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7-WEEKS OF YOGA TRAINING AND ITS EFFECTS ON FLEXIBILITY, RATE OF FORCE DEVELOPMENT, AND JUMP HEIGHT IN OLYMPIC WEIGHTLIFTERS

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By

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7-WEEKS OF YOGA TRAINING AND ITS EFFECTS ON FLEXIBILITY, RATE OF FORCE DEVELOPMENT, AND JUMP HEIGHT IN OLYMPIC WEIGHTLIFTERS

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ABSTRACT

7-WEEKS OF YOGA TRAINING AND ITS EFFECTS ON FLEXIBILITY, RATE OF FORCE DEVELOPMENT, AND JUMP HEIGHT IN OLYMPIC WEIGHTLIFTERS

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The purpose of the current study was to determine what effects 7-weeks of yoga training had on Olympic weightlifters flexibility, rate of force development, and jump height. Pre- and post-testing was performed consisting of flexibility and jump performance measurements. The participants performed a sit and reach test followed by a loaded overhead squat test with barbell. The overhead squat test was performed with reflective markers and recorded video to assess joint angles. A countermovement jump and snatch, at 80% of their one repetition maximum, was performed next to measure rate of force development and jump height. The participants then were split into control (n= 8) and experimental (n=9) groups, with the experimental group receiving 7-weeks of yoga training while the control group watched videos pertaining to weightlifting. After 7-weeks, the participants returned for post-testing. There was a significant difference within participants when comparing the pre-test and post-test values for the following variables: sit and reach, shoulder flexion, countermovement jump rate of force development, and snatch rate of force development decreased while knee flexion and ankle dorsiflexion increased. There was no significant interaction between the pre- and post-test and the condition. No significant difference was found between groups for any variable and effect sizes were all small or trivial. Yoga training does not seem to have an effect on weightlifting performance variables.

Keywords: Stretching, snatch, countermovement jump, sit and reach, 2-D Video

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LIST OF SYMBOLS AND ABBREVIATIONS

Countermovement Jump…………………………………………………………....CMJ

Rate of force development……………………………………………………….RFD

Range of motion…………………………………………………………………ROM

Partial eta^2 ……………………………...……………………………………………….ηp^2

CHAPTER 1: JOURNAL MANUSCRIPT

Introduction: Olympic weightlifting consists of two lifts, snatch and clean and jerk. Both are whole body movements which combine great strength, power, speed, kinesthetic awareness, technique, and flexibility (21,24,54,55). These athletes can lift 2-3 times their body mass overhead during competitions, and have been observed to have the highest power outputs recorded in sport (21,54,55).

Many factors contribute to a successful lift and have been broken down to help predict which lifters may excel in the sport. Obviously, technique and experience contribute to the performance differences between novice and expert weightlifters, however, Fry et al. (21) found that for weightlifters at a national competition vertical jump and torso angle during an overhead squat helped predict success. Other researchers have examined lower body power, muscular strength, flexibility, kinesthetic awareness, and body height and weight to help identify potential elite weightlifters (21). Many of these areas overlap and collectively demonstrate the need for a multitude of factors to excel in weightlifting.

Since weightlifting is an extremely powerful, strength-based sport, with very repetitive movements performed almost daily, the chance for overuse and/or traumatic injuries is present. Weightlifters need to have lower extremity power, muscular strength, flexibility, and technique, and if any of these factors are lacking it predisposes the athletes to injuries, primarily to the knee, low back, and shoulder (9). One way to help prevent injuries is to incorporate prophylactic rehabilitation protocols after using screening tools to identify possible weaknesses or imbalances. A commonly used tool is the overhead squat (OHS) test as described by the National Academy of Sports Medicine (11). The OHS test is a screening tool for weightlifter's flexibility that is extremely sport specific, with the athlete holding a bar overhead while performing a deep squat. This test has been shown to be a predictor of injury, identifies tight and overactive, or weak and underactive muscles and uncovers joint restrictions (7,38,43). The OHS test can also be filmed to measure joint angles and assess any restrictions (7,38,43).

Stretching can have an effect on the OHS test. If someone is more flexible, the compensations described previously will be less apparent, or not present. Chronic stretching aims to decrease injury and increase performance by increasing the compliance of the muscle and therefore reducing the energy needed to move the limb (4). Shrier (53) concluded that chronic stretching increased isometric force production and the velocity of contraction, but this was limited to single joint movements. Guissard and Dechateau (26) found that chronic plantar flexor stretching resulted in increased ankle flexibility but no changes in maximal voluntary contraction force, torque, or rate of force development. Other authors have come to similar conclusions, that chronic stretching does not impair performance in jumping and sprinting, and may actually increase performance compared to control groups (4,17,33). However, there is still no conclusive evidence that chronic stretching improves performance during multi-limb movements (4).

Yoga can be considered a type of chronic stretching. Flexibility of the lower extremity and the low back are common side effects of yoga training. Adequate range of motion is essential to all athletes and can help improve performance in sport and reduce injuries (3). Most yoga studies examine lower body flexibility through sit and reach tests and usually have participants train 1-2 times a week for between 45-90 minutes (3,10,18,45,51). The common theme of these studies is that yoga increases flexibility and usually the effects are seen as early as six weeks, even if the participants are only training once a week (10,15,18,51). Yoga has also been shown to increase lower extremity and low back flexibility significantly more than static stretching (56).

To our knowledge there have been few studies that examine force or power production over an extended period of any form of stretching (4). There is currently no research focusing on chronic yoga training in Olympic weightlifters and how it will affect their flexibility, rate of force development, or jump height. The purpose of this study was to determine what effects 7-weeks of yoga training had on Olympic Weightlifters flexibility, rate of force development, and vertical jump height. We hypothesized that weightlifters will increase their flexibility as demonstrated by the sit and reach test and the overhead squat test with an increase in rate of force development and jump height.

Methods:

Experimental Approach to the Problem: A repeated measures, longitudinal, experimental design was used. Initial testing was performed to determine baseline measures. After the initial testing, participants were randomly divided into the experimental and control groups, controlled for sex. The experimental group (n=9) completed ten, one hour sessions of hatha yoga over seven weeks. The control group (n=8) did not perform the asanas (posture) portion, but did participate in the meditation and centering.

While the experimental group performed asanas, the control group watched videos relevant to weightlifting culture. All participants were instructed to maintain their current activity level throughout the training period and all participants were on similar training cycles. Ten sessions of yoga training was determined to be a sufficient dose response to increase flexibility (10,18,51). All sessions were taught by a certified yoga instructor.

The class consisted of hatha yoga which combines asanas for strength and flexibility, and breathing techniques (pranayama) (3). The time schedule for each hour class can be seen in Table 1.

The yoga instructor selected postures that would target lower extremity, spinal, and shoulder mobility. Participation was recorded at the beginning of each session to ensure compliance.

After 7-weeks of yoga training the participants performed the same surveys, paperwork, and tests in the same order. Participants were instructed to consume the same diet 24 hours before their session time as recorded during the pre-test condition and all participants performed their testing at the same time of day as during their pre-test.

Subjects: Participants were 18 Olympic Weightlifters, 10 males and 8 females, currently training for competition at the Olympic Training Site at Northern Michigan University (Mean ± SD: age = 19.3 y ± 1.4; height = 167.0 cm ± 7.5; mass = 75.7 kg ± 22.5; Sinclair score = 259.9 ± 64.1; years of training = 4.4 y ± 3.3). They had no surgery in the previous six months, were physically able to perform a snatch, were currently training for competition, and had not practiced yoga regularly over the past six months (once a week for longer than one month). All experimental procedures were approved by the Institutional Review Board before the study commenced (HS15-685). Participants completed an informed consent, Physical Activity Readiness Questionnaire, 24-hour dietary survey, lower extremity functional scale (8), and Oswestry low back disability index (19) before any testing was performed (see Appendices A-E).

Procedures: Before the participants began yoga training, testing was performed to determine baseline measures. Participants were fitted with reflective markers on the 5th metatarsal head, lateral malleolus, lateral epicondyle of the knee, greater trochanter of the femur, and lateral acromion of the right side of the body, as well as one point on the lateral barbell (21,24,25,27,44). After fitting, participants rode a stationary bike for five minutes as a warm up (7). All testing was performed after the warm up in the following order: Sit and reach test, OHS test, countermovement vertical jump, and snatch lift. This order was selected to reduce the chance of fatigue (28).

The sit and reach test was performed using a custom built sit and reach testing device, participants sat with legs extended and bare feet flat against the sit and reach device. They exhaled and stretched forward as far as possible with one hand over the other, fingertips in line and held the end point for two seconds. This was repeated three times and the greatest range of motion (ROM) was used for analysis. This protocol has been used to determine flexibility in other studies and has been found to be highly reliable (18,22,45,50).

The loaded OHS test was performed next and recorded with 2-dimensional video (Casio EX-ZR10, Casio America Inc., Dover, NJ) in the sagittal plane from four meters away at 60 Hz (2). The participants were instructed in the same manner to standardize the starting position. Each subject performed the OHS with an Olympic barbell (determined by their sex) in bare feet, the feet were shoulder width apart, toes pointed straight forward, heels on the floor, arms overhead with the hands shoulder width apart, and elbows extended (7,21,38). Participants were then instructed to descend over two

two seconds (7). This was performed three times and the mean values for shoulder, hip, knee, and ankle angles were determined. All joint measurements were made in degrees and analyzed using MaxTRAQ 2D software (Innovision Systems Inc, Columbiaville, MI, USA); 2-dimensional video has been validated to accurately measure joint angles for this task (44).

Participants then performed two countermovement jumps (CMJ) on twin force platforms (OR6-2000 Advanced Mechanical Technology, INC. [AMTI], Watertown, MA), which collected data at 1000 Hz, to determine rate of force development (RFD) and jump height. The greatest height and RFD produced during the jumps were analyzed. Flight time and jump height were determined by the equation used by Moir (40). RFD was averaged over a 100 ms moving window (1). A one minute break was given between attempts to reduce the possibility of fatigue (28). The participants were instructed to jump as high as possible immediately following a counter movement; and using their preferred technique allowing the arms to swing and then reach overhead during the jump phase (21,50).

Finally, the participants were allowed to warm-up as needed over 10 minutes to be able to lift 80% of their maximum snatch attained in a competition. A rest period of two minutes was given between each of the three attempts to reduce the possibility of fatigue. Only successful lifts were counted, and only the attempt which produced the greatest RFD was analyzed. 80% of their maximum was chosen because this has been shown to be the optimum percentage to reach peak RFD (54). RFD was analyzed using the same technique as for the counter movement jump described earlier. Participants were allowed to use their preferred technique to perform the three snatches.

Statistical Analyses: A 2x2 mixed ANOVA (group X pre/post) was used to determine significance with a confidence interval of p = 0.05. Effect sizes are reported using partial eta^2 (ηp^2). It was calculated using the formula: $\eta p^2 = SS^{effect}/(SS^{effect} + SS^{error})$, where SS^{effect} = effect variance and SS^{error} = error variance. Effect size interpretation was based on the scale for effect size classification of Hopkins (30). This scale is based on f-values for effect size and these were converted to ηp^2 using the formula: $f = (\eta p^2/(1- \eta p^2))0.5$. The scale for classification is as follows; <0.04 = trivial, 0.041 to 0.249 = small, 0.25 to 0.549 = medium, 0.55 to 0.799 = large, and >0.8 = very large. Seventeen participants completed the entire study and their data were used for analysis. One male participant dropped from the study and was not included in the statistical analyses; also, one male participant was unable to perform the post-test snatch due to injury.

Results: The participant's means and standard deviations for the variables of interest are shown in Table 2. The Greenhouse-Geisser adjustment was used because sphericity was violated. There was a significant difference within participants when comparing the pre-test and post-test values for the following variables: sit and reach, shoulder flexion, knee flexion, ankle flexion, CMJ RFD, and snatch RFD (Table 2). There was no significant interaction between the pre- and post-tests vs. condition and all effect sizes were trivial or small. No significant difference was found between groups for any variable and effect sizes were all small or trivial. (Table 2).

Discussion: The purpose of the current study was to determine what effects yoga training had on Olympic Weightlifter's flexibility, rate of force development, and vertical jump height. We hypothesized the weightlifters would increase their flexibility as demonstrated by the sit and reach and OHS tests, and increase their RFD and vertical jump height vs. control. This change did not occur with the results of our study. While there was a significant difference within subjects pre- and post-tests, there were no significant differences found in any measure between groups from pre- to post-test.

Since only 17 participants (9 experimental and 8 control) finished the study, estimated sample sizes were calculated according to Hopkins (31) to determine if there were sufficient participants in the study to find significant differences. Previous studies were reviewed to estimate the within-subjects standard deviations for the sit and reach test (18), 2-dimensional video joint ROM measures (46), jump height (41), RFD during a CMJ (32,34) and RFD during Olympic lifts (12). The estimated beneficial and detrimental effects on the participants was set at 150% of the within-subjects standard deviation. Using these data and methods, it was found that the current study had an adequate amount of participants to find a significant difference for all measures.

While there have been no studies examining the effects of yoga training on RFD, there have been many studies which examine yoga's effects on flexibility and ROM. Researchers have shown that yoga increases participants' sit and reach scores in as little as six sessions over six weeks (10,15,18,51). Yoga has also been shown to increase flexibility more than static stretching (56). There are two primary areas which show the greatest increase in ROM after performing yoga training, the lower back (15,51,52,56) and knee joint (20,23). The results of our study demonstrated that both groups had significantly decreased scores on the sit and reach test following training. The difference between our study and previous yoga studies could be that these studies have primarily focused on populations that were inactive or only mildly active before participating in the research. Our participants routinely practiced Olympic weightlifting four to six days a week. Olympic weightlifting also requires total body flexibility to be able to successfully complete a lift (21). Therefore, our participants may have already reached their necessary ROM for their sport. It is possible that due to their current training volume and intensity there may have been exercise induced muscle damage which caused a decreased ROM (57), but the same participants significantly increased their ROM at the knee and ankle during the OHS test. While shoulder ROM did decrease in both groups from the pre- to post-test, an increase in knee and ankle ROM probably caused a decreased need for hyperflexion during the OHS to maintain their balance. This was shown by Adelsberger and Tröster (2) who demonstrated that an individual with greater lower extremity ROM would place less torque on the shoulder during an OHS. They demonstrated that greater lower extremity ROM would lead to a better starting position, a more upright posture in the bottom position, more stability during the lift, and therefore, more successful lifts during Olympic weightlifting (2).

While chronic stretching and yoga training are not the same, there have been chronic stretching studies that have used populations similar to ours measuring changes in ROM over time (4,5,26,33). Behm et al. (5), as well as Guissard and Duchateau (26) found that after a chronic stretching program there was an increase in ROM for the areas stretched in active individuals. Behm et al. (5) specifically found a significant increase in the participants' sit and reach scores after four weeks of lower extremity stretching. However, Basett-Jones et al. (4) found that Division III female track athletes did not have a significant increase in ROM after a six week chronic stretching protocol, which is similar to our findings. Basett-Jones et al. (4) theorized participants did not increase their

ROM significantly because the athletes had already reached the “optimal” ROM for their sport. With similar changes in flexibility for both groups, regular training or an external factor that was not controlled for may have played a role in our study.

There have been no studies examining yoga’s effects on RFD, however some studies have investigated chronic stretching effects on RFD, jump height, and performance measures (4,5,26,33). There are different theories as to why stretching would increase RFD and jump height. The first is that with chronic stretching there is an increase in the compliance of the muscle and therefore requiring less energy to use the muscle (4). The second is that one can increase performance through stretch-induced hypertrophy (53), but this is unlikely to have occurred in our study because of our participant’s training level and an insufficient dose response to generate stretch-induced hypertrophy. For stretch-induced hypertrophy to occur the muscle must be stretched 24 hours per day (53). Shrier (53) concluded there was little evidence to support multi-joint increases in RFD, jump height and other performance measures, but there was evidence that single joint motions show increases in isometric peak force and velocity of contraction after chronic stretching. Research performed on multi-joint movements have mostly demonstrated minimal performance enhancement, except for a study conducted by Hunter and Marshall (33). These researchers split participants into four groups to examine the effects of power and stretching on CMJ and drop jump technique and height. They found that chronic stretching increased CMJ height but did not change technique, or alter drop jump performance (33). To our knowledge, this is the only study to demonstrate that chronic stretching increases CMJ height or RFD. Our study demonstrated that yoga training did not have a significant effect on jump height or RFD for the CMJ or snatch between groups. This agrees with other studies that have shown that after chronic stretching there were no changes to participant's jump height (4,5), RFD (26), velocity of contraction (26), or max force production (26). While there was no increase shown in any of these performance measures, there was also no significant decreases. Chronic stretching likely increases the stretch tolerance and not visco-elasticity, which differs from acute stretching, which led to this result (53).

Our study had the following limitations. The participants were on similar training cycles but were not on the exact same cycle, which may lead to slight differences in training volume and intensity. Along with these differences, the participants were not in their peaking phase during either the pre- or post-testing which may affect their RFD and jump height (14). Another limitation could be that more training sessions or a longer training period may have been needed to see the effects yoga had on flexibility and RFD in Olympic weightlifters (4,45).

Future research should continue to examine what effects yoga has on an athlete's ROM and force production. This research should be expanded to include other strength and power athletes as well as endurance athletes to compare the differences. Studies should also examine what differences there are between chronic stretching and chronic yoga on ROM and force production. Another interesting area of research would be to determine what psychological affects yoga may play in athletes due to the meditation and centering that is part of the training, and if this would help or hinder their performance.

Practical Application: 7-weeks of yoga training did not demonstrate any significant differences between groups on flexibility, rate or force development, or jump height. Based off our findings Olympic weightlifters can participate in yoga training without causing significant decreases in performance. The possible psychological benefits of yoga were not examined in our study and may play a factor in overall performance. Future studies should continue to study the effects of chronic stretching and yoga on performance variables in a variety of sports.

Table 1. One hour yoga class time allotment.

Experimental Group		Control Group	
Centering, yoga philosophy, and lesion instruction	5 minutes	Centering, yoga philosophy, and lesion instruction	5 minutes
Relaxation and breathing exercises	5 minutes	Relaxation and breathing exercises	5 minutes
Warm-up	10 minutes	Watch weightlifting videos	40 minutes
Yoga postures	30 minutes	Relaxation and closing	10 minutes
Relaxation and closing	10 minutes		

Table 2. Means and standard deviations for the variable of interest, and the effect sizes for between groups analysis.

Test	Group (N)	Pre	Post	Effect size
Sit and Reach [a] (cm)	Experimental (9)	27.7 (5.6)	26.1 (7.3)	.101
	Control (8)	32.1 (5.9)	29.6 (6.9)	
Shoulder Flexion [a] (degrees)	Experimental (9)	189.3 (6.0)	186.5 (8.2)	.009
	Control (8)	189.0 (7.5)	184.4 (7.3)	
Hip Flexion (degrees)	Experimental (9)	106.2 (19.8)	118.5 (13.2)	.026
	Control (8)	115.3 (17.1)	118.7 (18.5)	
Knee Flexion [a] (degrees)	Experimental (9)	118.7 (17.2)	127.7 (14.6)	.002
	Control (8)	119.0 (19.0)	124.7 (20.6)	
Ankle Dorsiflexion [a] (degrees)	Experimental (9)	89.7 (8.2)	101.4 (8.0)	.023
	Control (8)	94.7 (12.7)	100.8 (9.2)	
CMJ Height (cm)	Experimental (9)	49.3 (8.7)	47.8 (9.0)	.083
	Control (8)	43.8 (6.2)	45.3 (4.8)	
CMJ RFD [a] (N/s)	Experimental (9)	11165.1 (3341.2)	10629.3 (3021.2)	.002
	Control (8)	10914.9 (3729.2)	10386.8 (3181.6)	
Snatch RFD [a] (N/s)	Experimental (9)	8633.9 (2629.1)	7918.6 (1839.0)	.003
	Control (7)	8304.3 (2157.3)	7777.1 (2201.2)	

[a] denotes significance at the .05 level for within-subjects means and standard deviations.
CMJ = countermovement jump, RFD = rate of force development

CHAPTER II: LITERATURE REVIEW

Olympic weightlifting: Weightlifting competitions have been around for more than 4,000 years (54). The ancient Egyptians have drawings of individuals performing feats of strength in the tomb of Prince Baghit, and the ancient Chinese trained for strength events, which were highly valued in their society (54). Greek Olympics records show that they did not include strength and power events in the original games (54).

Modern weightlifting traces its origins from mid-1800's weightlifting clubs that began in Austria and Germany (54). 1896 was the first time that weightlifting was included in the Olympic games, considered part of the track and field events, but it was not permanently part of the games until the 1920 Antwerp Games (54). Only men were allowed to participate in weightlifting during the Olympics until a women's division was added at the 2000 Sydney Games (54). This was well after the first Women's World Championships which were held in 1987 in Daytona Beach, Florida (54).

Both men's and women's weightlifting currently consist of two lifts; snatch and clean and jerk. These are both whole body movements which combine great strength, power, speed, kinesthetic awareness, technique, and flexibility (21,24,54,55). These athletes can lift 2-3 times their body mass overhead during competitions, and have been observed to have the highest power outputs recorded in sport (21,54,55). Both lifts begin in a similar manner, with the only difference being the grip width on the bar. The snatch has a wider grip during the set up and liftoff than the clean and jerk. There are six phases included in the snatch (24,25,27,55): (Figure 1)

The first pull: From the barbell's lift-off until the first maximum knee extension
The transition: From the first maximum knee extension until the first maximum knee flexion
The second pull: From the first maximum knee flexion until the second maximum knee extension
The turnover: From the second maximum knee extension until the maximum height achievement of the barbell
The catch: From the maximum height achievement of the barbell until stabilization in the catch position with the barbell overhead
The rise: Standing from the catch position and holding the weight overhead until the confirmation signal sounds

Figure 1 demonstrates the lift-off as a separate phase, but is showing the set up position, and does not display standing up from the catch phase into the rise phase.

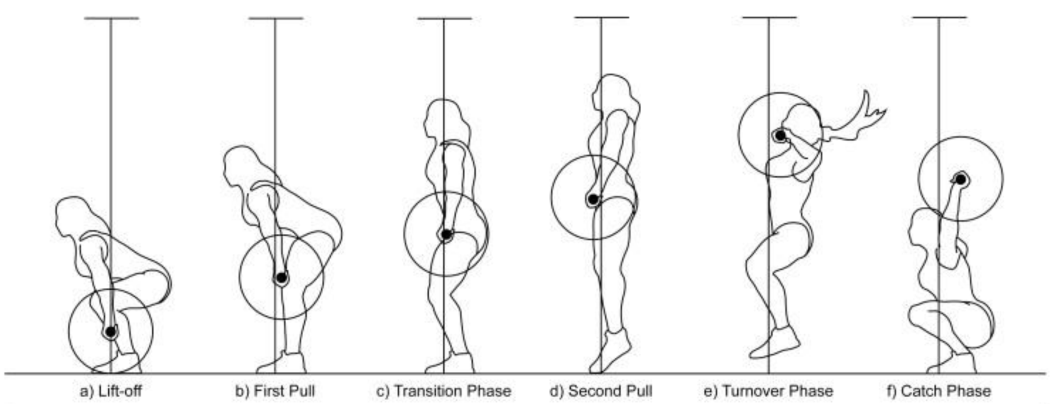

Figure 1. Stages of the Snatch (25)

During the second pull the barbell reaches its greatest velocity which can result in power outputs that range from 1300 to 4000 W for the snatch, depending on the athlete's size and ability (24). Typically, weightlifters produce their peak power outputs when lifting weights 70-85% of their one repetition maximum for pulling movements during the snatch and clean (54).

The clean and jerk lift has the same phases, only the hands are positioned closer together at the starting position and the catch is made on the anterior shoulders instead of overhead. After the rise phase, the athlete then must perform the jerk portion of the lift. This movement takes the barbell from on the chest to overhead in a quick dipping and driving motion.

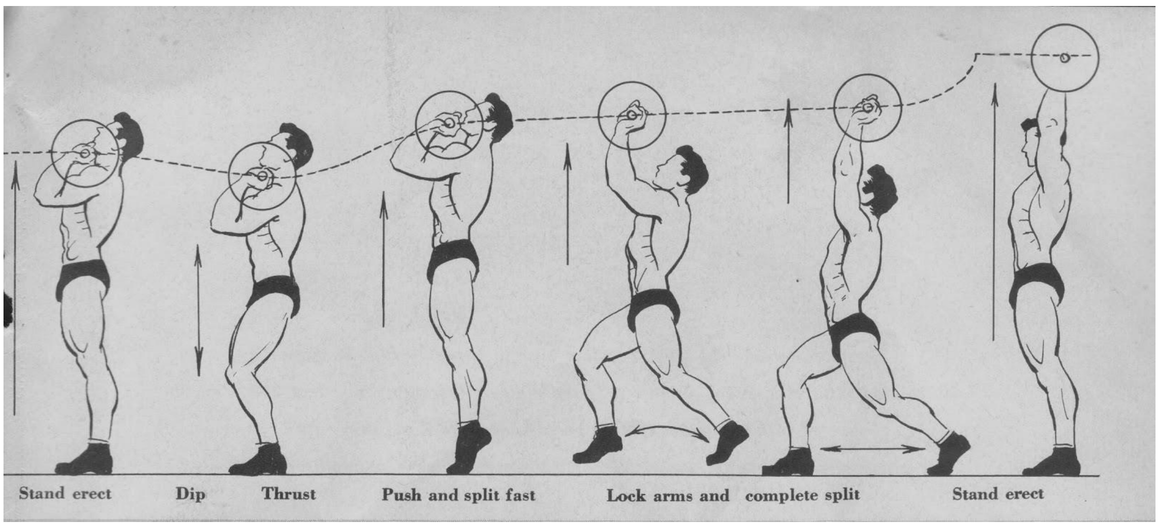

Figure 2. Stages of the Split Jerk (58)

Many factors contribute to a successful lift and have been broken down to help predict which lifters may excel in the sport. Obviously, technique and experience contribute to the performance differences between novice and expert weightlifters, however, Fry et al. (21) found that for weightlifters at a national competition body mass index explained 23.13% of the total variance, followed by vertical jump (22.78%), relative fat (18.09%), grip strength (14.43%), and torso angle during an OHS (0.9%). Other researchers have examined lower body power, muscular strength, flexibility, kinesthetic awareness, and body height and weight to help identify potentially elite weightlifters (21). Many of these different areas overlap and collectively demonstrate the need for a multitude of factors to excel in weightlifting.

Injuries in Olympic weightlifting: Since weightlifting is an extremely powerful and strength-based sport, with very repetitive movements performed almost daily, the chance for overuse and/or traumatic injuries is present. Weightlifters need to have lower extremity power, muscular strength and flexibility, and technique. If any of these factors are lacking it predisposes the individual to injuries, primarily to the knee, low back, and shoulder which account for 64.8% of injuries in this population (9). Common injuries associated with weightlifting are overuse related tendon injuries, anterior shoulder instability, clavicular osteolysis, spondylolysis, knee osteoarthrosis, and stress fractures. Traumatic injuries include ligament sprains, tendon and muscle strains, meniscal tears, fractures, tendon and muscle ruptures (9,47).

Calhoon and Fry (9) found that the injuries that elite weightlifters experienced were mostly tendinitis (68.9%) which is a preventable condition. They also found that most injuries required less than a day of training time lost (90.5%) (9). The injury exposure for weightlifters was calculated to be 3.3 injuries/1000 hours of weightlifting with the most common injuries at the knee, low back, and shoulder (9). The knee primarily was effected by tendinitis (85.0%), the low back and shoulder were primarily effected by strains (74.6%) and (54.6%) respectively (9). These injuries are more typical during the clean and jerk lift due to the increased weight being lifted (9). Calhoon and Fry (9) concluded that most knee injuries in weightlifting are from chronic inflammatory problems, not traumatic as observed in other sports. To help prevent injuries to these three areas, they suggest that weightlifters should focus on skill, flexibility, and strength throughout their career (9).

Raske and Norlin (47) examined injury rates of weightlifters over a period of five years and found they sustain mostly low back and knee injuries, but that shoulder injuries are also present. Low back injuries were reported in 30-50% competitors and 31% of competitors experienced osteoarthrosis (47). Unlike Calhoon and Fry, this study found that 93% of shoulder, 85% of low back, and 80% of knee injuries were major (a duration of symptoms for more than a month) (47). These numbers included both powerlifters and weightlifters. Shoulder and knee injuries are often overuse tendon injuries and occur from improper technique, too great a load, lack of strength, and lack of flexibility (47). Low back injuries can occur because the core must remain stable with the weight overhead during both the snatch and clean and jerk. If the low back does not remain stable, this can predispose the back to a plethora of injuries (47).

The low back is a commonly injured area, with most individuals experiencing low back pain at some point in their lives; in weightlifters, this is not different. Therefore, having a strong and stable core is key to injury prevention and can translate to optimal performance (40). The core is defined as the lumbar spine, muscles of the abdominal wall, the back extensors, the quadratus lumborum, the lastissimus dorsi, and psoas (40). In weightlifting, the athlete does not want any energy lost or wasted when it is transferred through the core to the barbell. McGill (40) showed that having instability in the lower back due to a weak core predisposes one to injury and prevents energy transfer from the legs through the body.

Another injury that effects weightlifters is patellofemoral pain syndrome, which can be successfully treated with rehabilitation protocols (39). Many of these protocols instruct the participants in corrective exercises to strengthen weak musculature, encourage proper movement patterns, increase proprioception, and focus on stretching tight musculature (39). McDermott and Waryasz (39) describe tight gastrocnemius, hamstring, iliotibial band, and quadriceps muscular as predisposing factors to developing patellofemoral pain syndrome. Luckily, stretching these muscles can help improve squatting patterns and limit the stress placed on the patellofemoral complex in a rather short period of time (39). Both static and dynamic stretching have been shown to improve range of motion (35). Other areas that can be stretched to limit this condition are hip adductors, hip abductors, hip external rotators, hip internal rotators and hip flexors (39). McDermott and Waryasz state that prevention is key to reducing complications and that finding individuals that are predisposed to patellofemoral pain syndrome early and assigning a prophylactic treatment protocol focusing on lower body strength, flexibility, and power production can help prevent this injury (39).

Finally, the shoulder is also a commonly injured area during weightlifting. Injuries are due to the large loads lifted overhead, lack of shoulder mobility, improper techniques, and high stress placed on the shoulder during certain training tasks (behind the head pressing motions) (36,42). Many injuries occur because the shoulder is not as mobile as the lift dictates. This primarily happens due to a loss of shoulder internal rotation and posterior capsule tightness (36). Olympic weightlifting requires the shoulder to be able to reach high levels of flexion, abduction and external rotation for optimal performance. Through high volumes and intensities, weightlifters can develop overuse injuries to the shoulder. Kolber et al. describes three main points to reduce shoulder dysfunction: 1) Incorporating exercises to strengthen the lower trapezius and external rotators; 2) Flexibility exercises designed to increase internal rotation and improve posterior shoulder mobility; and 3) Avoiding the 90/90 position, the shoulder at 90 degrees of abduction and the elbow at 90 degrees of flexion, during training with high loads (36).

One way to help prevent injuries is to incorporate prophylactic rehabilitation protocols, which can be added by introducing a screening tool to identify possible weaknesses or imbalances. A commonly used tool is the OHS test as described by the National Academy of Sports Medicine (11) and Gray Cook (13). (Figure 3) The OHS is an especially good screening tool for weightlifters because it is extremely sport specific, with the athlete holding a bar overhead and performing a deep squat. The overhead squat test has been shown to be a predictor of injury, identifies tight and overactive, or weak and underactive muscles and uncovers joint restrictions (7,38,43). After identification of these problems, individuals can be assigned an individualized corrective exercise program to assist in proper movement patterns, which can lead to injury reduction. Since the test is very closely related to the sport of weightlifting, the validity should be high. The overhead squat test can also be filmed to measure joint angles and assess any restrictions (7,38,43). Filming squatting tasks and recording the joint angles has been found to be as reliable as goniometer measurements if certain boney landmarks, greater trochanter of the hip, lateral epicondyle of the knee, lateral malleolus of the ankle, are used (44).

Common compensations utilized during the overhead squat test are as follows: 1) The heel lifting off the ground; 2) The feet turning outward from center; 3) The knees falling in or out (not tracking with the second and third toes); 4) The low back rounding or arching causing the torso to not stay in line with the tibia; 5) An asymmetrical weight shift while squatting; 6) The torso falling forward; and/or 7) The arms falling (not staying in line with the greater trochanter and deltoid tuberosity) (11).

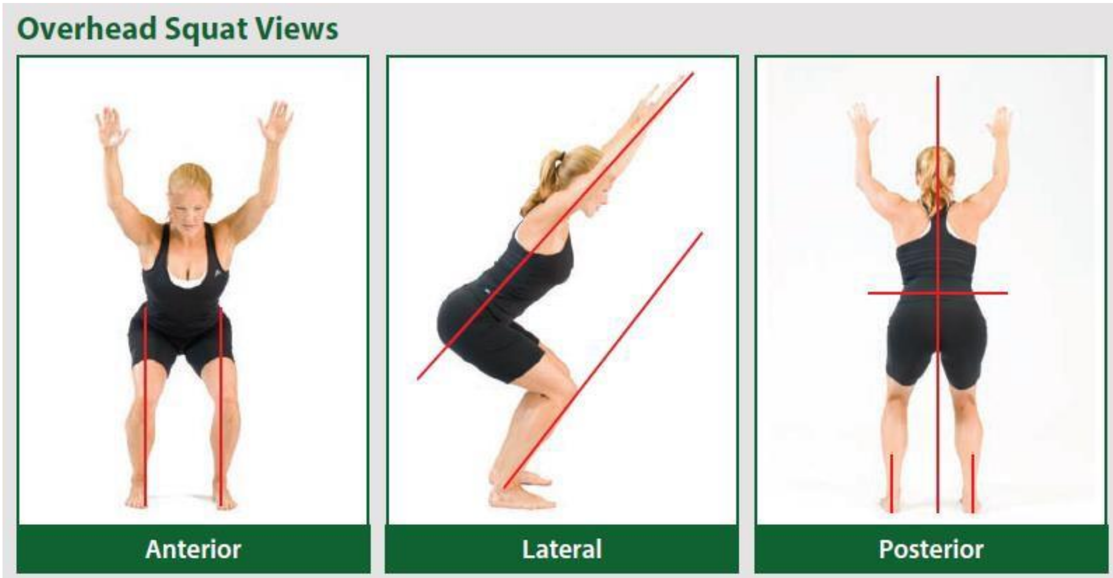

Figure 3. Proper Overhead Squat Technique. (11)

All of these compensations can be used to identify where restrictions are so corrective exercises can be prescribed to address them. This test has also been shown to be accurate in both males and females, with only slight variations in movement patterns between the sexes (38).

Stretching has an effect on the OHS test, if someone is more flexible the compensations described previously will be less apparent, or not present. Acute static stretching has been shown to change the center of pressure measurements during the OHS test, as well as front squat, but not air squats (2). Acute stretching helps the athlete improve their center of pressure during squatting tasks by moving the center of pressure towards the heels instead of the toes which creates a more stable environment (2). This more stable environment allows the athlete to attain a more optimal position during weightlifting which can lead to greater muscular strength capabilities by reducing the torque needed to be applied to the shoulder during a successful lift (2). Many snatch lifts fail in the catch position because of a lack of balance and stability which could be explained by the center of pressure being towards the toes instead of the heels (2). Adelsberger and Tröster (2) concluded that after static stretching the participants became more stable during the OHS, front squat, and deadlift. This improvement was due to a more upright posture that enabled the participants to maintain a center of pressure further back in their stance and resulted in the participants not having to "fight" against the weight (2).

Stretching: Most studies on stretching have focused on the acute effects of static and dynamic stretching on force production and power, with few focusing on training studies examining flexibility and RFD. To our knowledge there are no studies that examined chronic yoga training over a period of weeks and its effects on RFD or power. The research is currently conflicted about the acute effects of static stretching on force and power generation (6,37,50,53), but the majority consensus is that static stretching prior to subsequent performance in activities that require high velocities and power is contraindicated and that dynamic stretching should be performed (6). Dynamic stretching prior to an event either augments the force or power production, or has no effect (6,35). This is preferable to the chance that static stretching may decrease a competitor's power or force development and is most likely why dynamic stretching is favored as a pre-workout warm-up routine (6). If the goal is to increase flexibility, however, static stretching has been shown to increase flexibility greater than dynamic stretching over the same period (50).

Chronic stretching aims to decrease injury and increase performance by increasing the compliance of the muscle and therefore reducing the energy needed to move the limb (4). Behm et al (5) conducted a study involving 12 female subjects that participated in four weeks of chronic stretching, five times a week for the quadriceps, hamstrings, and plantar flexors. They were interested in improvements to ROM during drop jumps, and countermovement jumps, as well as jump height and technique. After four weeks of training, there was a 11.8% increase in sit and reach values and there was no effect of stretching on the performance of either the drop and countermovement jumps (5).

A second study examined how six weeks of static hamstring stretching affected ROM, sprint performance, and vertical jump performance (4). Participants were 21 female track athletes who performed static stretching for each hamstring four times a week, holding each stretch for 45 seconds. The researchers were interested in knee ROM, 55 meter sprint time, and mean vertical jump height. They found that flexibility training had no effect on sprint or vertical jump performance and a small, but non-significant effect on ROM. Bazett-Jones et al (4) hypothesized that there was no increase in jump performance because there was little change to ROM and that there may have not been changes to the muscles' compliance, which they did not measure. Another hypothesis was that the participants were active individuals and had already reached their "optimal" ROM for jump and sprinting tasks (4).

Guissard and Dechateau (26) examined the effects of 30 sessions of static stretching on maximal voluntary contraction, ankle dorsiflexion ROM, and muscle reflexes in 12 participants (26). They found that after ten sessions the participants had increased their ankle ROM, decreased passive stiffness and there was a small increase in passive torque at maximal dorsiflexion. There was little ROM or stiffness changes from the tenth session to the thirtieth session (26). There was no change in the maximal voluntary contraction torque and the rate of torque development after training, but flexibility increases and stiffness decreases were partially maintained a month post-intervention (26). The researchers concluded that while there may be a transient deficit in maximal voluntary contraction after stretching, chronic stretching does not impair the maximal force or speed of contraction (26).

Only Hunter and Marshall (33) have demonstrated that chronic stretching actually improves CMJ height. They examined how power training and stretching would affect CMJ and drop jump technique, height, and muscle stiffness (33). Participants were split into four groups, power, stretching, power and stretching, and control; and performed their respective intervention for ten weeks (33). The stretching group performed stretches to the hamstring, quadriceps, hip extensors, hip adductors and abductors, and plantarflexors four days a week holding each stretch for 30 seconds (33). Results showed that power training increased jump height and muscle stiffness, and that flexibility training aided the increases in CMJ height (33). Chronic stretching did not help increase drop jump measures or alter CMJ technique (33).

A review by Shrier (53) described seven studies which examined the effects of chronic stretching. The review concluded that chronic stretching increases isometric force production and the velocity of contraction, but this was limited to single joint movements (53). The explanation given for this was that acute stretching decreased visco-elasticity and increased stretch tolerance, while chronic stretching only increased stretch tolerance; decrease in visco-elasticity are responsible for decreased force and power production. The mechanism that accounts for performance enhancement with chronic stretching is thought to be stretch-induced hypertrophy (53). This hypertrophy, over time, could lead to increases in force and contraction velocity. Other studies have come to similar conclusions, that chronic stretching does not impair performance in jumping and sprinting, and may actually increase performance compared to control groups (4,17,33).

Yoga History: Yoga practice can be traced back at least 4000 years and was originally steeped in traditions of Vedic culture (3,20,29). The word yoga is derived form a Sanskrit word meaning to ‘unify’ or ‘join’ and there are many different forms of yoga around the world (3,20) The practice of yoga typically combines stretching with poses, diaphragmatic breathing, and meditation (20). Yoga consists of eight limbs, or characteristics that are practiced in most yoga sessions (48,49):

1. Universal ethical principles (yama)
2. Individual self-restraint (niyama)
3. Physical poses (asana)
4. Breath work (pranayama)
5. Quieting the senses (pratyahara)
6. Concentration (dharana)
7. Meditation (dyana)
8. Emancipation/Bliss (Samadhi)

Recently, yoga has gained popularity as a form of physical exercise because it is proposed to improve strength and flexibility (3,29). The most recognizable form of yoga practiced in the USA is hatha yoga, which means sun and moon (3,20). This type of yoga concentrates on physical health and well-being by combining postures for strength and flexibility, breathing techniques, and meditation (3). There are five forms of yoga commonly practiced today which include hatha, ashtanga, anasara, iyengar, and bikram. Ashtanga is sometimes referred to as power yoga and uses free-flowing movements called Vinyasa. Iyengar involves prolonged holds of poses in very strenuous positions. Finally, bikram is commonly referred to as "hot yoga" (20). Yoga has been shown to help the body in more ways than just improving flexibility and strength (3,29).

Yoga has recently been used to treat a variety of different medical conditions, these include; psychological, physical, hereditary, and many more. The most common conditions that yoga is used to treat are back and neck pain, anxiety, arthritis, depression, and fatigue (3,16,29). Yoga's therapeutic effects are suggested to come from increasing vagal stimulation and turning off the hypothalamic-pituitary-adrenal axis and sympathetic nervous system response to stress (48,49). There are many other conditions that have been cited to be managed or treatable by yoga practice as displayed in Table 3 (20).

In addition to the above medical conditions, yoga has also been shown to enhance general effects of wellbeing. These include improvements in self-efficacy, improved mood, energy, and happiness, better social relationships, better sleep, weight loss, and enhanced meaning in the lives of practitioners (18,48,52).

Yoga has been shown to relieve pain associated with many orthopedic conditions while also increasing strength, flexibility, cardiovascular markers and body alignment (3,18,29). Conditions extensively studied are low back pain, neck pain, carpal tunnel, and knee osteoarthritis. Yoga's effects on low back pain includes better movement patterns, less pain, increased function, and increased flexibility (15,51,52,56). These have been achieved in as little as seven days of intensive yoga immersion, but typically are seen over the course of six weeks of weekly or twice-a-week classes (18,51,56).

Knee osteoarthritis has also been treated successfully with regular yoga training. Specifically, eight weeks of hatha yoga has been shown to be as effective as medications and other conservative treatments at reducing pain, increasing function, and increasing flexibility (20,23).

Table 3. Medical Conditions that can be Managed or Treated with Yoga. Adapted from Field (20)

Physiological symptoms and disorders	Mindfulness and job stress anxiety (3,29,48) Depression (3,29,48) Sleep disorders (52)
Cardiovascular Conditions	Coronary artery disease (29,48) Hypertension (29)
Pain Syndromes	Low back pain (3,16) Headaches (3) Osteoarthritis Rheumatoid arthritis
Physical effects	Weight loss (48) Leg strength
Autoimmune and immune conditions	Asthma (16,29) Diabetes (48) Multiple sclerosis Breast cancer (48) Lymphoma
Pregnancy conditions	Hypertension and preterm labor Stress and vagal activity (52) Labor pain (16)
Physiological effects	Heartrate and blood pressure (29) Pulmonary measures

Summary: Enhanced flexibility of the lower extremity and the low back are common side effects of yoga training. Adequate range of motion is essential to all athletes and can help improve performance in sport and reduce injuries (3). Most studies have examined lower body flexibility through sit and reach tests, usually having had participants train 1-2 times a week for between 45-90 minutes (3,10,18,45,51). The common theme of all of these studies is that yoga increases flexibility and that usually the effects are seen as early as six weeks even if the participants are only training once a week (10,15,18,51). Yoga has also been shown to increase lower extremity and low back flexibility significantly more than static stretching over the same period (56).

Yoga has many beneficial side-effects, but with conflicting studies about how acute stretching could potentially decrease force production weightlifters may be hesitant to perform yoga. This hesitation could lead many weightlifters to not realize the potential benefits yoga has been shown to offer in other studies; specifically, increased flexibility (3,10,18,29,45), a more stable core (15,18), reduced low back pain (15,29,49,51,52,56), reduced knee pain (23,28) and positive physiological effects and positive self-image (20,29,48).

To our knowledge there has been few studies that examine force or power production over an extended period of any form of stretching (4). There is currently no research focusing on chronic yoga training in Olympic weightlifters and how it will affect their flexibility, rate of force development, and power. The purpose of our study was to determine what effects 7-weeks of yoga training had on Olympic Weightlifters flexibility and rate of force development. We hypothesized that weightlifters will increase their flexibility as demonstrated by the sit and reach test and the overhead squat test with an increase in rate of force development due to a more optimal starting position.

CHAPTER III: CONCLUSIONS AND RECOMMENDATIONS

7-weeks of yoga training did not demonstrate any significant differences between groups on flexibility, rate of force development, or jump height. Based on our findings Olympic weightlifters can safely participate in yoga training without significant decreases in performance. The possible psychological benefits of yoga were not examined in the current study and may play a factor in overall performance. Future studies should continue to examine the effects of chronic stretching and yoga on performance variables in a variety of sports.

Our study had the following limitations. The participants were on similar training cycles but were not on the exact same cycle. This may have caused slight differences in training volume and intensity. Along with these differences, the participants were not in their peaking phase during either the pre- or post-testing which may have affected their RFD and jump height (14). Another limitation could be that more training sessions or a longer training period may have been needed to see the effects yoga had on flexibility and RFD in Olympic weightlifters (4,45).

Future research should continue to examine what effects yoga has on an athlete's ROM and force production. This should be expanded to include other strength and power athletes as well as endurance athletes to compare the differences. Researchers should also examine what differences there are between chronic stretching and chronic yoga on ROM and force production. Another interesting area of research would be to determine what psychological affects yoga may play in athletes due to the meditation and centering that is part of the training, and if this would help or hinder their performance.

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APPENDIX A

NORTHERN MICHIGAN UNIVERSITY
SCHOOLOF HEALTH AND HUMAN PERFORMANCE

CONSENT TO ACT AS A HUMAN SUBJECT

Subject Name (print):__________________________________Date ___________

1. I hereby volunteer to participate as a subject in exercise testing. I understand that this testing is part of a study entitled: "7-weeks of yoga training and its effects on flexibility, rate of force development, and Peak Power in Olympic weightlifters". The purpose of this study was to determine what effects 7-weeks of yoga training have on Olympic Weightlifters flexibility, rate of force development, and peak power.

   I hereby authorize Andrew Ernst, Randall L. Jensen, and/or assistants as may be selected by them to perform on me the following procedures:

   (a) I understand that I will perform three sit and reach tests while seated on the floor.

   (b) I understand that I will perform three loaded overhead squats with the barbell on a force platform to measure center of pressure and that reflective markers will be attached to the right side of my body: shoulder, hip, knee, ankle, and foot. These markers will be used to assess joint angles while performing the overhead squat test.

   (c) I understand I will be videotaped performing the overhead squat so joint angles may be assessed.

   (d) I understand that I will perform two countermovement jumps on a force platform where rate of force development and peak power will be measured.

   (e) I understand that I will perform three snatch lifts at 80% of my maximum snatch lift successfully performed in competition while on force platforms, to measure rate of force development and peak power.

(f) I understand that if I am selected to be in the experimental group I will be asked to perform yoga training for 7 weeks, twice a week for an hour each session. If I am selected to the control group I will still have to attend yoga classes for 7 weeks, twice a week for an hour each session, but will watch weightlifting videos during the stretching portion of the yoga class.

(g) I understand that after the 7 weeks I will be asked to return for testing conducted in the same manner as the pre-testing conditions.

2. The procedures outlined in paragraph 1 [above] have been explained to me.

I understand that the procedures described in paragraph 1 (above) involve the following risks and discomforts: musculoskeletal injuries including but not limited to; muscle strains, ligament sprains, joint dislocations, concussions, and abrasions. There may be minor skin irritation and redness from the reflective marker placement and removal. I understand that there is potential risk of dropping the barbell. To prevent this risk, I will demonstrate the ability to safely perform the snatch before data collection begins. In order to minimize any of the above-mentioned risks. I understand that there is potential risks involved with yoga, but that the yoga training will be at a low level with no inverted poses. I understand that the examiners shall adopt the necessary measures to prevent them such as: using physical tests in accordance with my athletic conditioning and having a certified Athletic Trainer present during all attempts. However, I understand that I can terminate any testing at any time at my discretion. I should stop any test if I experience any abnormalities such as dizziness, light-headedness, or shortness of breath, etc.

3. I have been advised that the following benefits will be derived from my participation in this study: if it is shown that yoga training increases flexibility and rate of force development in the snatch lift this information can be used to reduce injuries and provide an alternative training strategy to be able to increase performance in the participants' sport. Having a possible reduction in time loss from injury and the potential to increase performance in the participants sport are extremely important to weightlifters. If I am selected to the experimental group I will receive free yoga training. Other than these possible aspects there will be no benefit to me individually.

4. I understand that Andrew Ernst, Randall L. Jensen and/or appropriate assistants, as may be selected by them, will answer any inquiries that I may have at any time concerning these procedures and/or investigations.

5. I understand that all data, concerning myself will be kept confidential and available only upon my written request. I further understand that in the event of publication, no association will be made between the reported data and myself.

6. I understand that there is no financial compensation for my participation in this study.

7. I understand that in the event of physical injury directly resulting from participation, compensation cannot be provided. However if injury occurs, emergency first aid will be provided and the EMS system activated.

8. I understand that I may terminate participation in this study at any time without prejudice to future care or any possible reimbursement of expenses, compensation, or employment status.

9. I understand that if I have any further questions regarding my rights as a participant in a research project I may contact Dr.Brian Cherry (906-227-2300) bcherry@nmu.edu, Assistant Provost of Graduate Education/Research of Northern Michigan University Any questions I have regarding the nature of this research project will be answered by Dr. Randall Jensen (906-227-1184)rajensen@nmu.edu or Andrew Ernst aernst@nmu.edu.

Subject's Signature:____

Witness:____Date:__________

APPENDIX B

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	**1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	**2. Do you feel pain in your chest when you do physical activity?**
☐	☐	**3. In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	**4. Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	**5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	**6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	**7. Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ____

SIGNATURE ________________________________ DATE ____________________

SIGNATURE OF PARENT ________________________ WITNESS ____________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

continued on other side...

APPENDIX C

Oswestry Low Back Pain Disability Questionnaire

Sources: Fairbank JCT & Pynsent, PB (2000) The Oswestry Disability Index. *Spine*, 25(22):2940-2953.

Davidson M & Keating J (2001) A comparison of five low back disability questionnaires: reliability and responsiveness. *Physical Therapy* 2002;82:8-24.

The Oswestry Disability Index (also known as the Oswestry Low Back Pain Disability Questionnaire) is an extremely important tool that researchers and disability evaluators use to measure a patient's permanent functional disability. The test is considered the 'gold standard' of low back functional outcome tools [1].

Scoring instructions

For each section the total possible score is 5: if the first statement is marked the section score = 0; if the last statement is marked, it = 5. If all 10 sections are completed the score is calculated as follows:

Example: 16 (total scored)

50 (total possible score) x 100 = 32%

If one section is missed or not applicable the score is calculated:

16 (total scored)

45 (total possible score) x 100 = 35.5%

Minimum detectable change (90% confidence): 10% points (change of less than this may be attributable to error in the measurement)

Interpretation of scores

0% to 20%: minimal disability:	The patient can cope with most living activities. Usually no treatment is indicated apart from advice on lifting sitting and exercise.
21%-40%: moderate disability:	The patient experiences more pain and difficulty with sitting, lifting and standing. Travel and social life are more difficult and they may be disabled from work. Personal care, sexual activity and sleeping are not grossly affected and the patient can usually be managed by conservative means.
41%-60%: severe disability:	Pain remains the main problem in this group but activities of daily living are affected. These patients require a detailed investigation.
61%-80%: crippled:	Back pain impinges on all aspects of the patient's life. Positive intervention is required.
81%-100%:	These patients are either bed-bound or exaggerating their symptoms.

Oswestry Low Back Pain Disability Questionnaire

Instructions

This questionnaire has been designed to give us information as to how your back or leg pain is affecting your ability to manage in everyday life. Please answer by checking ONE box in each section for the statement which best applies to you. We realise you may consider that two or more statements in any one section apply but please just shade out the spot that indicates the statement which most clearly describes your problem.

Section 1 – Pain intensity

- ☐ I have no pain at the moment
- ☐ The pain is very mild at the moment
- ☐ The pain is moderate at the moment
- ☐ The pain is fairly severe at the moment
- ☐ The pain is very severe at the moment
- ☐ The pain is the worst imaginable at the moment

Section 2 – Personal care (washing, dressing etc)

- ☐ I can look after myself normally without causing extra pain
- ☐ I can look after myself normally but it causes extra pain
- ☐ It is painful to look after myself and I am slow and careful
- ☐ I need some help but manage most of my personal care
- ☐ I need help every day in most aspects of self-care
- ☐ I do not get dressed, I wash with difficulty and stay in bed

Section 3 – Lifting

- ☐ I can lift heavy weights without extra pain
- ☐ I can lift heavy weights but it gives extra pain
- ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently placed eg. on a table
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned
- ☐ I can lift very light weights
- ☐ I cannot lift or carry anything at all

Section 4 – Walking*

- ☐ Pain does not prevent me walking any distance
- ☐ Pain prevents me from walking more than 1 mile
- ☐ Pain prevents me from walking more than 1/2 mile
- ☐ Pain prevents me from walking more than 100 yards
- ☐ I can only walk using a stick or crutches
- ☐ I am in bed most of the time

Section 5 – Sitting

- ☐ I can sit in any chair as long as I like
- ☐ I can only sit in my favourite chair as long as I like
- ☐ Pain prevents me sitting more than one hour
- ☐ Pain prevents me from sitting more than 30 minutes
- ☐ Pain prevents me from sitting more than 10 minutes
- ☐ Pain prevents me from sitting at all

Section 6 – Standing

- ☐ I can stand as long as I want without extra pain
- ☐ I can stand as long as I want but it gives me extra pain
- ☐ Pain prevents me from standing for more than 1 hour
- ☐ Pain prevents me from standing for more than 30 minutes
- ☐ Pain prevents me from standing for more than 10 minutes
- ☐ Pain prevents me from standing at all

Section 7 – Sleeping

- ☐ My sleep is never disturbed by pain
- ☐ My sleep is occasionally disturbed by pain
- ☐ Because of pain I have less than 6 hours sleep
- ☐ Because of pain I have less than 4 hours sleep
- ☐ Because of pain I have less than 2 hours sleep
- ☐ Pain prevents me from sleeping at all

Section 8 – Sex life (if applicable)

- ☐ My sex life is normal and causes no extra pain
- ☐ My sex life is normal but causes some extra pain
- ☐ My sex life is nearly normal but is very painful
- ☐ My sex life is severely restricted by pain
- ☐ My sex life is nearly absent because of pain
- ☐ Pain prevents any sex life at all

Section 9 – Social life

- ☐ My social life is normal and gives me no extra pain
- ☐ My social life is normal but increases the degree of pain
- ☐ Pain has no significant effect on my social life apart from limiting my more energetic interests eg, sport
- ☐ Pain has restricted my social life and I do not go out as often
- ☐ Pain has restricted my social life to my home
- ☐ I have no social life because of pain

Section 10 – Travelling

- ☐ I can travel anywhere without pain
- ☐ I can travel anywhere but it gives me extra pain
- ☐ Pain is bad but I manage journeys over two hours
- ☐ Pain restricts me to journeys of less than one hour
- ☐ Pain restricts me to short necessary journeys under 30 minutes
- ☐ Pain prevents me from travelling except to receive treatment

References

1. Fairbank JC, Pynsent PB. The Oswestry Disability Index. Spine 2000 Nov 15;25(22):2940-52; discussion 52.

APPENDIX D

THE LOWER EXTREMITY FUNCTIONAL SCALE

We are interested in knowing whether you are having any difficulty at all with the activities listed below because of your lower limb Problem for which you are currently seeking attention. Please provide an answer for **each** activity.

Today, do you or would you have any difficulty at all with:

	Activities	Extreme Difficulty or Unable to Perform Activity	Quite a Bit of Difficulty	Moderate Difficulty	A Little Bit of Difficulty	No Difficulty
1	Any of your usual work, housework, or school activities.	0	1	2	3	4
2	Your usual hobbies, re creational or sporting activities.	0	1	2	3	4
3	Getting into or out of the bath.	0	1	2	3	4
4	Walking between rooms.	0	1	2	3	4
5	Putting on your shoes or socks.	0	1	2	3	4
6	Squatting.	0	1	2	3	4
7	Lifting an object, like a bag of groceries from the floor.	0	1	2	3	4
8	Performing light activities around your home.	0	1	2	3	4
9	Performing heavy activities around your home.	0	1	2	3	4
10	Getting into or out of a car.	0	1	2	3	4
11	Walking 2 blocks.	0	1	2	3	4
12	Walking a mile.	0	1	2	3	4
13	Going up or down 10 stairs (about 1 flight of stairs).	0	1	2	3	4
14	Standing for 1 hour.	0	1	2	3	4
15	Sitting for 1 hour.	0	1	2	3	4
16	Running on even ground.	0	1	2	3	4
17	Running on uneven ground.	0	1	2	3	4
18	Making sharp turns while running fast.	0	1	2	3	4
19	Hopping.	0	1	2	3	4
20	Rolling over in bed.	0	1	2	3	4
	Column Totals:					

Minimum Level of Detectable Change (90% Confidence): 9 points

SCORE: _____/ 80

Please submit the sum of responses.

Reprinted from Binkley, J., Stratford, P., Lott, S., Riddle, D., & The North American Orthopaedic Rehabilitation Research Network, The Lower Extremity Functional Scale: Scale development, measurement properties, and clinical application, Physical Therapy, 1999, 79, 4371-383, with permission of the American Physical Therapy Association.

APPENDIX E

24-hour Dietary Survey	
Name:	
Date:	[redacted]
Time:	
To the best of your memory please fill out what you have eaten in the past 24 hours. Please include all food, drink, supplements, ect.	
Breakfast	
Lunch	
Dinner	
Snacks/Supplements	
Breakfast	
Lunch	
Dinner	
Snacks/Supplements	