stress on the shoulder, forearm, wrist, hands, and fingers is unavoidable when performing on instruments such as congas, snare drum, and marimba.

Research performed by Petre Teodorescu affirms that kinetic energy corresponds to the applications of some percussive forces on a distinct mechanical system.[8] This concept relates to continuous hand movement while striking a drum. A study conducted by Monica Milanovich and Steven Nesbit indicates that the radius path of the hand plays an important role in directional path by gaining power over centripetal forces as noted in sporting activities.[9] This is a direct correlation to the swing mechanism of a hand and practical application in drumming.

The Council on Sports Medicine and Fitness recommends that resistance training is suitable for both children and adults, showing substantial impact on the strengthening of muscles and the prevention of injuries through several measurable health indicators such as muscle size and increased efficiency in recorded strength tests.[10] Daniel Becque, John Lochmann, and Donald Melrose explain that nutrition and dietary supplementation

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[7] Joel Krentz, et al., "The effects of ibuprofen on muscle hypertrophy, strength, and soreness during resistance training." *Applied Physiology, Nutrition, and Metabolism* 33.3 (2008): 470-475.
[8] Petre Teodorescu, *Mechanical Systems, Classical Models* (Dordrecht: Springer, 2007), 17.
[9] Monica Milanovich and Steven Nesbit. 2014. "A Three-Dimensional Kinematic and Kinetic Study of the College-Level Female Softball Swing," *Journal of Sports Science & Medicine* 13, no. 1: 187.
[10] Council on Sports Medicine and Fitness, "Strength Training for Children and Adolescents, 2008" *The American Academy of Pediatrics* 107 no. 6: 1470.

found in physical fitness have great effect on human performance in areas such as increased speed on studied treadmill exercises, and increased power on studied resistance exercises. Both affirm that ingesting an oral creatine supplement, that provides the same effect as the naturally occurring metabolite, before arm bending activities is of great value to training, leading to greater impact in arm flexor muscular strength, more flexibility in the upper extremity, and gains of fat free mass compared to strength training alone.[11]

Becky Dorner and Mary Posthauer reveal that 45% of elder adults in the USA are affected by sarcopenia**,** meaning 'poverty of flesh.**'** This is a condition characterized by loss of muscle mass resulting in mobility issues, fractures, falls due to a lack of physical activity, and decline in caloric and protein intake as recommended by nutritionists. In such cases, the key nutritional recommendation includes protein of 0.8 g/kg of body weight per day.[12] Dorner and Posthauer clarify that metabolic changes in adults lead to less protein production.[13] Protein supplementation of 15 to 20 grams leads to an increase of muscle strength as a result of resistance exercise, and 25 grams of creatine advances the effect of exercise on sarcopenic individuals.[14]

Tissue metabolism, more so than muscle volume, is an effective way of examining the response of muscle to protein in the context of exercise and nutrition. However, as explained by Tipton and Wolfe, this issue is surrounded with many questions concerning the amount of protein required to ensure effective resistance

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[11] Daniel Becque, John Lochmann and Donald Melrose. "Physical Fitness and Performance Effects of Oral Creatine Supplementation on Muscular Strength and Body Composition, 2000" *Physical Fitness and Performance* 32 no. 3: 656.
[12] Kevin D. Tipton and Robert R. Wolfe, "Protein and Amino Acids for Athletes" *Journal of Sports Sciences* 22 (2004), 1.
[13] Becky Dorner and Mary Posthauer. "Nutrition's Role in Sarcopenia Prevention, 2012" *Today's Dietitian* 14 no. 9: 62.
[14] Ibid.

training for muscle building. In the context of athletes, an increase in protein has great influence in overall body and muscle nitrogen balance.[15] Similarly, Wolfe and Tipton clarify that both endurance and resistance exercises result in an increase in mixed muscle protein synthesis, meaning that these activities enhance the way the body adapts to physical activity.[16]

Avery Faigenbaum clarifies that injury related to youth resistance training is associated to poor training techniques and lack of dietary support**.** He advocates that the practice of a balanced diet and resistance training lead to stronger body muscles. Most importantly, this combination reduces chances of injury. For effective resistance training, nutritious food is required. The National Health and Nutrition Examination Survey in 2010 revealed than average American women consumed 70.1 grams of protein per day and the average American man consumed 101.9 grams of protein per day.[17] However, the Center for Disease Control and Prevention (CDC) recommends that adult women in a healthy weight range consume 46 grams of protein daily and adult men in a healthy weight range consume 56 grams of protein daily.[18] People who engage in resistance training require more than the CDC's recommendations in order to support muscle repair, and increase bone and muscle growth. However, sedentary adults who consume the amounts of protein the National Health and Nutrition Examination Survey found, may find negative side effects of this high-protein diet such as weight gain, increased risk of heart disease, and fatigue.[19]

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[15] Tipton and Wolfe, "Protein and Amino Acids for Athletes" 67.
[16] Tipton and Wolfe, "Protein and Amino Acids for Athletes," 70.
[17] National Center for Health Statistics, "Adults' daily protein intake much more than recommended," *The Blog of the National Center for Health Statistics*, http://nchstats.com/category/nhanes/ (accessed 4.16.14).
[18] Center for Disease Control and Prevention, "Protein," *Nutrition for Everyone*, http://www.cdc.gov/nutrition/everyone/basics/protein.html (accessed 4.16.14)
[19] CK-12 Foundation, *Human Biology: Digestion and Nutrition*, (CK-12 Foundation, 2012), 185.

The American Alliance for Health, Physical Education, Recreation, and Dance, recommends that physical activities including dancing, skipping, and balancing can lead to improved human performance. The organization clarifies that physical and nutritional education has a great impact on human movement.[20] Despite positive effects attributed to both physical and nutritional education, most school curricula only provide limited amounts of time devoted to these subject areas.[21]

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[20] Bradley J. Cardinal, Felicity M. Powell, and Miyoung Lee. "Trends in International Research Presented Through the Research Consortium of the American Alliance for Health, Physical Education, Recreation and Dance (1965–2008)." *Research Quarterly for Exercise and Sport* 80, no. 3 (2009): 454-459. http://dx.doi.org/10.1080/02701367.2009.10599583 (accessed February 1, 2014).

[21] Mary Story, Marilyn S. Nanney, and Marlene B. Schwartz. "Schools And Obesity Prevention: Creating School Environments And Policies To Promote Healthy Eating And Physical Activity."*Milbank Quarterly* 87.1 (2009): 71-100.*The Milbank Quarterly*. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2879179/ (accessed June 14, 2014).

CHAPTER TWO: CARPAL TUNNEL SYNDROME

Carpal tunnel syndrome is a direct result of compression of the median nerve at the wrist and is one of the most prevalent injuries among performing musicians. The design of the human body makes us susceptible to this injury, making the surgical cure (carpal tunnel release) one of the most common surgeries in the United States.[22] The median nerve extends from the neck down through the arm and carpal tunnel at the base of the wrist to supply the thumb, index, middle, and ring finger with motor innervation. The nerve sends impulses from the hand and fingers that consequently control the motion of the fingers and thumb. The carpal tunnel, which the median nerve runs through, is a narrow tunnel that makes it more susceptible to injury than other nerves because of the tight space the nerve must travel through. In the carpal tunnel, the median nerve is surrounded by flexor tendons that swell and compress the nerve during or after periods of physical stress involving the shoulder, forearm, wrist, hand, or fingers. This added swelling may result in less mobility and severe, or chronic pain due to overuse, repetitive stress, or unnatural pressure being applied to the median nerve.[23] Aside from pain, symptoms of compression of the median nerve include: numbness in the fingers, pain in gripping, tingling in the hand, decreased grip strength, and reduced object control precision.[24]

There are several parts of the body that contribute to carpal tunnel syndrome. These parts are the median nerve, shoulder, forearm, wrist, hand, and fingers. The injuries caused by this syndrome are classified as mild (grade 1), mild (grade 2),

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[22] National Institute of Neurological Disorders and Stroke, "Carpal Tunnel Syndrome Fact Sheet," http://www.ninds.nih.gov/disorders/carpal_tunnel/detail_carpal_tunnel.htm (accessed 4.16.14).
[23] Darin Workman, "Carpal Tunnel Syndrome," *Percussive Notes* (June 2003): 8-13.
[24] Hyunkook Jang, "The Effects of Dynamic Wrist Workloads in Risk of Carpal Tunnel Syndrome" (Doctor of Philosophy, The Pennsylvania State University), 1.

moderate (grade 3), or severe (grade 4). An example of a severe injury refers to compression neuropathy where constant numbing occurs in the hand and fingers and grip strength is significantly reduced. Carpal tunnel syndrome belongs to two groups of injuries called compression neuropathy and entrapment neuropathy.[25] The most common entrapment neuropathy syndromes are carpal tunnel and cubital tunnel. Compression and entrapment neuropathy result from exertion of pressure over a point in a nerve as it travels from the upper limb downwards. The compression hinders transmission of nerve impulses throughout the affected area such as the palm side of the hand, the thumb, and fingers. In most cases this condition results in a loss of sensation and reduced mobility in the thumb and fingers. At times, this is accompanied by a sharp feeling of pain.

A third common compression neuropathy is ulna neuropathy. Ulna neuropathy is second only to carpal neuropathy in frequency of occurrence. Ulna neuropathy results from compression of the ulna nerve at the wrist, or elbow region. This nerve passes through the cubital tunnel, which is located at the elbow. External compression forces such as the continuous impact related to playing congas can also cause ulna neuropathy.[26] This neuropathy is one of the most common injuries in the upper extremity region of the human hand.

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[25] Richard Lederman, "Neurological Problems of Performing Artists," in *Textbook of Performing Arts Medicine*, ed. Brandfonbrener Sataloff Lederman (New York: Raven Press, 1991), 171-183.
[26] R. Luchetti, & P.C. Amadio, *Carpal Tunnel Syndrome*. (Berlin: Springer, 2011.), 11.

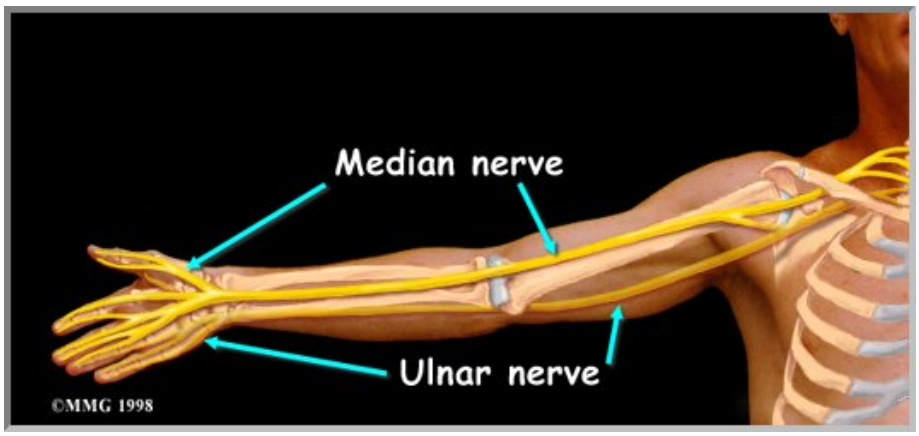

Figure 1. The median and ulnar nerves running through the upper extremity[27]

Repetitive movement such as constant striking of an instrument can stress the median nerve at the shoulder resulting in injury.[28] Most of the physically strenuous jobs such as carrying heavy instruments or using large motions to play percussion are done using the shoulders. The movements required in practicing, or performing on instruments such as drum set, multiple percussion, or many world percussion instruments result in repetitive stress to the median nerve in the shoulder region, consequently leading to greater risk of carpal tunnel syndrome. The shoulder has the largest range of motion of any joint in the body; however, this mobility creates instability because the shoulder can move on many different planes. It is imperative to enhance muscular stability through the strengthening of connective tissue in this region because the shoulder is necessary in delivering the rest of the arm to the point of impact for most percussive strokes.[29] If the shoulder in unstable, the likelihood for injury in the forearm, wrist, hand, and fingers

[27] Medical Multimedia Group, *A Patient's Guide to Open Carpal Tunnel Release* (Missoula, MT: Medical Multimedia Group, 2003a).
[28] Gregory Lehman, "Resistance Training for Performance and Injury Prevention in Golf," *Journal of the Canadian Chiropractic Association* 50, no. 1 (2006).
[29] Darin Workman, "The Percussionist's Shoulder: Rehabilitation in Practice," *Percussive Notes* February (1993): 72.

rises due to overcompensation by muscle groups that are not naturally adapted to perform these desired tasks.[30]

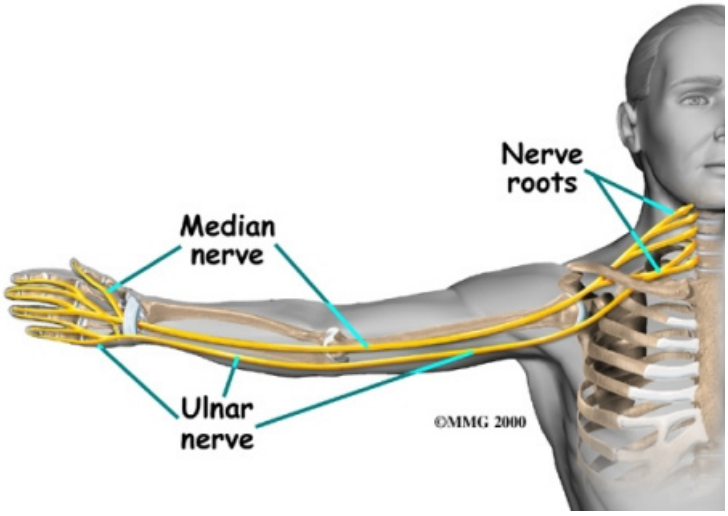

Figure 2. Median Nerve at the Elbow[31]

The forearm consists of two bones, the radius (which runs down the thumb side of the arm) and the ulna (which runs down the pinky side of the arm). Both of these bones attach at the elbow enabling a rotating motion on a single plain.[32] The median nerve provides sensory information for the muscles of the forearm. This complex series of muscles surrounds the radius and ulna bones, which include the abductor pollicis longus, anconeus, brachioradialis, extensor carpi, radialis brevis, extensor carpi radialis longus,

[30] Bronwen Ackermann, Roger Adams and Elfreda Marshall, "Strength of Endurance Training for Undergraduate Music Majors at a University," *Medical Problems of Performing Artists* (March 2002): 33-41.
[31] Medical Multimedia Group, *Median Nerve at the Elbow* (Missoula, MT: Medical Multimedia Group, 2000).
[32] Alan Watson, *The Biology of Musical Performance and Performance Related Injury* (Lanham, Md.: Scarecrow Press, 2009), 392 (accessed 2.1.13).

extensor carpi ulnaris, extensor digiti minimi, extensor digitorum, extensor pollicis brevis, extensor retinaculum, and flexor carpi ulnaris.[33]

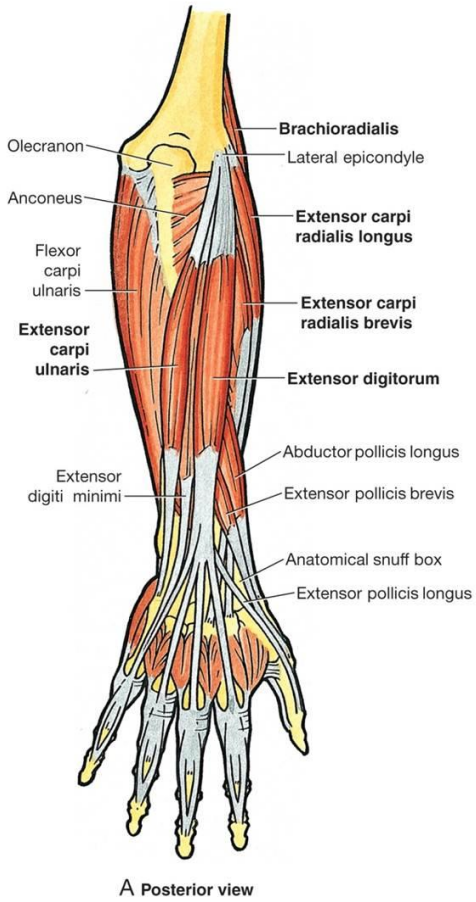

Figure 3. A Posterior View of the Forearm[34]

Pronation and supination (rotation at the wrist when the hand moves from palm side up to palm side down) are the specific movements that are controlled by the aforementioned

[33] Daniel H. Matulionis, "A Functional Study of the Forearm Musculature of the Human and Macaca Mulatta," *BIOS* 37, no. 1 (Mar., 1966): 3-14, http://www.jstor.org/stable/4606638 (accessed 2/23/2013
[34] "Flashcards - kinesiology final – Trapezius (action application of trapezius | StudyBlue." *StudyBlue*. N.p., n.d. Web, http://www.studyblue.com/notes/note/n/kinesiology-final/deck/2928212 (accessed 4/21/2014).

group of muscles.[35] The group of muscles in the forearm also serve two other functions: wrist movement involving flexion, extension, abduction and adduction, and grip.[36] Flexion in the wrist occurs when the fingers are extended, the palm is facing down, and the wrist is bent downward. Extension in the wrist occurs when the fingers are extended, the palm is facing down, and the wrist is bent upward. Abduction in the wrist occurs when the fingers are extended, the palm is facing down, and the wrist bends so that the thumb moved closer to the body. Adduction in the wrist occurs when the wrist occurs when the fingers are extended, the palm is facing down, and the wrist bends so that the thumb moves away from the body. These motions produce many percussion-related strokes. For example, when playing snare drum wrist flexion brings the stick to the drumhead and wrist extension brings the stick away from the drumhead. Wrist abduction and adduction are typically used when performing block chords on keyboard percussion instruments that have one natural and one accidental voiced in each hand simultaneously.

The median nerve passes through the wrist, hand, and innervates the fingers and is responsible for coordination of motion in the hand and fingers. This nerve's impairment therefore hinders mobility of hand and fingers resulting in a lack of physical facility to perform on percussion instruments. Any injury in the forearm that results in partial injury of the median nerve can lead to carpal tunnel syndrome. Carpal tunnel syndrome occurs when the flexor muscles that surround the median nerve in the wrist swell and exert pressure on the median nerve. This pressure results in compression of the nerve and consequent injury. Repetitive actions that involve the hand or fingers, such as drumming techniques that engage in repetitive finger motion, many frame drumming techniques, or

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[35] Ibid.
[36] Jang, *The Effects of Dynamic Wrist Workloads in Risk of Carpal Tunnel Syndrome*, 1.

tabla techniques, can contribute greatly to stress on, or compression of the median nerve. When this compression results in injury, the individual can develop carpal tunnel syndrome to some degree. Great physical trauma involving these regions can also injure the median nerve and contribute to carpal tunnel syndrome.[37] Performing on percussion instruments such as snare drum with a tight grip and tensed muscles in the shoulder, forearm, wrist, fingers, and thumb may result in great physical trauma, even if the action is not repetitive.

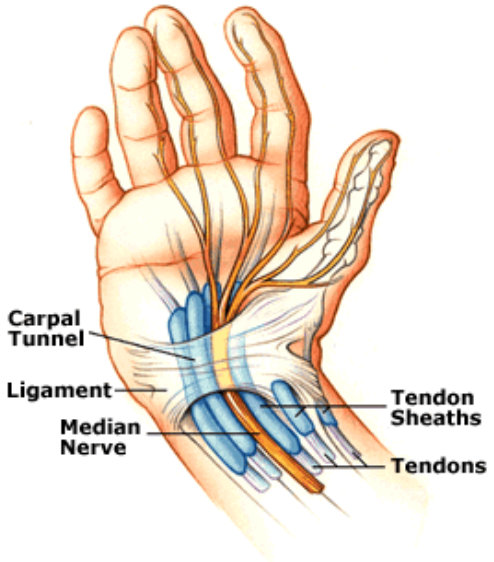

Figure 4. The Median Nerve Passing Through the Carpal Tunnel [38]

The causes of injury to the median nerve may vary from severe traumatic experiences to mild repeated actions involving the hands and fingers. These actions contribute to an increase in stress, compression, and injury of the median nerve. The

[37] Suparna Damany, and Jack Bellis, *It's Not Carpal Tunnel Syndrome!: RSI Theory and Therapy for Computer Professionals*. (Philadelphia: Simax, 2000).
[38] Medical Multimedia Group, *A Patient's Guide to Open Carpal Tunnel Release*. (Missoula, MT: Medical Multimedia Group, 2000).

repetitive actions that result in stressing the nerves are cumulatively referred to as repetitive motion disorders. For percussionists, these disorders are manifested from various gestures such as repeated strokes on a drum, or from absorbed vibration as a result of tense practice or performance with a mallet or stick. Both contribute to stress on the median nerve and can cause injury. Sudden extreme stress can also cause injury to the median nerve due to stretching or compressing of the nerve. Carpal tunnel syndrome results in both loss of mobility and stiffness in the hand and fingers, especially the thumb. This is primarily because of median nerve impulse transmission impairment.

Several symptoms associated with carpal tunnel syndrome including: loss of mobility, feeling of numbness, swelling of the fingers, and a general feeling of weakness in the fingers and hand. In addition, sharp pain is often felt in the hand, wrist and elbow region. This pain is experienced when the median nerve is compressed or injured, which is usually accompanied by swelling of fingers.

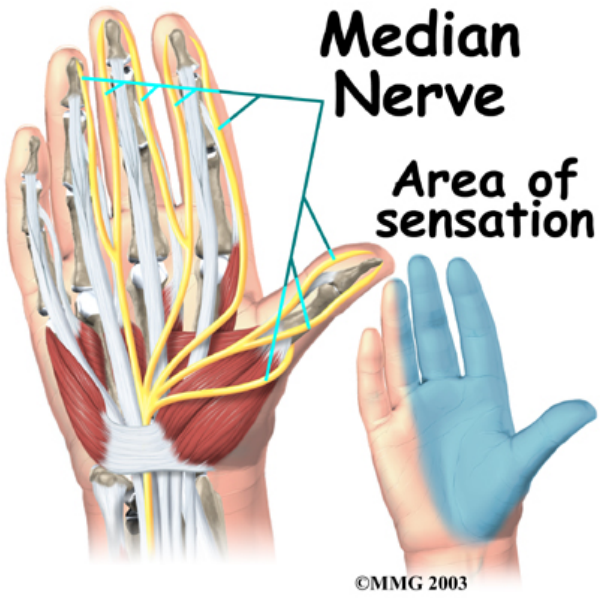

Figure 5. Median Nerve in the Wrist and Hand[39]

Methods of prevention for carpal tunnel syndrome include carefully avoiding overworking, or stressing the wrist, hand and fingers. Having resting periods after practice or performance helps to prevent overworking the hands and/or fingers. Regular exercises and a healthy diet are some of the preventive measures that diminish the development of conditions such as diabetes and obesity that contribute greatly to carpal tunnel syndrome.[40] Obesity and diabetes can often cause insufficient blood flow to certain nerves, making the body's nerves more susceptible to compression.

Exercises designed to prevent carpal tunnel syndrome include the use of a resistance band to strengthen the flexor muscles of the wrist and avoid stress of the median nerve. By developing the muscles surrounding the median nerve the habitual stress of playing certain percussion instruments can become less detrimental. Developing

[39] Medical Multimedia Group, *Wrist Anatomy Nerve* (Missoula, MT: Medical Multimedia Group, 2003b).
[40] National Institute of Neurological Disorders and Stroke, "Carpal Tunnel Syndrome Fact Sheet," http://www.ninds.nih.gov/disorders/carpal_tunnel/detail_carpal_tunnel.htm (accessed 4.21.14).

ergonomic motions associated with playing percussion instruments can also help greatly to reduce the chances of developing carpal tunnel syndrome. Employing motions that are efficient and work with natural human physiology significantly help to reduce stress on the musculoskeletal system of the upper and lower extremities. For percussionists, using performance techniques that promote proper body mechanics help prevent many performance related injuries.[41]

[41] R. Luchett, and P.C. Amadio, *Carpal Tunnel Syndrome* (Berlin: Springer, 2011.), 45.

CHAPTER THREE: TENDINITIS AND TENDINOSIS

Tendinitis refers to the inflammation of the tendons that results from injury, or repetitive actions. Tendinosis is a non-inflammatory condition that is predominately caused by overuse and is typified by degeneration of collagen fibers.[42]

Tendinitis is classified as acute inflammatory tendinitis, or true tendinitis.[43] Tendonitis based injuries are then classified according to the specific areas affected such as elbow tendinopathy, partellar (kneecap) and Achilles tendinopathies, as well as rotator cuff tendinopathy. Examples of this classification would be Achilles tendinitis, which affects the Achilles tendon that connects calf muscle to heel bone; rotator cuff tendinopathy, which affects the muscles and tendons that surround the shoulder region; patellar tendinopathy, which affects the patellar tendons, and elbow tendinopathy, which affects the elbow tendons.[44]

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[42] Karim Khan, et al. "Overuse Tendinosis, Not Tendinitis," *The Physician and Sports Medicine* 28, no. 5 (May 2000).
[43] Heber Murray, "Tendinosis Vs. Tendinitis," Elite Sports Therapy, http://www.elitesportstherapy.com/tendinosis-vs--tendinitis (accessed March 25, 2013).
[44] Edward Holtman, *Tendinitis Can Be Cured: Cure Yourself of Tendinitis*. (Bloomington, IN: AuthorHouse, 2009).

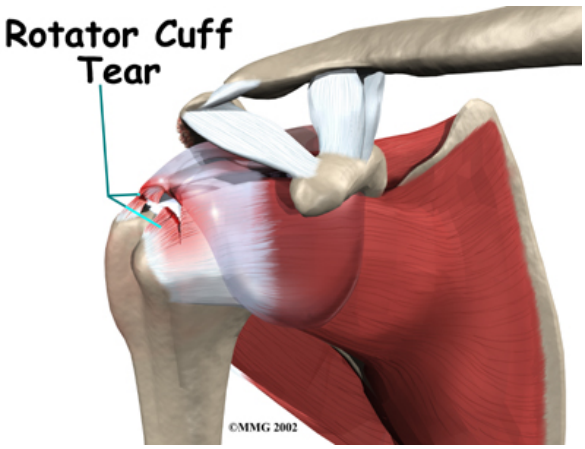

Figure 6. Rotator Cuff Tear[45]

Tendinitis is caused by mechanical stress, which is exerted to the tendons either by traumatic injury or by repetitive action of the upper or lower extremities. Overstretching, or sudden extreme stress of the tendons also results in damage of the tendon.[46] This type of stress may occur when percussionists use large motions to create a stroke on instruments such as concert bass drum, or orchestral cymbal crashes.

For percussionists, tendinitis occurs due to the high frequency in which we use our upper and lower extremities (arm from shoulder to fingers and leg from hip to toes) to perform in a repetitive fashion. The physical abrasion the tendons located near the shoulder and elbow incur are of particular concern. The rotator cuff tendons, located in the shoulder region, and common extensor tendons, located in the elbow region, are very susceptible to injury because they are activated when performing strokes that require a large motion.

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[45] Medical Multimedia Group, *Median Nerve at the Elbow* (Missoula, MT: Medical Multimedia Group, 2000).
[46] Elaine Harniman et al. "Extracorporeal Shock Wave Therapy for Calcific and Noncalcific Tendinitis of the Rotator Cuff: A Systematic Review," *Journal of Hand Therapy,* 17 vol. 2, 137.

Tendinosis occurs when microtears damage the cells of a tendon. Tennis elbow is a form of tendinosis that occurs in the forearm, and is often confused with a form of tendinitis. When someone is diagnosed with the injury known as tennis elbow the common extensor tendon is damaged at the lateral epicondyle. The lateral epicondyle serves as an attachment point at the elbow for the common extensor tendon, allowing for forearm and wrist motion. These tendons attach the lateral epicondyle to the muscles that extend the wrist. Performing on percussion instruments in ensembles such as marching percussion require the type of repetitive actions that may lead to the development of lateral epicondilitis.

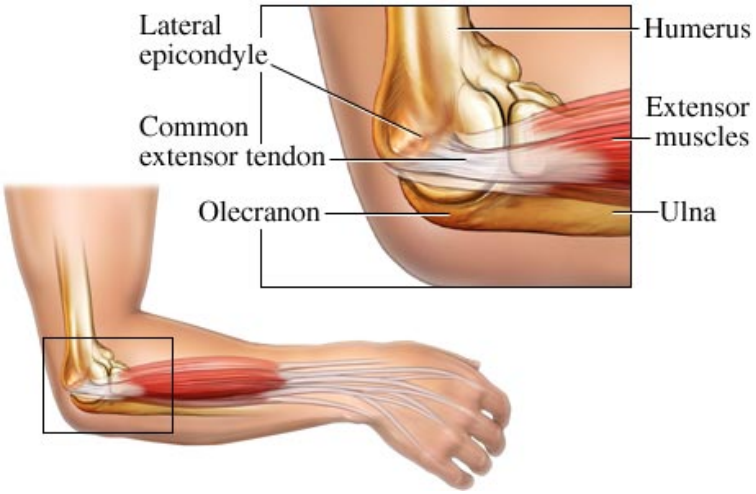

Figure 7. Common Extensor Tendon[47]

The common extensor tendon connects to multiple muscles that are activated when the elbow is extended and when the wrist is bent toward the forearm. This form of

[47] Health Line Info, *Tennis Elbow*, 2012), http://www.howardluksmd.com/sports-medicine/tennis-elbow-prp-luks-westchester-ny/.

tendinosis is of particular concern for percussionists because of inherent wrist flexion and extension when performing percussive strokes. Factors that contribute to tendinitis and tendinosis include overuse, improper technique, stress and lack of conditioning.[48]

Progressive resistance training is a method of building strength and dexterity through eccentric and concentric motions, and increasing variable weight by small increments, while plyometric exercises use the force of resistance from bodyweight, and are designed to build speed and strength in order to produce the most force in the least amount of time.[49] Plyometric exercises typically use someone's own bodyweight to create a force of resistance. In contrast, resistance training typically uses free weights, resistance bands, or machinery to generate a force again the direction of motion. Muscles that are not properly conditioned to perform specific tasks are more susceptible to damage. To properly condition the body to perform, muscles in the forearm, upper arm, shoulder, and upper back must be strengthened to increase stability in the elbow.[50]

Tendons are pieces of connective tissue made predominately of collagen that connect muscles to bones.[51] The proteins in collagen fibers weave together to create strong pieces of connective tissue that together connect to bone, making strong bonds, that allow the body to move. When tendons are injured, the related muscle groups fail to perform their designed tasks to an optimal level. Early detection signs of conditions such as tendinosis and tendinitis include pain in the elbow, sharp or constant pain from wrist movement/gripping, and stiffness. Symptoms of tendinitis include pain when moving,

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[48] A. Sinclair, "Tennis Elbow in Industry," *British Journal of Industrial Medicine* 22, no. 2 (Apr., 1965): 144-148, http://www.jstor.org/stable/27722030 (accessed 3/26/2013).
[49] John Paulson, *Plyometrics and Plyometric Training* (Online: Amazon Digital Services, 18.
[50] Mayo Clinic Staff, "Tennis Elbow," Mayo Clinic Information and Toold for Healthy Living, http://www.mayoclinic.com/health/tennis-elbow/DS00469 (2013).
[51] Richard Bennett, *How to Cure Your Tennis Elbow: The Best, Up-to-Date Treatments and most Effective Exercises to Eliminate Your Painful Symptoms; the Brace and Exercise Band to use; Your Prognosis and Prevention* (Online: Free Journalists, 2012), 41.

pain when sleeping at night and feeling of tenderness along the tendon. Other symptoms include swelling of the affected tendon and area in which it occurs accompanied by redness of the area; a lump can also form along the tendon. A feeling of weakness or stiffness in the affected area is also common.

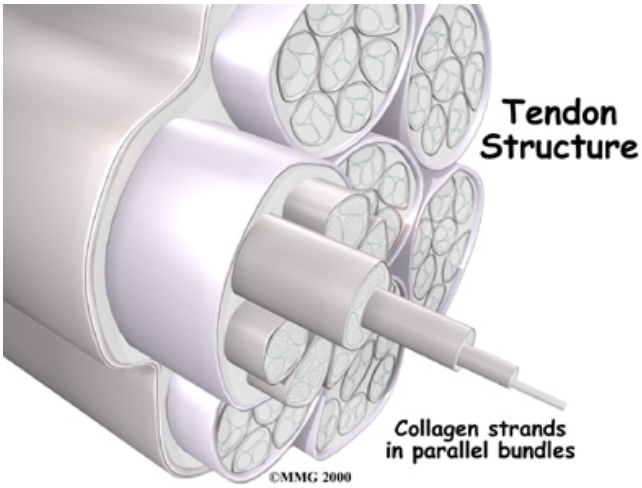

Figure 8. Tendon Structure[52]

Tendinitis can be prevented in various ways such as using resistance band wrist curls to strengthen the wrist tendons and prevent their mechanical damage, thoroughly warming-up to avoid sudden shock to applicable muscle groups, and performing with ergonomic techniques. Resting after a long period of activity is also a good way of preventing tendinitis.[53] Keeping the motion of the limbs in line with each other helps to avoid side loading of a joint. This reduces exertion of pressure to the tendons and helps to prevent tendinitis. Keeping a constant motion over time prevents the overloading of weight to the various body parts. Sitting for a extended periods of time is not recommended, because it puts a lot of pressure on only one part of the body. When seated

[52] Medical Multimedia Group, *Median Nerve at the Elbow*
[53] Harninman et al, Extracorporeal Shock Wave Therapy for Calcific and Noncalcific Tendinitis of the Rotator Cuff: A Systematic Review, 140.

and performing on percussion instruments, it is recommended that the performer adjust their posture to ensure proper distribution of weight. Maintenance of good cardiovascular health helps to increase blood flow to tendons. This increases the tendon health as well as strength, and enables them to resist pressure from stretching and compression. Maintaining a healthy weight also contributes greatly to easing the pressure on tendons.

CHAPTER FOUR: BURSITIS

Throughout the body, there are organisms called bursae, which are slippery sacs containing synovial fluid. The primary task of the bursae and synovial fluid are to reduce the friction between joints and tissue that move in different directions. Multiple bursa are termed bursae, and are positioned around the bones and serve as padding between muscles and tendons and the bone. For example, in front of the knee or behind the elbow, bursae are present to permit the joint to move with minimal friction action against the skin. Inflammation of the bursae, means that the bursa has lost the gliding motion due to being swollen. This causes a space shortage in the room set apart for movement of bones and tendons and is the cause of the injury known as bursitis.[54] There is no official classification scheme for bursitis, however, it is described according to the site of the affected bursa such as the ankle, knee, elbow, hip or shoulder.[55]

There are two types of bursae associaed with bursitis. Constant bursae, which are formed during early childhood are located between bones, skin, or tendons and have synovial cells that emit a lubricating fluid that create ease of movement between two different surfaces, and, adventitial bursae, which form later in life as a result of recurring trauma, or though pressure and friction and are considered abnormalities. Since they are abnormalities, adventitial bursae do not have synovial fluid and they either develop over a benign tumor (known as osteochondroma), or bunions that usually appear on the toes. [56]

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[54] Karen Salzman, Wade Lillegard, Janus Butcher, "Upper Extremity Bursitis." *American Family Physician*, *56* (2007), 1801.
[55] Ibid.
[56] F. Colas, and J. Nevoux, "The Subscapular and Subcoracoid Bursae: Descriptive and Functional Anatomy." *Journal of Shoulder and Elbow Surgery*, *13* (4) (2004), 455.

Percussive movements that engage the shoulder may damage bursae especially when performing on hand drums such as congas, timbao, or cajon because the shoulder is often used to produce strokes for these instruments. The shoulder is an intricate joint where a number of bones, ligaments and muscles connect to the upper extremity and to the chest. The shoulder is responsible for delivering the hand to a desired location making it very active in percussion performance. [57] Even if the hand, wrist, and fingers are engaged to produce a particular stroke on an instrument such as concert snare drum, the shoulder must stabilize the rest of the upper extremity so that the hand, wrist, and fingers may complete their tasks. Bursae in the shoulder are engaged when the arm moves away from the body. They also glide under the shoulder blade when the upper extremity (arm from shoulder to elbow) is raised. Shoulder bursitis occurs when there is a swelling and thickening in the bursa between the top of the humerus, also known as the arm bone, and the acromion, which is the protrusion of the shoulder blade.[58] Between the arm and the protrusion of the shoulder blade are the rotator cuff tendons and the bursae that protect the tendons. In normal movement, the tendons slide easily within the space between the bones. However, when stressed, the space becomes too narrow and eventually leads to the bursae and tendons becoming inflamed. As a result of swelling and thickening, the space around the bursae gets so small that every time the tendons move the bursae are pinched.[59] Repetitive use of the shoulder, as required when performing on many world percussion instruments, may cause irritation and damage to the bursae and cause bursitis. Early symptoms of bursitis include pain in the upper arm, stiffness in the upper arm, and

[57] Ibid, 458.
[58] Salzman et al., 1806.
[59] Ibid, 1809.

trouble lifting using the upper extremity.[60] Although there are many symptoms that may indicate the development of bursitis, the only confirming methods of diagnosis are x-ray or ultrasound imaging and blood tests.

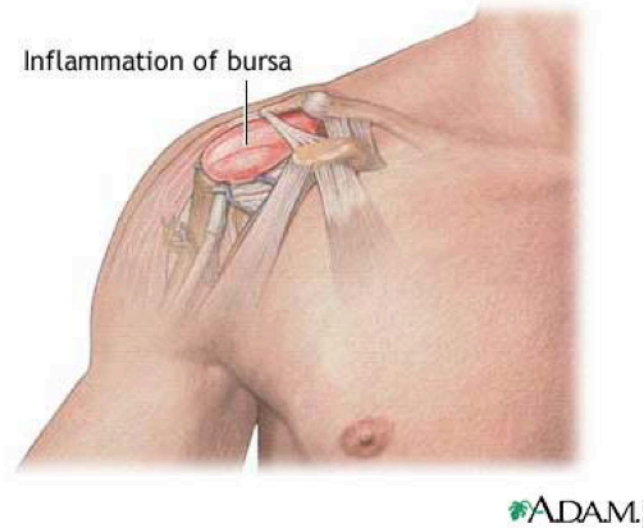

Figure 9. Inflamed bursa in the shoulder. [61]

The shoulder is especially susceptible to bursitis due to the extended range of motion of the rotator cuff. [62] The rotator cuff is responsible for providing stability in the shoulder and consists of the tendon ends of the supraspinatus; the infraspinatus; the teres minor; and the subscapularis. The supraspinatus allows for abduction of the arm at the shoulder. The infraspinatus stabilizes the shoulder and rotates the arm externally. The teres minor allows for lateral movement of the arm from the shoulder, and, subscapularis

[60] Janet Horvath, *Playing Less Hurt: An Injury Prevention Guide for Musicians* (New York: Hal Leonard, 2010), 256.
[61] A.D.A.M. Images, *Normal Palmar Carpal Ligament*Adam Medical Sales, 2007).
[62] Workman, *The Percussionist's Shoulder: Rehabilitation in Practice*, 72.

allows the arm to turn inward towards the body.[63] Due to the repetitive movement associated with playing percussion instruments special attention should be paid to the shoulder. It is advantageous to enhance the muscular stability in the region around the rotator cuff through the strengthening of these tendons because the shoulder is necessary in delivering the rest of the arm to the point of impact for a stroke.[64] If the shoulder is unstable, the likelihood for injury in the forearm, wrist, hand and fingers rises due to overcompensation by muscle groups that are not adapted to perform a specific task.[65] The shoulder is also the final joint to absorb shock while playing; this puts excess stress on the joint and creates micro-tears in the rotator cuff. This author recommends a *free rebound* approach to drumming to assist in the reduction of absorbed vibrations, consequently reducing the risk of bursitis. *Free rebound* is an approach to playing percussion instruments that uses as little tension as necessary to produce a stroke with the intent of allowing the stick, or mallet to vibrate as much as possible without physical resistance. This approach also reduces the amount of shock the body absorbs from playing percussion instruments because the playing implement is allowed to absorb residual energy instead of the body.

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[63] Ibid.
[64] Ibid.
[65] Ackermann, Adams and Marshall, *Strength of Endurance Training for Undergraduate Music Majors at a University*, 33-41.

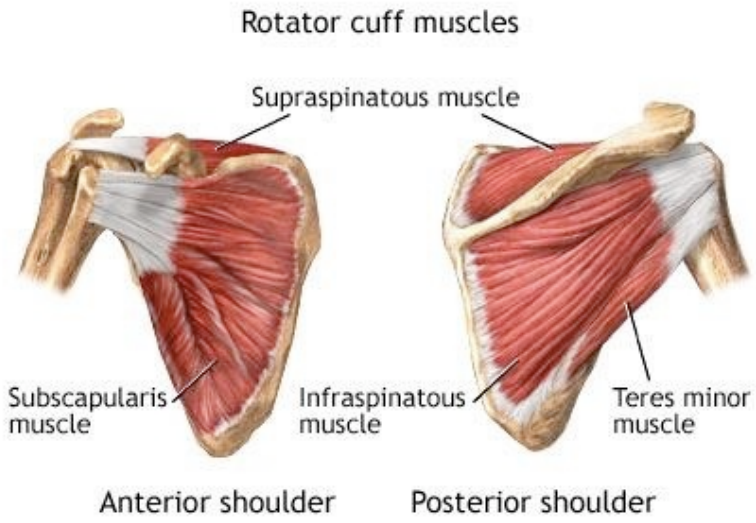

Figure 10. Rotator cuff muscles[66]

There are three upper extremity bursae that can be affected by bursitis: the olecranon bursae, which are located at the olecranon bone that connects to the humerus at the elbow and runs through the forearm; the subacromial bursae, which are located at the boney area known as the acromian, or shoulder blade, and; the subscapular bursae, which are located at the subscapularis muscle near the shoulder blade connecting to the rotator cuff. The shoulder bursitis mentioned above falls under the subacromial bursae since the shoulder is part of the upper extremity. Subscapular bursitis is the type of bursitis that is located amid the frontal surface of the scapula, which is located above the posterior wall of the chest. The subscapular bursitis is located amid the shoulder joint capsule and the tendon belonging to the subscapularis muscle. Subscapular bursitis occurs when the bursa

[66] A.D.A.M. Images, *Rotator Cuff Musclesm,* Adam Medical Sales, (2007).

between the subscapularis muscle tendon and the neck of the scapula is irritated or injured.[67]

Olecranon bursitis is caused by either a traumatic injury to the elbow, or minor injuries caused by repetitive movement such as leaning on the tip of the elbow on a solid surface, or performing for an extended amount of time on a snare drum, drum set, or marimba.[68] Olecranon bursitis is also informally known as students elbow or elbow bump.[69] The olecranon bursa is located between the loose skin and the bone at the rear of the elbow. In normal cases, the olecranon bursa's surface is flat and slippery but after irritation, inflammation occurs.[70] Olecranon bursitis is characterized by an accumulation of fluid in the irritated bursa.

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[67] Ibid, 1810.
[68] Floemer et al., "MRI Characteristics of Olecranon Bursitis," 32.
[69] "Bursitis Johns Hopkins Orthopaedic Surgery." Bursitis Johns Hopkins Orthopaedic Surgery. http://www.hopkinsortho.org/bursitis.html (accessed April 21, 2014).
[70] Frank Floemer, William Morrison, Greg Bongartz, Hans Ledermann, "MRI Characteristics of Olecranon Bursitis." *American Journal of Roentgenology*, *183* (2004), 30.

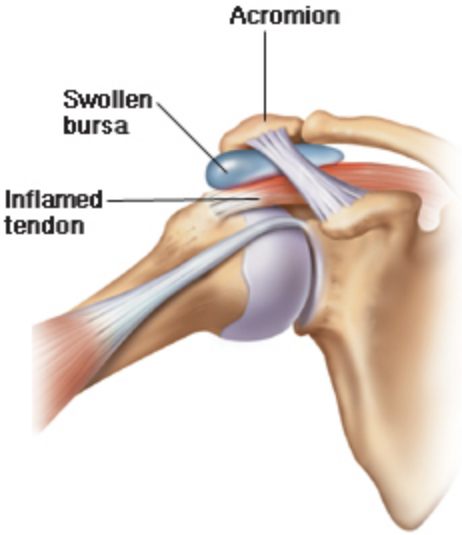

Figure 11. Shoulder Bursitis[71]

The subacromial bursa shields the movement of the supraspinatus tendon, which is located in the rotator cuff, between the humerus bone and the acromion. In most cases subacromial bursitis is caused by repetitive overuse of the tendon and injury to the bursae, which results in inflammation of the bursae. The inflammation process increases synovial cells that amplify collagen development and the production of fluid inside the bursa sac. As a result, there is a severe reduction of the synovial fluid layer outside the bursa, which acts as a lubricated surface for tendon movement.

[71] "Physio Works - Physiotherapy Brisbane." Bursitis Shoulder. http://physioworks.com.au/injuries-conditions-1/bursitis_shoulder (accessed April 21, 2014).

Figure 12. Elbow Bursitis[72]

Unlike the subacromial and olecranon bursae, subscapular bursae are more commonly inflamed because of uncharacteristic bony frames, or tissue changes that affect the movement of the scapula over the posterior wall of the chest. Such factors include unnatural, or uncommon bone structures and the advent of arthritis. However, limited internal range of motion can cause injury to the subscapularis tendon that can also lead to bursitis.[73]

One of the notable symptoms in upper extremity bursitis is pain, which occurs due to the inflamed bursa trying to establish movement. In the case of subacromial bursitis, the supraspinatus tendon is also injured which causes additional pain to that of the

[72] Medical Multimedia Group, *Muscles of the Rotator Cuff*, (Missoula, MT: Medical Multimedia Group, 2001)
[73] Colas and Nevoux, "The Subscapular and Subcoracoid Bursae: Descriptive and Functional Anatomy," 463.

inflamed bursa.[74] Stiffness also arises in upper extremity bursitis because the usually flat slippery surface of the bursa (which facilitates the movement of bones and tendons with little friction) is inflamed and has an accumulation of fluid.[75] Because of the pain and stiffness, difficulty in movement characterizes upper extremity bursitis. The difficulty in movement is linked to the pain and the loss of shoulder motion, which is formally known as adhesive capsulitis, or frozen shoulder in common terms.[76]

Among percussionists, upper extremity bursitis can be avoided through precautionary measures. Upper extremity bursitis is common among drummers because the majority of movements entail a significant amount of shoulder and elbow motion. The most important precaution to prevent upper extremity bursitis is to limit overusing the muscles in practice sessions where there are a lot of repetitive procedures. The best way to stop overusing upper extremity muscles is to establish structure in practice sessions in order to avoid unplanned and prolonged practice. Furthermore, preventing upper extremity bursitis through gradually exercising the upper extremity is an effective way for an individual to be better prepared for regular musical practice sessions.

When combined, resistance band shoulder external and internal rotation exercises are excellent workouts, and actually will help strengthen the upper extremity muscles and joints. Adopting such workouts lessen the possibility of bursitis developing. Resistance band shoulder external rotation exercises enhance the rotator cuff muscles and stretch out anterior muscles that can limit external rotation.[77] A resistance band shoulder internal rotation exercise enhances internal joint movement; more specifically, the internal range

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[74] Ibid, 466.
[75] Ibid, 467.
[76] Ibid.
[77] Colas and Nevoux, 483.

of motion. This type of exercise is best for preventing injury to the subscapularis tendon.[78] There is no defined strategy to avoid olecranon bursitis, but because constant leaning on the elbow can be hazardous, it should be avoided.[79]

Large muscle groups in the upper extremity are activated when percussionists use the shoulder to deliver their hand to a specific location. Active preparation and consistent training using resistance exercises are beneficial elements to ensure a long, injury-free career due to acclimating his body to the normal stresses percussionists must endure. Through methodical resistance training, the body is able to adapt to the excessive stress imposed by playing percussion instruments and prepare itself for any strenuous performance.

[78] Ibid, 485.
[79] Ibid.

CHAPTER FIVE: FOCAL DYSTONIA

Dystonia is a neurological ailment that is characterized by involuntary muscle contractions that manifest in unusual body positions. Focal dystonia tends to affect the areas of the body that are used the most frequently. For percussionists, these areas include the shoulder, elbow, forearm, wrist, hand, and fingers.[80] Neurologically, focal dystonia is characterized by the breakdown of the sensorimotor cortex, which encompasses the maps of the whole body controlling voluntary movement.[81]

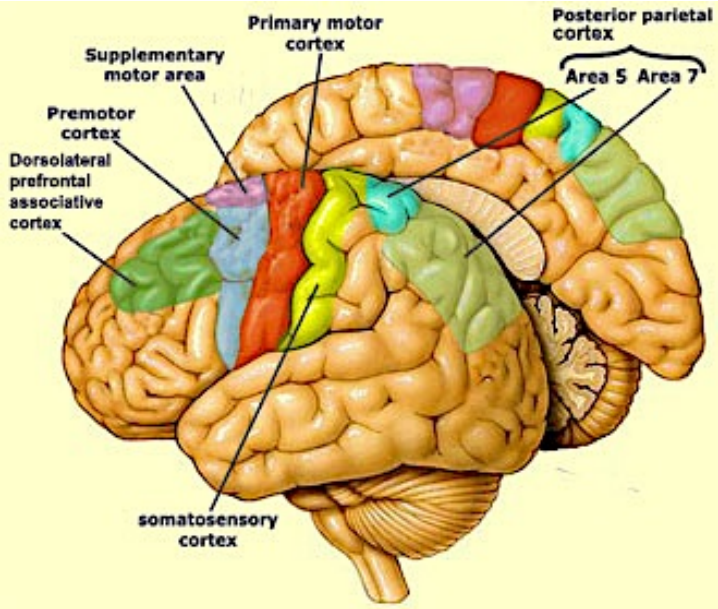

Figure 13. The Motor Cortex[82]

Under typical circumstances, when the brain tells one finger to twitch, the finger simply twitches. Furthermore, all the other fingers are silenced whereby they do not make

[80] Scott Brown, "Focal Dystonia in Musicians," *Western Journal of Medicine*, *157* (6) (2002), 679.
[81] Eckart Altenmüller and Hans Jabusch, "Focal Dystonia in Musicians: Phenomenology, Pathophysiology, Triggering Factors, and Treatment," *Medical Problem Perform Art Journal*, *25* (1) (2010), 5.
[82] *The Motor Cortex*. Digital image. *The Brain From Top to Bottom*. McGill University, Web.

any movement. But, with focal dystonia in the hand, the signals leading to the fingers overlap and, as a result, lose their specific guided boarders from the brain.[83] Consequently the brain loses selectivity because it is not able to restrain the rest of the fingers.

As a result of dysfunction in the fingers, the palm is heavily affected. In fact, most musicians have a very difficult time establishing a proper grip on their instruments due to the presence of focal dystonia. One clear example is a percussionist's ability to hold sticks or mallets. Without the ability to control the fingers, the palm is rendered ineffective.[84] Hand dystonia adversely affects the wrist and forearm because musicians affected with the ailment can experience sudden involuntary movements such as flexing and trembling.[85] For a percussionist, hand dystonia may cause the hand, involuntarily, to grip more or less during a performance making it difficult to control wrist, forearm, or finger motion.

For percussionists, focal dystonia is characterized by the breakdown of normal neurological functioning of the shoulder, elbow, forearm, wrist, hand, and fingers. The breakdown is commonly attributed to repetitive motion. According to medical tests using transcranial magnetic stimulation, doctors confirm that over training causes enlargement and overlapping in cortical maps.[86] A genetic correlation has not been proven for focal

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[83] Victor Candia, Thomas Elbert, Eckart Altenmüller, Harald Rau, Thomas Schäfer, and Edward Taub, Constraint-Induced Movement Therapy for Focal Hand Dystonia in Musicians. *The Lancet Journal*, 42 (2009), *356*.
[84] Ibid, 357
[85] Ibid.
[86] Hasegaw, Yoshiteru, Tatsuya Kasai, Hiroshi Kinoshita, and Susumu Yahagi. "Modulation of a motor evoked response to transcranial magnetic stimulation by the activity level of the first dorsal interosseous muscle in humans when grasping a stationary object with different grip widths." Neuroscience Letters299, no. 1-2 (2001): 1-4. http://www.chrisdonnellymusic.com/wp-content/uploads/2012/02/Pascual-Leone1995.pdf (accessed April 22, 2014).

dystonia, but there is an unproven hypothesis developed by Mark Hallett that claims genetically attributed loss of inhibitory interneurons, which protect the brain against overstimulation, might be the fundamental cause of the discrepancies that are studied in focal dystonia.[87]

The symptoms of focal dystonia among percussionists include lack of precision in playing instruments, an involuntary curling and extension of the fingers, an uncontrollable flexing of the wrists and forearm, swelling in the hand, wrist, and forearm, and, although uncommon, thalamic cysts may develop. The preliminary symptoms of focal dystonia are very subtle and may be evident only after extended physical exertion, fatigue, or stress. After some time, the symptoms may become more obvious or prevalent. However, focal dystonia of the hand often manifests without any pain at all.[88]

Medical research does not confirm the exact cause of focal dystonia. However, several preventive measures help percussionists avoid the ailment. A *free rebound* approach to playing percussion instruments is a useful technique that leads to less fatigue, and consequently less physical exertion. *Free rebound* allows a percussionist to use ergonomic motions to perform instead of using muscular force, aiding in the prevention of focal dystonia. The most important factor in preventing focal dystonia among percussionists is to discontinue practice when fatigued. Research shows that playing instruments or singing while fatigued forces the brain to make up new processes to make up for the lack of energy that eventually could lead to focal dystonia.[89] Percussionists should become more aware of their practice habits because a perfectionist attitude can

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[87] Hallett, Mark. "Neurophysiology of dystonia: The role of inhibition." Neurobiology of Disease 42, no. 2 (2011): 177-184.
[88] Candia, et al., 358-359.
[89] Ibid, 372-374.

increase stress levels, which tends to promote detrimental practicing habits. When such attitudes are recognized they need to be fully addressed with professional assistance, through a psychologist, due to the sensitive nature of individual psychological health.[90] When a percussionist decides to change long standing playing techniques it is very important that they understand that the abrupt change in such patterns can trigger the beginning of dystonia.[91] Developing new techniques to play different percussion instruments, or preparing for a performance may trigger this change in practice mentality. It is important for developing percussionists to acknowledge that the slow road to developing technique is much faster than the road to recovery.

[90] Brown, 683.
[91] Ibid, 387.

CHAPTER SIX: THE FUNCTION OF THE DIET IN ACHIEVING OPTIMAL PERFORMANCE

It is no secret that a well-balanced diet and proper nutrition play an important role in everyday life, but what effect can diet have on a percussionist's career? Percussionists expend tremendous amounts of energy during periods of high performance. The intensity coupled with the unusual duration of activity make percussionists especially susceptible to injury, fatigue, loss of muscle mass, and loss of bone density.[92] In order to balance the high-energy expenditures in percussion performance, high-energy intake is necessary. Although this concept seems simple (energy intake – energy expenditure = energy balance), not all calories are made equally.[93] Sheer caloric intake is only a small part of a well-balanced diet.[94]

The human body is comprised of millions of cells that require water, carbohydrates, proteins, fats, vitamins, and minerals in order to function properly.[95] Due to the physicality associated with playing percussion instruments, and repetitive motion being the primary cause of bursitis, special attention should be paid to nutrition to obtain an optimal level of performance. A proper diet should promote the health of the individual both in the short and long-term. It should help provide immunity for small ailments such as a common cold, but a

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[92] W. H. Forbes, "The Effects of Hard Physical Work upon Nutritional Requirements," *The Milbank Memorial Fund Quarterly* 23, no. 1 (Jan., 1945): 89-96, http://www.jstor.org/stable/3348004 (accessed 7/8/2013).
[93] Janet Raloff, "Nutrition," *Science News* 149, no. 18 (May 4, 1996): p. 287, http://www.jstor.org/stable/3979828 (accessed 7/8/2013).
[94] Barbara Willenberg and Melinda Hemmelgarn, "Nutrient Needs of Young Athletes," *The Elementary School Journal* 91, no. 5, Special Issue: Sports and Physical Education (May, 1991): 445-456, http://www.jstor.org/stable/1001885 (accessed 7/8/2013).
[95] Ibid.

proper diet would also help prevent muscle cramps after a long day of training, thus enhancing adaptation and recovery between and after training sessions. A balanced diet enables the percussionist to achieve optimal body weight and attain the required body fat levels for performance. A variety of foods, including wholegrain breads and cereals, leafy green vegetables, low fat dairy products, and lean meat, helps percussionists maintain balanced nutritional habits.

A properly balanced diet provides percussionists with the required energy and nutrients to meet the demands associated with training and exercise. A balanced diet reflects on musical performances prior to, during, and after the activity.[96] Knowing what types of foods to eat, when to eat these foods, and how much of these foods to consume all contribute to optimizing musical performance among percussionists. For example, meals dense with carbohydrates consumed three to four hours before performance can have a positive effect on the performance. Diets containing fat or protein however, may cause digestive discomfort during performance if consumed three to four hours before a performance.

For performing musicians, the uncertain time schedule coupled with the unavailability of fresh food may make it difficult to maintain a balanced diet. Nutritional experts insist that musicians should ensure that they consume a balanced nutritional diet in 70-80% of their daily meals.[97] This will help the body recover from processed foods that musicians might be forced to eat due to their busy schedules. Healthy snacks including apples and nuts eventually ward off the

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[96] Eleanor Whitney and Sharon Rolfes, *Understanding Nutrition* (Australia: Wadsworth, Cengage Learning, 2011), 28.
[97] A. Ralph, *Human Nutrition and Dietetics* (Edinburgh: Churchill Livingstone, 2000).

harmful effects of processed foods. Furthermore, the constant intake of nutrient-dense supplements is recommended to maintain optimal energy levels.

The consumption of fatty foods is also a topic surrounded by misconceptions. According to health science, not all fats are bad. Polyunsaturated fats contain omega-3 which contains fatty acids that are important for good health.[98] Certain nuts, fish, olive oil, avocado, and canola are full of healthy fats. During rehearsal, the normal demand for hydration can increase dramatically as exhalation and perspiration increase.[99] Large amounts of water from the body are lost in the process. Drinking water lessens fatigue and aids physical performance. Additionally, it is advisable to drink up to one half of one's body weight in ounces of water daily.[100]

Resistance training together with proper nutrition equates to a useful method of injury prevention. Routine resistance training alone is not adequate in accomplishing the goal for optimum physiological performance. According to nutritionists, physical therapists, dieticians, and physiologists, a combination of both proper diet and resistance training has passed the test of effectiveness in injury prevention. However, the question of amount of food consumption required for proper output remains a major concern to a large portion of the musical community.

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[98] Eleanor Whitney and Sharon Rolfes, *Understanding Nutrition.* (Australia: Wadsworth, Cengage Learning, 2011), 30.
[99] Ibid.
[100] Ibid.

CHAPTER SEVEN: CARBOHYDRATES

Percussionists require superior speed, strength, dexterity, and stamina during performances to perform at an optimal level. Maintaining proper blood sugar levels through the consumption of appropriate carbohydrates at the right time is an essential factor in achieving this optimal performance. As a result, proper diet and exercise should be considered equally important to practice.

The function of a dietary carbohydrate is to supply glucose that fuels the body. Glucose is the sugar that provides the body cells with energy. Carbohydrates are used in the body to spare proteins in their work of tissue building.[101] Another role of carbohydrates is fat oxidation, which is the breaking down of fat to release energy. Carbohydrates also play an important role in the gastro intestinal function in the body.[102] The sugar in carbohydrates, called lactose, promotes growth of bacteria, which helps in the synthesis of vitamin B-complex and adding flavor.[103]

Carbohydrates are the primary source of fuel for the body and can reduce muscle soreness and enhance muscle recovery.[104] They consist of branches of simple sugars and serve the function of maintaining healthy blood glucose levels during periods of activity.[105] Glucose is also a building block for carbohydrates, of which the human body depends for its primary source of energy.[106] Unlike proteins, carbohydrates in the body

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[101] Michael Clark, Scott Lucett and Rodney Corn, "NASM Essentials of Personal Fitness Training," in *Nutrition and Supplements*, eds. Michael Clark, Brian Sutton and Scott Lucett, 4th ed., Vol. 4 (Philadelphia: Jones & Bartlett Learning, 2008), 477.
[102] Ibid, 478
[103] Anna Halász and Radomir Lásztity, *Use of Yeast Biomass in Food Production*. (Boca Raton: CRC Press, 1991).
[104] Clyde Williams, "Assessment of Physical Performance," *BMJ: British Medical Journal* 309, no. 6948 (Jul. 16, 1994): 180-184, http://www.jstor.org/stable/29724193 (accessed 7/8/2013 12:53:56 PM).
[105] Ben Benardot, "Carbohydrates," in *Advanced Sports Nutrition: Second Edition* (Electronic: Heman Kinetics; 2 edition, 303.
[106] Willenberg and Hemmelgarn, *Nutrient Needs of Young Athletes*, 445-456.

have limited storage capacity. This means that *when* carbohydrates are consumed is as important as *what* carbohydrates are consumed. Although carbohydrates span a wide range of different types of food, not all serve the same function. There are two types of carbohydrates: complex and simple carbohydrates. Furthermore, carbohydrates in food are present in three types, including starch, sugar, and fiber.

Examples of foods rich in starch include, corn, beans, potatoes, oats and rice.[107] Whole grains are more nutritive than refined grains because they contain bran, germ, and endosperm, unlike refined grains that only contain germ and endosperm. Sugar is also referred to as a fast-acting carbohydrate. Sugars are of two types, the natural occurring such as those in milk and fruits, and the added sugars mostly found in sweet desserts. Fiber that comes from plants is the indigestible part of a diet that helps the human body feel full and satisfied after eating.[108]

Fruits, vegetables, and grains are all carbohydrates but perform different functions within the body. Simple carbohydrates are simple sugars and are separated in two categories; monosaccharaides and disaccharides.[109] Monosaccharaides are made up of one sugar (i.e. fructose, glucose, or xylose) while disaccharides are created from two chemically bonded monosaccharaides (i.e. sucrose and lactose).[110] Most fruits, white flour, honey, milk, candy, and sodas are considered to be simple carbohydrates. Due to the simple structure of the monosaccharaides and disaccharides, the body breaks these foods down more quickly than complex carbohydrates. As a result, simple carbohydrates

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[107] Gary Gardner, Brian Halweil, and Jane A. Peterson. *Underfed and Overfed: The Global Epidemic of Malnutrition*. (Washington, DC: Worldwatch Institute, 2000.), 9.
[108] Halász and Lásztity, *Use of Yeast Biomass in Food Production*. (Boca Raton: CRC Press, 1991).
[109] Ben Benardot, "Carbohydrates," in *Advanced Sports Nutrition: Second Edition*, Electronic: Human Kinetics; 2 edition, 349.
[110] Ibid.

can only provide energy or temporary relief of fatigue for a short amount of time.[111] Although there are health benefits from certain simple carbohydrates, it is advised that these foods be consumed in moderation because many are dense in calories but not in nutrients.[112]

Complex carbohydrates are structures that are made of three or more linked sugars and can be separated into two categories, oligosaccharides and polysaccharides.[113] The difference between the two categories of complex carbohydrates is that oligosaccharides contain two to ten simple sugars while polysaccharides contain more than ten. These complex carbohydrates are found in whole grains, legumes, and starchy vegetables. Complex carbohydrate foods are considered healthier than many simple carbohydrates because the energy obtained from eating them is released over a longer period of time.[114]

It is the recommendation of the United States Food and Drug Administration that an athlete consumes between 2.5 – 6 grams of carbohydrates per pound of bodyweight per day.[115] For example, a man who is 180 pounds should consume anywhere from 450 – 1080 grams of carbohydrates daily. The reason for this large deviation is determined by the amount of daily energy expenditure, type of energy expenditure, and environmental variations. Besides the amount of carbohydrates consumed daily, the time when they are consumed is also very important. To ensure sufficient energy and balanced insulin levels

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[111] Clark, et al "NASM Essentials of Personal Fitness Training," 479.
[112] Benardot, *Carbohydrates*, 303.
[113] Ibid, 315.
[114] Clark, et al "NASM Essentials of Personal Fitness Training," 478.
[115] United States Food and Drug Administration, "How to Understand and use the Nutrition Fact Label," http://www.fda.gov/Food/IngredientsPackagingLabeling/LabelingNutrition/ucm274593.htm.

throughout the practice sessions or performances, complex carbohydrates such as whole grains should be incorporated into the first meal of the day.[116]

If there are moments of fatigue during a practice session or performance, simple carbohydrates like those found in fruit should provide an ample boost of energy. Although all fruits contain carbohydrates, some raise the body's blood glucose levels more quickly than others. These fruits are generally high on the glycemic index and can provide temporary relief of fatigue very effectively.[117] Fruits that are high on the glycemic index include bananas, pineapple, grapes, and watermelon. In contrast, fruits that are low on the glycemic index will raise blood glucose levels only a small amount over a long period of time.[118] Fruits that are low on the glycemic index include apples, pears, berries and oranges. Fiber also assists in blocking the absorption of sugars and will help maintain blood glucose levels instead of spiking them. High fiber fruits include apples, bananas, oranges and berries.

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[116] Benardot, *Carbohydrates*, 303.
[117] Ibid.
[118] Ibid.

CHAPTER EIGHT: PROTEIN

Protein is widely accepted as an essential nutrient for optimal nutrition. In ancient Greece, for example, elite athletes were encouraged to eat meat and drink wine before athletic events. Current Olympians have reported that they consume more than three times the daily-recommended amount of protein, making protein supplementation a multibillion-dollar industry.[119] For percussionists, appropriate protein intake is critical because of the aerobic and anaerobic actions required in their practice and performances.[120] Similarly, playing a percussion instrument requires long states of physical motion and high physical intensity, both necessitating above average amounts of dietary protein to optimally perform.[121]

Many understand that protein is an essential part of optimal nutrition, however, dietary misinformation has become widespread resulting in an uninformed population. A dietetic study, which spanned the scope of ten states in America, concluded that a substantial percentage of the population was malnourished, or at a high risk of developing nutritional problems.[122] The results of this study are startling and help to explain the obesity epidemic that is plaguing America.[123] Simply stated, this means that many Americans are not only overweight, but also not receiving ample amounts of essential nutrients. In fact, a large portion of the nutritional imbalance (found in the ten states

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[119] Kevin Tipton and Robert Wolfe, "Protein and Amino Acids for Athletes," *Journal of Sports Sciences* 22 (2004): 65-79.
[120] Forbes, *The Effects of Hard Physical Work upon Nutritional Requirements*, 89-96.
[121] Micheal Clark, Scott Lucett and Rodney Corn, "NASM Essentials of Personal Fitness Training," in *Nutrition and Supplements*, eds. Michael Clark, Brian Sutton and Scott Lucett, 4th ed., Vol. 4 (Philadelphia: Jones & Bartlett Learning, 2008), 468-472.
[122] Jacob Jacoby, Robert Chestnut and William Silberman, "Consumer use and Comprehension of Nutrtion Information," *Jounral of Consumer Research* 4, no. 2 (1977): 119-128.
[123] Ibid.

surveyed) was due to excessive protein throughout the population's diet.[124] A basic understanding of the function of protein is necessary for the non-musicians to balance their diets, but further, a comprehensive understanding of the structure, function, and source of protein is necessary for percussionists.

Proteins are organic compounds known as polymers, which are made of amino acids, that are linked together in chemical bonds. They contain hydrogen, carbon, nitrogen, oxygen, and sulfur.[125] Proteins consist of at least two amino acids linked by a peptide bond.[126] The twenty amino acids that create proteins are broken down into two categories: essential amino acids and non-essential amino acids. Essential amino acids are not produced by the body, and as a result must be consumed by various food sources.[127] Non-essential amino acids can be synthesized within the body from food sources containing nitrogen, carbohydrates, and fat.[128] Semi-essential amino acids are a subcategory of non-essential amino acids and are used in times of bodily distress. These acids are not normally essential for a proper diet. There are eight different types of proteins which include: hormonal, structural, enzymatic, defensive, transport, storage, receptor, and contractile. These seven proteins represent the numerous biological functions of proteins.[129] Sources of protein include milk, eggs, beans, and meat.

The primary function of protein is to build and repair tissue and structures.[130] Other functions of proteins include transportation and storage of molecules, increasing

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[124] Ibid.
[125] Ruth Nussinov, *Computational Protein-Protein Interactions*. (Hoboken: CRC Press, 2009).
[126] Clark, Lucett and Corn, *NASM Essentials of Personal Fitness Training*, 468-472.
[127] Ibid.
[128] Benardot, *Carbohydrates*, 303.
[129] Abby Thompson, Mike Boland, and Harjinder Singh, *Functions of The Seven Types of Proteins*. (Amsterdam Boston: Academic Press/Elsevier, 2009).

[130] Ibid.

the rate of chemical action in the body through enzymes, providing immediate energy and fat storage, and creation of hormones.[131] The defensive protein containing immunoglobulin is formed in the white blood cells to prevent bacteria attacks. Structural proteins, such as collagen, keratin, and elastin, are used to form the connective framework of the muscle, bones, and tendons.[132] Before a protein can be used, it must be broken down into whole amino acids through digestion. After the protein is denatured (loses structural integrity), the peptide bonds are broken down, separating the amino acids into small fragments.[133] These fragments are disassembled even further in the digestive process until they reach the small intestine where they are absorbed into the bloodstream.[134]

Amino acids come from dietary protein, which include meats, fruits, vegetables, grains, and dairy products. A food that supplies all of the essential amino acids in appropriate ratios is considered a complete protein. The majority of complete proteins consist of animal products such as whole eggs, milk, meat, and yogurt. Foods that are lacking in one or more amino acids are incomplete proteins. Incomplete proteins come primarily from plant sources such as grains, legumes, seeds, and vegetables. Proteins from these sources can be combined with other incomplete proteins to enhance and complement their effectiveness.

For a percussionist, protein is particularly important because of its ability to repair tissue and supply energy. During prolonged periods of performance, the risk of injury and

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[131] Ibid.
[132] Ibid.
[133] Clark, Lucett and Corn, *NASM Essentials of Personal Fitness Training*, 468-472.
[134] Ibid.

damage to muscular tissue greatly increases.[135] It is important to consume adequate amounts of protein on a regular basis to recover from these injuries.[136] The peculiar motions associated with playing certain percussion instruments (i.e. marching cymbals, four-mallet marimba), coupled with the extra weight of holding a playing implement make percussionists susceptible to injury. When a percussionist cannot modify technique to facilitate safer playing, the most beneficial alternative is to supply his or her body with sufficient nutrition to repair damage. Over time, a percussionist who consumes enough protein in a balanced diet will build a certain amount of muscle in the areas of the body used most.[137] Strengthening muscles in these commonly used areas will help prevent injury and help enhance the ability to perform.

The United States Food and Drug Administration recommends that sedentary adults should consume 0.4 grams of protein per pound of body weight per day. This means an inactive man who weights 180 pounds should consume 72 grams of protein daily.[138] However, the protein recommendations for active adults who participate in strength and endurance exercises nearly doubles. Since percussionists fit into both of these categories, due to performing both aerobic and anaerobic exercises, the daily recommendation would be between 0.5 and 0.8 grams of protein per pound daily.[139] So a 180 pound percussionist would need to consume between 90 and 144 grams of protein per day, depending on the length and type of intensity used for his or her performance. Furthermore, it is recommended that 10-35% of an active person's daily calories come

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[135] Williams, *Assessment of Physical Performance*, 180-184.
[136] Jeff Volek, "Importance of Protein for Ultra-Endurance Athletes," (.)
[137] Timothy J. Carroll and others, "Resistance Training Enhances the Stability of Sensorimotor Coordination," *Proceedings: Biological Sciences* 268, no. 1464 (Feb. 7, 2001): 221-227, http://www.jstor.org/stable/3067559 (accessed 2/23/2013 12:29:23 AM).
[138] Clark, Lucett and Corn, *NASM Essentials of Personal Fitness Training*, 468-472.
[139] Ibid.

from protein.[140] Proteins are very necessary for percussionists because they repair and restore muscle damage and exhaustion caused by intense musical practice sessions.

Protein is one of the body's most important nutrients and is necessary for everyday life, however, overconsumption of this nutrient can cause many negative side effects. Chronic overconsumption of protein is associated with heart disease, kidney damage, osteoporosis, and even cancer.[141] Although protein intake is important, if it is not in balance with carbohydrates, fat, and water, the positive effects are diminished.[142]

[140] Ibid.
[141] Ibid.
[142] Ibid.

CHAPTER NINE: FATS

Approximately 34% of the calories in the average American diet come from fat. However, it is a recommendation of the American Heart Association that less than 30% of the daily caloric intake come from fats.[143] Fats (lipids) serve many purposes in the body, however the main function of dietary fat is to supply energy. Lipids are the most concentrated source of energy the body can consume, almost doubling the caloric value per gram of carbohydrates or proteins. In order to save proteins from being used for fuel, dietary fats allow protein to perform the more significant role of building and repairing.[144] Fats also transport certain vitamins in the bloodstream. Vitamins such as vitamin B and vitamin C are water-soluble, meaning they can dissolve in water and be absorbed by the body at any time. Some vitamins, such as vitamins A, D, E, and K, are fat-soluble, meaning they can only be absorbed in the presence of fat. Fat cells move these fat-soluble vitamins through the cell wall of the intestine so they may be absorbed into the bloodstream.[145] Other functions of fats are; initiating the release of hormones contributed to satiety (feeling full), prolonging digestion, protecting organs, and regulating nutrients in the cells of the body.[146]

The different kinds of fats include those that the body makes from excess calories, and others that are present in plants and animals also known as dietary fats. Fats are further broken down either as saturated, monounsaturated, polyunsaturated, or trans fats.[147] The chemical makeup of fats includes carbon, hydrogen, and oxygen and the

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[143] CK-12 Foundation, *Human Biology: Digestion and Nutrition*, (CK-12 Foundation, 2012), 137.
[144] Ibid,165.
[145] Ibid.
[146] Clark, Lucett and Corn, "NASM Essentials of Personal Fitness Training," in *Nutrition and Supplements*, eds. Michael Clark, Brian Sutton and Scott Lucett, 4th ed., Vol. 4 (Philadelphia: Jones & Bartlett Learning, 2008), 486.
[147] Ibid.

components of fat include fatty acids, and glycerol.[148] Different types of fats have varying amounts of hydrogen and carbon atoms, however, there is always a greater proportion of hydrogen atoms than oxygen atoms. The ratio of hydrogen to oxygen allow for fats to store proportionally more energy than many other foods like carbohydrates.

Due to the active nature of percussionists, the recommended total fat ingestion is between 20-25% of calories, with most of it coming from polyunsaturated and monounsaturated fatty acids sources such as seafood, nuts, and vegetable oils. Polyunsaturated and monounsaturated fats have been shown to reduce the risk of heart disease, and lower blood pressure levels. Polyunsaturated fats also contain the essential fats omega-6 and omega-3 that the body cannot produce itself. It is recommended by the CK-12 Foundation that active adults limit their ingestion of products that are high in trans fatty and saturated acids because they can cause health complications such as an increased risk of heart disease and stroke.[149] Saturated fats, like trans fats cause an increase of low-density lipoprotein cholesterol levels raising the risk of heart disease. Most trans fats are man-made substances that convert liquid fat into a solid by adding a hydrogen atom in a process call hydrogenation.[150] Examples of food containing trans fats are fast food, stick margarine, shortening, fried food, and many pastries.[151]

Dietary fats have been given a poor reputation in relation to the obesity epidemic in America. Although unhealthy fats are a large contributor to weight gain, good fats are essential in a balanced nutrition plan. Carbohydrates and proteins have similar negative

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[148] CK-12 Foundation, *Human Biology: Digestion and Nutrition*, 176.
[149] Ibid.
[150] Clark, et al "NASM Essentials of Personal Fitness Training," 486.
[151] Ibid.

side effects to unhealthy dietary fats when consumed in large proportions. As a result, the key to a proper nutritional plan is proper balance.

CHAPTER TEN: WATER

Nutrients are essential for normal bodily functions to perform at optimal levels and include important vitamins and minerals. They also play an important role when trying to optimize physical performance. Some of these nutrients include: water-soluble vitamins (able to dissolve in water) such as A, D, E, and K, and fat-soluble vitamins (absorbed by fat cells), such as vitamins B and C. Vitamins are necessary for a variety of biologic procedures, including digestion, growth, mental attentiveness and resistance to diseases.[152] Additionally, minerals are substances that help the body by controlling the balance of fluids in the body and directing the progression of nerve impulses. Minerals are the main substance in bones and teeth that serve as building blocks for cells and enzymes.[153] Some of the major minerals include: calcium, magnesium, phosphorus, potassium, sodium, sulfur and chloride. In the context of a balanced diet, all of these nutrients help the body attain homeostasis allowing for optimum performance to be achieved. Water is an essential nutrient in the human diet that allows the body to achieve homeostasis and perform basic tasks for survival. An understanding of the function of this nutrient and how the body uses it is essential to optimizing musical performance.

The components of water include two hydrogen atoms, and one atom of oxygen (H_2O). Water has no food value, but it accounts to 55-65% of body weight.[154] The body cannot store water constantly and therefore it is always necessary to continuously drink water.[155] Water helps keep the body hydrated; it aids in the transport of nutrients,

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[152] Ibid.
[153] Ibid.
[154] Clark, Lucett, and Corn, "NASM Essentials of Personal Fitness Training," in *Nutrition and Supplements*, eds. Michael Clark, Brian Sutton and Scott Lucett, 4th ed., Vol. 4 (Philadelphia: Jones & Bartlett Learning, 2008), 490.
[155] A. Ralph, A, Human *nutrition and dietetics*. (Edinburgh: Churchill Livingstone, 2000).

elimination of waste in the body, regulation of body temperature, and is used in chemical and metabolic reactions in the body.[156]

The human body loses water throughout the day from evaporation through perspiration, breathing, absorption, bowel movements, and urine. To compensate for this constant loss of hydration, it is recommended by most medical professionals that beverages be consumed that contain water. The goal of consuming water is to allow the body to achieve homeostasis, which occurs when the body reaches a state of equilibrium so that normally involuntary processes can function properly.[157] While practicing or performing a percussionist may lose a significant amount of water, consequently depleting the body of essential nutrients required for optimum performance. It is especially important to stay hydrated in dry, or humid climates. In dry climates sweat may evaporate off the skin more quickly, consequently causing rapid dehydration. And, humid climates may cause the body to produce more sweat, creating a faster rate of dehydration.

The amount of water necessary to achieve homeostasis varies greatly depending on many physiological, and environmental factors. The intensity of physical activity plays a large part in daily water recommendations, as well as genetic factors that contribute to perspiration levels. Environmental factors also contribute to perspiration levels due to heat and humidity levels. As a result, there is no definitive equation for calculating am individual's recommended water intake. As a rule of thumb, adults are encouraged to consume 8-13 glasses of water daily. However, due to the inherent

[156] Clark, et al, "NASM Essentials of Personal Fitness Training," 490.
[157] Ibid.

perspiration caused by physical exercise, active adults are recommended to consume significantly more than 13 glasses.[158]

Overconsumption of water is also of concern when trying to achieve optimum musical performance. If too much water is consumed, the body's homeostasis is upset, which may lead to a variety of health problems such as hyponatremia (electrolyte imbalance), and strain on the kidneys. Overconsumption of water is uncommon, but may lead to constipation, mineral depletion, kidney disease, degenerative bone disease, or muscular disorders.

Water can be found in many different food sources. Approximately 20 percent of water intake comes from foods such as fruits, vegetables, grains, and proteins. However, diuretic beverages such as alcohol, coffee, and tea may deplete the body of essential water and should not be used as a source of hydration.

Signs of dehydration include thirst and fatigue; however, thirst alone is a poor indicator of dehydration. Thirst can be a symptom of a disorder, or simply a byproduct of certain elements of a diet such as increased sodium intake. The best indicator for dehydration is the color of your urine. Clear or light yellow urine typically reveals that a person is well hydrated, while people who have dark yellow urine are typically dehydrated.[159]

In general, it is advisable to consume small amounts of water throughout the day to achieve proper hydration. Consuming large quantities of water at one time is not a suitable means of achieving appropriate hydration. In fact, consuming water in this fashion may flush water-soluble vitamins through urine. Any nutrient in excess may

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[158] Ralph, *Human Nutrition and Dietetics*.
[159] Ibid, 4293.

cause harmful side effects to the human body and homeostasis may only occur when the body is given essential nutrients in balance with one another.

CHAPTER ELEVEN: CONCLUSION

Percussionists are physiologically more closely related to athletes than most other instrumentalists due to the physicality required to perform on certain percussion instruments. Large motions from multiple muscle groups are required to create many sounds as a percussionist, potentially putting the body at risk of injury. Similar to the way an athlete trains their muscles to be proficient in playing their sport, the percussionist's body must be trained in a manner that readies itself for common stresses. Studies conducted by the American College of Sports Medicine have shown that resistance training is a valuable tool for injury prevention.[160]

Many current injury prevention strategies that involve the upper and lower extremities of the body are deficient because they force players to alter their technique while playing different instruments. Consequently, changing technique alters sound quality and, at times, dexterity. Some of these current strategies that we are discovering are not as effective as previously thought including using an arm brace to stabilize the wrist, altering one's grip and fulcrum to allow for less impact, and changing playing implements to be less abrasive.[161]

Comprehensive training programs that include progressive resistance and plyometric exercise have been found to enhance movement, improve functional abilities, and reduce injuries among athletes.[162] Percussionists will also benefit by incorporating physical training programs into their practice routine. The injuries that are associated

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[160] Jay Hoffman, *Resistance Training and Injury Prevention* (Indianapolis: American College of Sports Medicine, 1.

[161] Darin Workman, *The Percussionists Guide to Injury Treatment and Prevention: The Answer Guide to Drummers in Pain (*Routledge, 2006), 311.

[162] A. D. Faigenbaum, "Resistance Training among Young Athletes: Safety, Efficacy and Injury Prevention Effects," *British Journal of Sports Medicine* 44, no. 1 (01, 2010): 56-63, http://ezproxy.library.unlv.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=47344184&site=ehost-live (accessed 2/18/2013).

with progressive resistance and plyometric exercises are most often due to improper technique or lack of supervision.[163] It is important that percussionists utilize ergonomic motions not only in practice and performance of their instruments, but also during physical training. The added benefits outside of injury prevention also include increased strength, power, dexterity, and speed. Additionally, logic would presume that overall coordination is enhanced through resistance training.[164]

By using physical training exercises, percussionists will enhance various parts of the musculoskeletal system. Resistance training reinforces bone, connective tissue, and muscle that are prone to injury during practice and performance with percussion instruments. Through resistance exercises, bone mineral density is increased, which allows the tissue to adapt to physical stress.[165] Increased bone mineral density and bone strength have a direct positive correlation and can be factors in preventing various performance related injuries. Connective tissue consists of cells and fibers such as collagen that provide support for the body. Resistance training is shown to increase size and strength of ligaments and tendons of which collagen is a primary component. Furthermore, muscle imbalance is a large contributor to musculoskeletal injuries that can be corrected through resistance training.[166] Damage to the musculoskeletal system will inhibit percussionists from achieving optimal musical performance, and by using physical exercises to strengthen the body a percussionist will decrease their chance of injury.

This document provides scientifically based information explaining how to achieve optimal performance and prevent injuries for percussionists. Through physical

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[163] Robert Malina, "Weight Training in Youth – Growth, Maturation and Safety: An Evidenced Based Review." Clinical Journal of Sports Medicine, no. 16 (2006): 478–87.
[164] Carroll and others, *Resistance Training Enhances the Stability of Sensorimotor Coordination*, 221-227.
[165] Hoffman, *Resistance Training and Injury Prevention*, 1.
[166] Ibid., 2

training and proper dietary habits, percussionists will not be inhibited by their physical limitations. Those who read *The Percussionist Bodybuilder: Optimizing Performance Through Exercise and Nutrition* will learn how to meet the physical demands of playing percussion instruments in high-energy performance situations and prevent performance related injuries. It is my desire that performance related injuries will be taken more seriously among percussionists, and that this document may be used as a definitive resource to optimize musical performance.

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