The Effect of a 12-week Calisthenic Dryland Program on Functional Movement Screen and Pain Scores for Young Swimmers

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Introduction

In recent years, the sport of swimming has evolved precipitously due to increased competition and improved new training methods to be applied for optimal swimming performance (Scott, 2016). Consequently, pain and injuries caused by competitive swimming have received large attention. Although swimming is often seen as a “low-impact” sport, a recent study classified swimming as a “high-overuse” sport, ranked second behind tennis (Stracciolini, et al., 2015). Current and past injury history was evaluated in over 1,600 athletic pediatric patients between 5-17 years participating in over thirty sports. If injuries were found to occur in at least 65%, the sport was categorized as “high-overuse.” Among swimmers, 83.6% of those who completed the study were considered to suffer from overuse injuries.

In swimming, the most common area of pain or irritation is located around the shoulder, followed by the knees and the back. These injuries may result in swimmers having to modify training intensity and volume, which in turn can affect their future performances. Two variables strongly correlate with shoulder pain in swimmers: 1) hours of training and 2) volume in yards or meters (Tate, Turner, Knab, Jorgensen, Strittmatter, & Michener, 2012; Harrington, Meisel, & Tate, 2014). In a cross-sectional study, Tate and colleagues (2012) found shoulder pain and disability occurring in 18-23% of 236 female swimmers across four different age groups. The most common symptoms for children below age 12 are reduced shoulder flexibility with latissimus dorsi tightness and reduced strength in the middle trapezius. Swimmers above age 12 showed symptoms of diminished core endurance and tightness in pectoralis minor. In fact, it is likely that shoulder symptomatic swimmers have shorter pectoralis minor muscle than asymptomatic swimmers (Harrington, Meisel, & Tate, 2014). In another study, 80 Australian elite swimmers aged 13-25 completed 23 clinical tests, of which 53 swimmers underwent an additional MRI examination: 91% of the swimmers reported shoulder pain; 54% unilateral and 37% bilateral pain. During activity, 80% reported pain and 70% specified the pain occurring during overhead activity. Along with the pain, shoulder stiffness was seen in 68% of the swimmers. MRI findings show that supraspinatus tendon thickness is correlated with the level of training ($P < .0001$), years in training, and hours per week in training ($P < .01$). The risk for tendinopathy doubles if swimmers exceed 15 swimming hours per week. Joint laxity and impingement are also correlated with swimming, but there are no current correlation showing that repetitive swimming increases joint laxity (Sain, et al., 2010). All swimmers who showed tendon thickness correlated strongly with impingement pain and supraspinatus tendinopathy ($P < .00001$), which occurred in 69% of the swimmers who completed the MRI screening, and each swimmer had a positive impingement sign.

The second most prevalent injury among swimmers is knee pain. Powerful and repetitive knee extensions from flutter- and dolphin kicking in combination with turns have a traumatic effect on the patellafemoral joint, in which the quadriceps are being overworked (Rodeo, 1999). Additionally, breaststrokers put tremendous pressure on the medial compartments of their knees during the kick phase (Vizsolyi, et al., 1987). The forceful long-lever adduction of the legs puts an enormous torque on the knee. If the joint is not sufficiently strong and stable, the risk of injury increases. In a controlled cross-sectional study, 13 swimmers who were 14-15 years old underwent MRI scans. Out of the 26 knees examined, 69.2% revealed one or more abnormalities, compared to a control group where 32.1% of the knees showed one or more abnormalities, making knee abnormality frequency statistically significant ($p=0.013$) (Soder, Mizerkowski, Petkowicz, & Bldisserotto, 2012).

The low back is another frequently reported pain area for swimmers. A fairly recent study shows that lumbar disc degeneration is the plausible explanation (Kaneoka, et al., 2007). Fifty-six elite Japanese swimmers, ages 18-24 years underwent MRI scans. This study shows that there is a significant difference among swimmers who are exposed to higher volume of swimming and more years of training. To extrapolate, swimmers were categorized into a high-load vs. low-load group, as years of training and training hours week are most strongly correlated with low back pain. Lumbar degeneration was found in 68% of high-load swimmers and 29% of low-load swimmer, which is significantly higher ($p= .021$).

Injury for an athlete can be devastating and have damaging effect on the psyche and return to the sport (Wadey, Evans, Hanton, & Neil, 2012). Athletes cope differently with their injuries from one another and will have contrasting severity on their careers. Recently, Mahler (2015) introduced an epidemiological 35-year old study supporting a strong hypothesis that injury prevention contributes to performance improvement. Prevention of injury is therefore necessary in order for an athlete to maintain their health in combination with intense and consistent periods of training. To prevent injuries for youth swimmers, reported recommendations of exercises for 11-year old swimmers should center their attention towards developing the core and overall athleticism, but what remains unclear is if shoulder pain and disability is reversible without manipulating swimming volume or hours. No comprehensive or applied exercise programs exist to the public today where the effectiveness of the program is evaluated. This intervention is innovative, as it takes fundamental prevention tactics from professionals into an applied form (Cools, Johansson, Borms, & Maenhout, 2015); Injury Prevention Programme, 2010; McGill, 1998; (Nichols, 2015); Riewald & Rodeo, 2015; Salo & Riewald, 2008; Tovin, B. J., 2006; Wanivenhaus, Fox, Chaudhury, & Rodeo, 2012). The purpose of this project is to examine how an age- and sport specific 12-week exercise program affects functional movement and impingement scores in young competitive swimmers. It was hypothesized that the program will negatively affect pain and positively affect FMS scores.

Methods

Subjects. Thirty-three (16 boys and 17 girls) competitive swimmers (age 12 ± 0.2) from a local swimming club in Salt Lake City, Utah were recruited to participated in this project. A project description and informed consent was sent out to parents with help from the club director. To fit the inclusion criteria, the participants needed to: 1) be competitive swimmers, 2) be able to perform calisthenic dryland exercises, and 3) be between 10-14 years without attending high school. Subjects were semi-randomly assigned to either a control (C) group, or an experimental (E) group. If the participants had a poor history of attendance on Mondays and Wednesdays, the option to switch them from E to C and vice versa, was open as the intervention sessions were on those days. Table 1 summarizes the final subject information.

Table 1. Participants

Subjects	Age	Control	Experiment
Male	13 ± 0.7	8	6
Female	12 ± 0.2	8	7
Total	12 ± 0.2	16	13

Project Survey. All subjects were given a 2-part project survey to complete, comprised of: 1) health & injury (HI) and 2) performance log (PL) (appendix a). HI was assessed completely from the subject's perspective for safety precautions. Although not used for any statistical analysis, PL included a performance log consisting of 11 questions with answers scaled one through ten. The subjects' past seven days were the reference point in how they perceived their physiological and psychological well-being. The purpose of the survey was to stand as a safety net to ensure that all participants were healthy enough to be part of the project.

Functional Movement Screening. To assess improvement in neuromuscular functioning, participants completed a modified FMS. The original FMS has seven tests with maximal score of 21 points. Since the FMS has been improved in professional football players after an off-season training intervention (Kiesel, Pilsky, & Butler, 2011), it can be expected that there will be change from a 12-week intervention in young swimmers; however, since football and swimming vastly differ in biomechanics and bioenergetics from one another, a modification of the FMS was created to fit swimmers.

This project's FMS includes nine different functional movement exams to assess functional movement and balance (appendix c). No research is currently investigating if balance can improve scores in this setting, but since evidence exists that balance can reduce the risk for knee injury in high school students (Emery, Cassidy, Klassen, & Rosychuk, 2005), it is argued in this project that balance should be an important part of assessment in youth swimmers. Therefore, the maximum score for the swim specific FMS is 27 points. Each exercise was scored 0-3; three = a perfectly executed movement without any joint compensation; two = a movement performed with particular joint compensation in order to execute the exercise; one

= a very poorly executed movement with visual joint compensation and evident muscular strength & imbalance; and zero was recorded if the athlete experienced pain during any movement. Appendix B, section one outlines testing procedures and scoring.

Pain and Impingement. This section and scoring system is manual completely innovative, and influenced by athletic training testing (appendix c) (Konin, Wiksten, Isear Jr., & Brader, 2005). The purpose of adding this is two-fold: 1) to see if pain associated in swimming can be reversible, and 2) to find a convenient solution to easily assess swimmers on deck. Appendix B, section two outlines the testing procedures.

This section is comprised of four tests to manually assess shoulder- and lumbar impingement, and knee pain. A maximum of 3 points could be recorded on each shoulder (6pts total), 2 points for each knee (4pts total), and 2 points for two different tests for the low back (4pts total), equaling a maximum of 14 points. The added total score on each limb for the shoulder and knee, and each test for the lumbar spine, was the recorded score on the test.

For the shoulder and knee joints, the total points recorded on each limb were the official score. Similarly to score the lumbar spine, the scores from the two different tests were added. Interpretation of the scoring in this section is different; zero = no pain or damage is associated with the assessed joint; one = there is a slight associations of pain and the pain being perceived per angle manipulation is ≤4 on a 1-10 scale; two = there is noticeable sensation on joints with angle manipulation, pain perceived is >5; three (only shoulder) = there is clear impingement with little angle manipulation.

Intervention. The E group completed the 12-week intervention comprising of 2 230-minutes dryland sessions per week. At week 8, the participants got one week break from the intervention due to State Championships. In total, the project lasted 15-weeks including pre- and post data collection, but only 12-weeks of dryland training.

The training program was divided into three different meso-cycles for optimal training adaptations: 1) introduction to exercises and technique expectations, 2) general strength, and 3) power introduction. The main areas of focus for this intervention was to rebalance the shoulder rotator cuff muscles, improve balance, and stabilize the trunk for adolescent swimmers, based on what current literature suggest in combination with innovative ideas to create a 12-week introductory calisthenic dryland program. Shoulder prevention was incorporated into every session and was the main focus area of this project, highly influenced and applied from Tovin (2006). In a randomized clinical trial, it was revealed that a structured in-home balance training program for high school students 15-16 years of age improved static and dynamic balance (Emery, Cassidy, Klassen, & Rosychuk, 2005). This project therefore focused heavily on improving static and dynamic balance in order to see how the properties within the knee change in a 12-week program (Emery, Cassidy, Klassen, & Rosychuk, 2005; Vizsolyi, et al., 1987). Spinal control and pelvic movement understanding was also highly emphasized in this program as there is evidence for a lumbar region stability and core endurance and lower back health (McGill, 1998). Appendix D summarizes the intervention exercises with progressions and has exercise examples from the program.

Data Analysis. Mean and standard deviations were calculated for all variables at pre-test and post-test time-points for FMS and impingement. A mixed-design 2 x 2 ANOVA test was used to examine whether statistically significant differences existed between groups across the two time-points. The effect of interest was the group x time interaction. The analysis was conducted using SPSS (v.24.0) statistical software package and a criterion alpha level of $p < 0.05$ was used to determine statistical significance.

Results

Twenty-nine participants completed the project. One swimmer was removed from the E group due to excessive shoulder pain. Another three subjects failed to complete the post-testing.

There was a main effect over a course of time for FMS between groups (Fig. 1, $P<0.0001$). The mean score pre-test score for the C group was 19.5 (SD 3.2) and for the E group was 17.5 (SD 3.0). The mean post-test score for the C group was 16.8 (SD 3.9) and for the E group was 18.7 (SD 3.4).

No effect was found on pain scores between groups (Fig. 2, $P=0.231$). The mean score pre-test score for the C group was 3.9 (SD 2.6) and for the E group was 4.1 (SD 3.4). The mean post-test score for the C group was 3.8 (SD 2.4) and for the E group was 2.7 (SD 2.4). Table 2 summarizes all participants FMS and pain scores. The results of the repeated measures did not indicate that one particular test has a significant impact on the combined main effects for FMS and pain. Table 2 summarizes pre-test and post-test changes in score for all participants in pain and FMS.

Table. 2 Changes in pain- and FMS scores from pre-to post-test

	Pre-Test	Post-Test	*P*
Total Pain	4 ± 0.5	3.2 ± 0.5	0.231
Total FMS	18.5 ± 0.6	17.7 ± 0.7	<0.001

Discussion

There is no current literature that examines the effectiveness of a training program on FMS and pain scores. The results of this project support that a 12-week introductory dryland program significantly improves modified FMS scores in swimmers 10-14 years. In addition, there seems to be a trend in pain decrease during the span of a competitive swimming season. Finally, the findings of this project suggest that discrepancies exist within what swimmers perceive their pain levels at and what they actually are. While these results are promising, caution should be taken then interpreting the findings, as the power of the project is low (0.231).

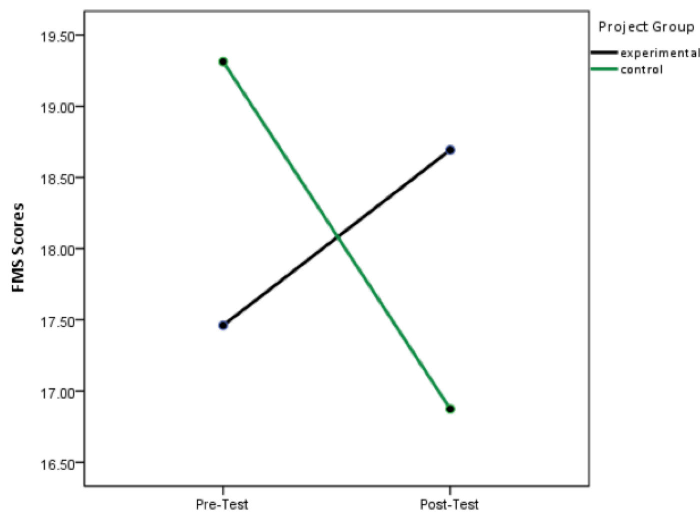

Figure 1. Change in total Functional Movement Screen (FMS) scores for young swimmers before and after the 12-

The outcome of this project confirms and builds on Kiesel and colleagues (2009) findings that FMS score improvements in professional football players following an off-season intervention (P<0.01). In addition, it is evident that a swimmer who does not undergo a strategic dryland program has significantly increased risk to decrease in land-based functional movement in comparison to the swimmer who does. However, this is not linked to any pain, as no statistical significance exists, although there seems to be a trend suggesting that the intervention group's pain decreased more than the control group.

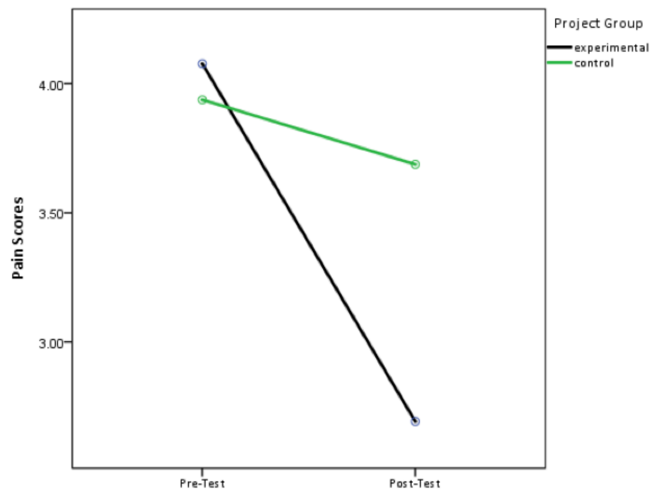

Figure 2. Change in total pain scores for young swimmers before and after the 12-week intervention.

Injuries are so common in swimming that the higher the level of the competitive swimmer, the more likely the swimmer will have supraspinatus tendinopathy ($p<0.0001$) (Sain, et al., 2010). At the 2013 FINA World Championships in Barcelona, it was clear that some swimmers competed with an injury. The prevalence was significantly higher among females (36.7%) than males (28.6%) ($p<0.005$) (Mountjoy, et al., 2015). This project becomes a stepping-stone toward understanding swimming-related injuries and complaints about pain, and how they potentially can be avoided or controlled throughout a part of a season without interfering with performance.

One of the most repeated movements in swimming is overhead internal rotation (IR) of the shoulder (Stracciolini, Casciano, Levey Friedman, Meehan III, & Michelo, 2015). There are several major muscle groups that create forward propulsion that act in tandem with stabilizing muscles. The supraspinatus muscle, primarily known to abduct the shoulder from an extended position, acts as an IR-muscle when the shoulder is flexed (Yu, Ackland, & Pandy, 2011), therefore making it a relevant rotator-cuff muscle. This means that the supraspinatus is active both in the swim recovery- and catch phase, which lessens its recovery time between strokes.

Sain and colleagues (2010) also make a strong case for how tendinopathy may arise. Their diagram is based on a running-rat model that simulates the stress put on shoulders in swimming and showcases that significant change can occur in the thickness of the tendon. They mean that with excessive repetitive swimming motions, specifically overhead internal rotation, the tendons around the shoulder take a direct hit, causing forceful trauma to the cells surrounding the shoulder. This results in the release of stress-activated protein kinase (JNK). Persistent JNK-activation has the potential to inaugurate apoptosis – cell death –, which results in thickening of the tendon. Collagen fibrils formed under these circumstances will undergo additional stress; the balance for equilibrium will be lost and this results in the deterioration of the tendon. Although Sain's theory is yet to be confirmed, it prompts the question: Why there is such a high incidence of shoulder injuries in swimmers?

Lastly, there seems to be discrepancy between swimmers' perception of injury or pain, and how their joints react with certain joint angle manipulation. Table 3 outlines the differences in The findings of the inconsistency between how swimmers feel and what their body is actually going through are something for all swim coaches to consider in the future. This means that any injuries a swimmer experiences during his or her career will most certainly have developed over an extended period of time. We can see differences in how a 12-year old swimmer can report zero pain or injury, while in fact their joints have already begun the process of an injury by starting to release excessive amounts of JNK.

Table 3. Discrepancy:
Pain Perception vs. Actual Impingement

	All Participants
Survery Pain PRE	9 (31.0%)
Survey Pain Post	10 (34.5%)
Impingement PRE	25 (86.2%)
Impingement POST	26 (89.75)

Although no current data exists, there seems to be a trend where swimmers start reporting more back pain as they get older. A potential explanation is that the build-up in lumbar disc degeneration makes the area very fragile in the transition from high-school swimming to college, where the athlete is heavily exposed to resistance training (Kerr, Baugh, Hibberd, Snook, Hayden, & Dompier, 2015). Heavy vertical loading of an already fragile spine in combination with accelerated progression may be a potential explanation to why lower-back pain is more common among older swimmers. Current literature suggests that the high prevalence of low back pain in swimmers is due to forceful back extensions in butterfly and breaststroke. However, this theory seems to be missing an important factor for the rotational strokes. Kaneoka et al. (2007) found that the different strokes could impact the prevalence for lumbar disc degeneration differently: 38% were freestylers, 25% were backstrokers, 16% were breaststrokers, and 20% were butterflyers. A potential explanation is due to excessive trunk rotations that the rotational strokers (freestyle and backstroke) put their lumbar spine through. A few limitations exist in this project. The sample size was small due to availability of swimmers with combination of limited time to collect participants, which has an impact on project power. Secondly, this is the first known project that uses completely manual testing methods for FMS and impingement assessments to look for interactions. Therefore, the validity of the project could be questioned. In addition, training adaptations in the E group may have been hindered as attendance for the dryland sessions was recorded between 74-97%, where the participants missed between 1-6 dryland sessions out of 26. More optimal results may have been present if equipment usage was included in study protocol, as opposed to solely calisthenic movements in combination of adding stretching of pectoralis minor. Lastly, the intervention is difficult to replicate as it is written from at strength and conditions specialists perspective.

In conclusion, this project demonstrates that functional movement can be improved in young swimmers during a competitive season in swimmers who undergoes strategic dryland training, whereas movement on land tends to worsen in without it. Swimming coaches should consider implementing a safe introductory dryland program to swimmers before adding too advanced movements, which can be harmful for underdeveloped athletes and jeopardize their future performance. The goal should be to minimize the future risk of injury for the swimmers in order to maintain longer and more sustained training periods to improve performance.

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Appendix A

Project Questionnaire

Part 1: Personal Information

Full Name: ___________________________________ Date of birth: ____________

Known weight (lbs):_______ Known height: _______ Circle: BOY GIRL

Part 2: Health Information

Are you under any current medical diagnosis? YES NO

If yes, what is your diagnosis? Does it affect your swimming (i.e. asthma)?

____

Have you fractured any bones within the last 24 months? YES NO

If yes, when & where? And are you still suffering from any limitations?

____

Do you have any current muscular- and/or joint-pain? YES NO

If yes, where? And for how long? Is it because of swimming or outside activity?

____

******you only have to continue if you have current pain or injury . . .*
skip to Part 3 if you don't have any pain.

Please circle any that apply . . .

When does it hurt the most?

When I swim During dryland On very rare occasion Any time I exercise

Does the pain come after a certain time during swim practice? YES NO

If yes, at what point of practice does it occur?

____

Please list any exercises or movements *<u>that may</u>* be of limitations for you . . .

____

Please explain when you are feeling pain the most and how that feels . . .

Part 3: Performance Log

On average,
How many times per week do you swim? _________________
How many yards do you swim per *practice?* _______________
Please circle one

In the past week . . .

How fatigued have your muscles been?

1 2 3 4 5 6 7 8 9 10

How sore have your muscles been?

1 2 3 4 5 6 7 8 9 10

How stressed have you been feeling?

1 2 3 4 5 6 7 8 9 10

How well have you been sleeping?

1 2 3 4 5 6 7 8 9 10

How well have you been eating?

1 2 3 4 5 6 7 8 9 10

How hydrated have you been?

1 2 3 4 5 6 7 8 9 10

How difficult is it to stay focused on one specific task?

1 2 3 4 5 6 7 8 9 10

How distracted do you get by teammates or classmates?

1 2 3 4 5 6 7 8 9 10

How fast are you feeling in the pool right now?

1 2 3 4 5 6 7 8 9 10

How strong are you feeling right now?

1 2 3 4 5 6 7 8 9 10

How healthy are you feeling right now?

1 2 3 4 5 6 7 8 9 10

Subject Name: ______________________________ Date: _____________

Appendix B

Functional Movement Screening and Pain Testing Procedures

Functional Movement Screening

Overhead Squat. Subject stands with feet slightly wider than hips, holds a dowel overhead wider than shoulder width in a closed pronated grip, while trying to maintain the dowel in line with the shoulder throughout the movement. Subject is instructed to squat down until the femur is parallel to the ground, and stand up. The scoring has previously been explained and is replicated in this project (Kiesel, Pilsky, & Butler, 2011). This test places great biomechanical demand on the subject, where strength, mobility, and stability are evaluated.

Hurdle Step. First, the subject's knee height was measured and a rubber band hurdle was then set up accordingly in front of their toe. With the dowel resting on the back, the subject was asked to flex their hip to move their knee and foot over the hurdle to touch their toe on the other side of the hurdle and back as graciously as possible. After two attempts on their first leg, they alternated their stance and had another two attempts on the opposite leg. This test has the ability to reveal hip and core instability on either side of the body.

In-Line Lunge. The same measured knee height was used to measure toe-to-heel distance, where the subject was instructed to stand in one straight line with the dowel placed behind their back in line with their spine. They were then asked to complete a controlled lunge until their rear knee gently contacted the ground, while keeping their chest as upright as possible, and stand back up again. After two attempts on their first leg, they alternated their stance and had another two attempts on the opposite leg. This test has the ability to reveal balance ability, hip and quadriceps tightness, and hip and core instability.

Shoulder Mobility*.* This exam is only performed once with a baseline measure of the subject's fist length to determine test score. Viewing the subject posteriorly, they were asked to, with a closed fist, reach one arm over their head and reach as far down their neck, and their opposite arm behind their back and as close to their superior fist. If the fists are within a fist length apart, the score is 3. A score of 2 is received if the fists are within 2.5-3 fist lengths apart. 3 or more fist lengths apart is a score of 1. This test is a good indicator of how the muscular development of the upper back and shoulder impacts shoulder mobility.

Wall Streamline*.* This exam is not an original FMS test and is also only preformed once. The subject is placed near a wall with the heels within two inches of touching the wall. It is important that the subject understands how to activate the core by posteriorly tilting their pelvis to get lumbar contact with the wall. Four main points of contact are obligatory: gluteals, lumbar spine, thoracic spine and head. The subject is then asked to get in to as perfect of a streamline as possible, while remaining all points of contact. A score of 3 is given if very minimal effort is required to maintain the position for ≤ 5s. If the subject can get in to the position but not maintain it and if any tightness is reported in their shoulders, thoracic spine, or abdominal area, they receive a 2. A score of 1 is given if a noticeable lumbar lordsis is evident and they report significant tightness in the same three locations. This exam reveals the ability of the swimmer to get into the most optimal position required to carry as much top speed as possible after a start and in every turn. The inability to perform this test may be the result of excessive tightness or muscular weakness. This test is added as an assessment because it reveals important and relevant information in regards to the swimmers' ability to hold a streamline, which is the fastest position in swimming.

Trunk Stability Pushup*.* The subject is asked to assume a pronated position on the ground. With their hands wider than shoulder width and hands in line with the upper part of their head, they were asked to perform as perfect of a pushup as possible. If the subject could maintain a straight line from their heels through knees, hips, back shoulders, neck and head, they received a 3. A score of 2 is given if a slight, but noticeable lack of strength is evident, which would cause a misalignment from heels to head. If their trunk would drop excessively and a noticeable break in form is evident, a score of 1 is received.

Tuck Jump*.* This exam is not an original FMS test and is added because a subject may score a 3 in the first three tests, but still have hip weaknesses or knee pain, which can be exposed in this exam. The subject is asked to stand in hip width and perform three tuck jumps by flexing their hips to bring their knees up close to their chest in the air, while trying to plant their feet at the starting point, without their heels contacting the ground in between jumps. If the jumps are gracious and performed with the legs in constant line with hips, a score of 3 is given. If slight knee valgus is noticeable in between jumps, a score of 2 is given. If the subject’s knees came in contact with each other in between jumps, a score of 1 is given.

Contralateral Toe Touch-2-Reach*.* This an inventive test created to specifically examine balance. The subject was asked to stand on one leg with the opposite knee flexed to 90 degrees, while reaching overhear with opposite arm to standing leg. They were then instructed to touch the reaching hand to their standing toes and come back to starting position without moving their planted foot. A score of 3 was received if the movement was continuous, feet did not move and knees stayed in line with toes. If the knees showed sign of valgus, or if the movement was irregular, a score of 2 was given. If the subject could not maintain feet in place and the counter leg touched the ground, a score of 1 was received.

Ipsilateral Toe Touch-2-Reach. This exam has the same scoring criteria, is performed slightly differently in order to reveal any core and balance imbalances. The starting positing is the same, except for a shift in overhead reaching arms to the same arm as the planted foot.

The second part of testing is not part of the original FMS. It includes five exams to examine any concealed impingement or pain in the subjects' shoulders, knees and back and requires the examiner to move and manipulate the joint positions. The exam scores will depend on the level of pain the subject reports back and will vary from 0-4. If pain is revealed, the subjects were asked to quantify the pain 1-10: pain sensation between 1-4 scores 1, and 5-10 scores 2.

Pain & Impingement Testing

Shoulder Impingement. Known as the Hawkins-Kennedy Impingement Test (HKIT), particularly examines impingement in the supraspinatus. For the purpose of scoring, the exam was be performed at three different positions that all scored differently in the FMS. As the subject was sitting on a table with their upper extremities relaxed, the examiner placed one have on the subject's elbow and the other around their wrist. Their shoulder and was then laterally flexed to 90 degrees and elbow flexed to 90 degrees. The examiner then internally rotated the shoulder beyond functional angles. If pain was felt in this position a score of 3 is given. The second position that scores a 2 moves the shoulder approximately 45 degrees in horizontal adduction before internally rotating the shoulder. The last position scores a 1 and positions the shoulder at 90-degree horizontal adduction of the shoulder before internally rotating. If any of the last two positions reported pain ≥ 6 received an automatic extra point.

Knee Varus-Valgus. This test is was a modification of the Hughston Plica Test. The subject assumed a supine position with all limbs extended and relaxed. The examined placed one hand on the heel to apply pressure, and the other one on the knee for stability. Pressure was placed on the medial- and lateral border of the knee. For medial pressure, the hand on the knee is placed on the medial border, and for lateral pressure the hand is placed on the lateral border. For either direction, if pain was recorded to be ≤ 5 it scored 1, and ≥ 6 scored a 2. If pain was perceived to be ≤ 5 it scored 1, and ≥ 6 scored a 2.

Spinal Flexion-Leg Extension. This test was a modification of the Sitting Root Test in which sciatic nerve pain is being examined. The subject was sitting on a table with their upper- and lower extremities relaxed. They were then instructed to extend one leg and then to flex their cervical and thoracic spine. If pain was recorded to be ≤ 5 it scored 1, and ≥ 6 scored a 2.

Upward Facing Dog-2-Child's Pose. The subject is asked to assume a pronated position on the ground. With their hands placed outside their chest, they are then instructed to push themselves up to an upward facing dog, spinal hyper extension, followed by going in to child's pose, full hip and knee flexion with arms on the ground fully flexion with the head resting close to the ground. Another point is added if the pain is higher than 5, and/or if the pain is evident in both movement patterns.

Appendix C

Functional Movement Screening & Pain Scoring Sheet

SWIM FMS

FUNCTIONAL MOVEMENT SCREEN

Scoring Sheet

NAME		DATE	AGE
SWIM GROUP		GENDER	
HAND/LEG DOMINANCE		PRIMARY STROKE & DISTANCE	

	Test		Raw Score	Final Score	Comments
1	Overhead Squat				
2	Hurdle Step	R			
	Hurdle Step	L			
3	In-Line Lunge	R			
	In-Line Lunge	L			
4	Shoulder Mobility	R			
	Shoulder Mobility	L			
5	Wall Streamline				
6	Trunk Stability Pushup				
7	Tuck Jump				
TOTAL			/21		
Balance					
8.1	Contralateral Toe Touch-2-Reach	R			
	Contralateral Toe Touch-2-Reach	L			
8.2	Ipsilateral Toe Touch-2-Reach	R			
	Ipsilateral Toe Touch-2-Reach	L			
TOTAL			/6		
Impingement/Pain					
1	Shoulder Impingement	R			
	Shoulder Impingement	L			
2	Knee Varus-Valgus	R			
	Knee Varus-Valgus	L			
3	Up-Dog / Child's Pose				
4	Leg Extension-Spinal Flexion				
TOTAL			/14		

Appendix D

Intervention Outline

Mesocycle 1: Introductory & Technique									
	Day 1	Week 1		Week 2		Week 3		Week 4	
Block	Exercise	Reps/Time	Set(s)	Reps/Time	Set(s)	Reps/Time	Set(s)	Reps/Time	Set(s)
Posture Warm-Up	Standing Pelvic Tilt	1:00	1	1:00	1	1:00	1	1:00	1
	Supine Abdominal Brace	15 x :02	1	15 x :02	1	15 x :02	1	15 x :02	1
	Cat/Cow	20	1	20	2	10	2	10	2
	4-Point Table Top Extension	10	1	10	2	5	2	5	2
	Child's Pose	:10	1	:10	2	:05	2	:05	2
Shoulder Warm-Up	Pumps	15	1	10	2	15	1	10	2
	Handles	15	1	10	2	15	1	10	2
	90/90	25	1	20	2	25	1	20	2
	Low Ext. Shoulder Rotation	25	1	20	2	25	1	20	2
Main Set: Back & Core	Long-Lever Scap Retraction	15	1	20	1	10	2	10	2
	Spinal Sit-up	5	1	5	1	5	2	5	2
	Prone "Y"	15	1	20	1	10	2	10	2
	Spinal Sit-up	5	1	5	1	5	2	5	2
	Slide Outs	10	1	20	1	10	2	10	2
	Prone Shoulder "I"	15	1	20	1	5	2	5	2
Core & Shoulder Stability	Stratight Arm Plank	:15	3	:15	4	:20	5	:20	5
	Day 2								
Hip & Posture	Table Top Hip Series	5	2	5	2	5	2	5	2
	Bird Dog	5	2	5	2	5	2	5	2
Set 1: Knee & Hip stability	1L 90/90 Balance	:45	2	:45	2	1:00	2	1:00	2
	Side Lying Hip Abduction	15	2	15	2	15	2	15	2
	Side Lying Hip Adduction	25	2	25	2	25	2	25	2
Recovery Set	Standing Hip Circles	5	1	5	1	5	1	5	1
	Lateral Trunk Flexion	5	1	5	1	5	1	5	1
	Hip Flexion & Extension	5	1	5	1	5	1	5	1
Main Set: Legs	ISO Squat	3 x :05	2	:15	2	3 x :05	3	:15	3
	ISO Split Squat	:10	2	2 x :05	2	:10	3	2 x :05	3
	Supine 1L Raise	15	2	15	2	10	3	10	3
	Scorpions	5	2	5	2	5	3	5	3

Mesocycle 2: General Strength									
	Day 1	Week 6		Week 6		Week 7		Week 8	
Block	Exercise	Reps/Time	Set(s)	Reps/Time	Set(s)	Reps/Time	Set(s)	Reps/Time	Set(s)
Warm-Up	Pumps & Handles	10	1	10	1	10	1	10	1
	90/90 & Low Rotation	20	1	20	1	20	1	20	1
	Scap Pushup	10	2	10	2	15	1	20	1
	Straight Arm Thoracic Rotation	3	2	3	2	3	2	3	2
	Side Lying Scap Rotation	3	2	3	2	3	2	3	2
	Shoulder Series: Y/T/I	10	1	10	1	10	1	10	1
	Prone External Rotation	20	1	20	1	20	1	20	1
	Slide Outs	5	1	5	1	5	1	5	1
Main Set	Eccentric Pushup	6	2	5	3	4	4	5	4
	ISO Glute Bridge	:20	2	:15	3	:20	4	:30	4
	Wall Sit	:15	2	:20	3	:30	4	:45	4
	Prone 90/90 Scap Retraction	25	2	20	3	15	4	20	4
	Day 2								
Warm-Up	Pump & Handles	10	2	10	2	10	3	10	3
	1L Shoulder Series: T/Y/I	5	2	5	2	5	3	5	3
	1L Toe Touch	5	2	5	2	5	3	5	3
Set 1	Mobility Squat	5	2	5	2	5	3	5	3
	Plank Up-Down	5	2	5	2	5	3	5	3
	Split Squat	10	2	10	2	15	3	15	3
Set 2	Bent Leg Side Plank	:15	2	:20	2	:15	3	:20	3
	Spinal Situp	3	2	3	2	5	3	5	3
	Bent Leg Side Plank Dips	10	2	10	2	10	3	10	3
	Straight Arm Plank Knee-2-Elbow	5	2	5	2	5	3	5	3

Mesocycle 3: Power Introduction

	Day 1	Week 9		Week 10		Week 11		Week 12	
Block	**Exercise**	*Reps/Time*	*Set(s)*	*Reps/Time*	*Set(s)*	*Reps/Time*	*Set(s)*	*Reps/Time*	*Set(s)*
Warm-up	Table Top 1L Hip Series:								
	CW, CCW, Fire Hydtrant, Hip Ext.	10	1	5	2	15	1	10	1
	1L Adductor Raise	20	1	10	2	25	1	20	1
	1L Abductor Raise	10	1	20	2	15	1	20	1
	Back Bridge Marches	:30	1	:15	2	:20	2	:45	1
	Kneeling Shoulder Series:								
	Slide Outs, T/I	5	1	5	1	5	1	5	1
	Prone External Rotator Cuff Series:								
	90/90 & Diamond External Rot.	10	1	15	1	20	1	10	1
	Plank Steps	:10	2	:20	2	:30	1	:45	1
	Mobility Squat	5	1	5	1	5	1	5	1
Dynamic	Spiderman w/Hip Circle	5	1	5	1	5	1	5	1
	Pigeon	5	1	5	1	5	1	5	1
	Quad-Pull	5	1	5	1	5	1	5	1
	Straight Leg Kick	5	1	5	1	5	1	5	1
Main Set	Jump-Land	10	3	10	4				
	MAX Squat Jump					5	3	6	4
	Dead Bug	5	3	5	4				
	Hollow Hold					:15	3	:20	4
	1L Toe-Touch-Jump	5	3	5	4	5	3	5	4
	1L Lateral Jump					5	3	5	4
	Supine 1L Raise	15	3	10	4	15	3	10	4
	Slow Maximal Swimmers	5	3	5	4				
	Speed Swimmers					:20	3	:30	4
	Day 2								
Warm-up	Pumps & Handles	15	1	15	1	10	1	10	1
	Staggered Y/T/I	5	1	5	1	10	1	10	1
	Lunge-Rotation	5	2	5	2	5	2	5	2
	Wide Stance Lateral Lunge	5	2	5	2				
	Lateral Lunge-Trunk Flexion					5	2	5	2
	Bird Dog	5	2	5	2	5	2	5	2
Main Set	Glute Bridge-2-1L Extension	6	3	6	3	5	4	5	4
	Long Lever Plank Rotation	6	3	6	3	5	4	5	4
	Plank Hop Squat	5	3	5	3	6	4	6	4
	1A Plank Up-Down	5	3	5	3	5	4	5	4
	Star V-Up	4	3	5	3	6	4	10	4
Core Set	Tuck Extension	10	3	10	3	10	4	10	4
	Advanced Swimmers	10	3	10	3				
	Blackburn					10	4	10	4
	Side Elbow Plank	:15	3	:15	3	:20	4	:30	4