Spring 5-14-2020

Impact of weight training on sprint swimming

Griffin Patterson
gdpatte@bgsu.edu

Impact of weight training on sprint swimming
Griffin Patterson

Paper submitted in partial fulfillment of HNRS 4990

Research Question

This research is being done to help determine the best way for swimmers to train in order for them to get the best results both in the efficiency of their stroke as well as their time. I propose to address this question by conducting a two-month study in which swimmers will be doing four weeks of just swim training and four weeks of swim training plus weights and having post trials of three race-pace 50 freestyle swims after both. In competitive swimming to achieve a faster time and a more efficient stroke technique as measured by a lower arm stroke index, I am asking the question: Is it more advantageous to use swim training alone <u>or</u> swim training augmented by weight training?

Hypotheses

Hypothesis	Explanation	Time Measured
Null	No difference between pure swimming and swim training + weights	Pre Test, Post Test 1&2
Alternate 1	Pure swim training > swim training + weights regardless of time	Pre Test, Post Test 1&2
Alternate 2	Swim training + weights > pure swim training regardless of time	Pre Test, Post Test 1&2
Alternate 3	Pure swim training before swim training + weights is superior	Pre Test & Post Test 2
Alternate 4	Swim training + weights before pure swim training is superior	Pre Test & Post Test 2

The research question could have resulted in at least one of five hypotheses. The null hypothesis states that no differences in swim time or arm stroke index would exist between pure swim training versus swim training augmented by weight training. The first two alternative hypothesis examine the directs effects of pure swim training vs. swim training augmented by weight training. The first alternative hypothesis suggests that pure swim training would result in faster times/ lower arm stroke index than swim training that is augmented by weight training. The second alternative hypothesis proposes that swim training augmented by weight training always would result in faster times/ smaller arm stroke index than swim training alone. The third and fourth alternate hypothesis examine the order of the conditions. The third alternative hypothesis proposes that swim training that is performed before swim training + weights would produce superior effects (i.e., faster swim times/ lower arm stroke index). Finally, the fourth alternative hypothesis proposes that swim training + weights practiced before swim training alone should produce faster swim times/ lower arm stroke index results. Of course, in reality, there are at least 9 hypotheses since I planned to assess two dependent measures (i.e., swim time and arm stroke index) as a way to discern training differences.

Literature Review

In conducting my literature review, I discovered a relatively few evidence-based papers (i.e., published in scholarly journals) on the effects that weight training may have on swim performance. Across the studies, the results were mixed. Baumrtová, Jebavý, and Hojka (2017) found that explosive power has an effect on swimmers swimming in short course pools. García-Ramos, Tomazin, Feriche, Strojnik, de la Fuente, Argüelles-Cienfuegos, … Štirn (2016) showed that the lower body workouts helped the performance of the start that swimmers used in competition. Furthermore, research reflected in the articles by Manske, Lewis, Wolff, and Smith (2015) and Tate, Harrington, Buness, Murray, Trout, and Meisel (2015) showed that dry-land workouts could be instrumental in injury prevention for swimmers as well as perhaps contributing to faster performance times.

Many coaches are still hard pressed to put aside their "pool-only-mentality." While articles like Perna, Bologna, Degli Agosti, and Rondanelli (2018) have looked into comparing Crossfit to swimming and shown that there are positive effects of weight training on swimming, they did not focus on the performance times that resulted from the swimmers' workouts constructed in different ways. Due to this we are still do not have a strong published evidence base whether or not weight training actually increases the performance of swimmers or if the time of practice should be spent solely in the water.

After reviewing the literature revolving around weight training, I searched to see if there had been any studies of swim training vs. swim training accompanied by weight training; however, I found none that addressed that specific question. Then I decided to look at what the best possible dependent variables (measures) to test would be and came up with time (speed) and efficiency of the stroke. I was not yet aware of how best to test the efficiency of stroke so I looked into more research and that is when I found studies such as Ortiz and Colomina (2019) which showed a good way to set up a component time analysis as well as Marinho, Silva, Reis, Costa, Brito, Ferraz, and Marques (2009) that used critical stroke rate. Then in order to better understand the arm stroke rate analysis using the arm stroke index, I looked at the article by McMurray (1990). After looking at all of these articles I was able to understand the necessity for this study, create appropriate hypotheses as to what might occur, and design a research methodology to both ensure swimmer safety and obtain accurate objective results.

Method

Proposed "Activity"

I planned to test the hypotheses for my project by employing a training method that included two independent variables (i.e., training condition and time of measurement) and two dependent variables (speed and efficiency). The training conditions were 1) swimming only training and 2) swimming training plus weight training. The two dependent variables of speed and efficiency would be measured by the swimmers' race-paced times for 50 yards and their arm stroke index for the same 50 yard swim. Each of these measures would be collected at three time points: before training starts, after first 4 weeks of training, and at the end after the second 4 weeks of training. As part of the research design, I planned to conduct a pre-test at the beginning of the study (i.e., the first day prior to any training) to obtain a baseline as well as make sure that each participant was at a roughly comparable level of swimming performance. I wanted to know that there were no significant outliers before the study began to better make sure that what was being tested was having an effect on the result and not just previous coaching and/or natural talent. By using a within-subject, repeated measure design, I aspired to control existing differences among participants.

To complete this project, I had planned to test 4-8 college-age volunteers of similar age (18-22 years), gender, and previous swimming experience. Three one-hour systematic swim workouts and swim plus weight training workouts per week (see Appendices B and C) would have been provided for each participant and used over two, one-month training periods. These workouts were designed to focus on improving (i.e., lowering) the arm stroke index and time as they related to the 50 freestyle sprint. The workouts in the water would have focused not only on improving the participants time but also their stroke efficiency. This would have been done by teaching them to expand their reach and strengthen their pull in hopes to reduce their arm stroke index. The weighted workouts would have focused on strengthening the explosive power and strength in the swimmer. The study was to have been conducted using a variation on a time series design in which a pre-test would have determined whether the volunteer participants were similar enough in swimming performance so that I could have used a matching design across groups. Also, the pre-test served as the baseline measures of swimming performance against which each swimmer's two post-test performances were compared to themselves.

Independent Variables (Conditions)

The participants would have been matched and assigned to a group for the first month. Group one would have spent the first month (i.e., four weeks) using only swim training while the second group would have spent the first month conditioning with swim training that was augmented with weight training. At the end of the first month I would have conducted post-test 1 on all participants. The post-test 1 would have been identical to the pre-test (i.e., 3 trials of race-paced 50 yards swimming, timing each 50 and calculating the arm stroke index for each 50 swim.

Following the post-test 1 completion, the groups would have switched places with the first group spending the second month (i.e., weeks 5-8) swim training augmented with weight training while the original second group trained with swimming only. At the end of the second month, I would have conducted a second and final post-test of 3 x race-paced 50 yard swims.

Every participant would have been given the same training workouts when they were completing the swimming only workouts as well as when they were completing the swim training augmented with weight training workouts. As designed, each participant would spend the same amount of time during the week within the gym doing weight training. The proposed schedule was that all participants spend approximately an hour a day for three days a week at the gym/pool completing the assigned workouts.

Dependent Variables (measures)

The dependent variables (measures) that were to have been tested within this study included the time required to swim each of 3 time trials of a 50 freestyle within a short course 25 yard pool as well as calculating the arm stroke index ratio for each swimmer during their 50 yard freestyle. The arm stroke index would have been calculated by the number of strokes that the swimmer used during their 50 yard freestyle divided by the time that it took to complete the 50 yard freestyle (i.e., velocity). The arm stroke index would have shown us the swimmer's efficiency as strokes per distance per time.

Institutional Review Approval

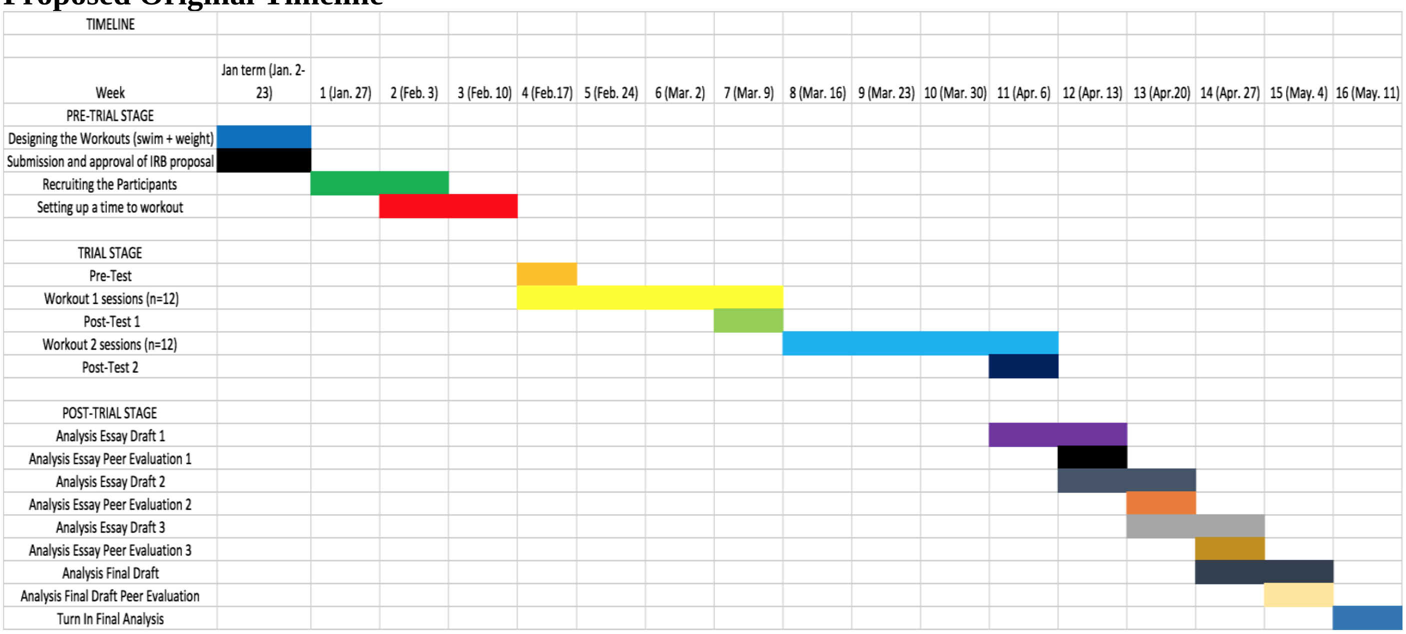
Before beginning the study, I had to gain approval from the BGSU Institutional Review Board (IRB) because I was using human subjects in my research. In the original proposal I submitted to the IRB my marketing materials, an explanation of the study, and the consent form. I requested an expedited review due to the study consisting only of mild exercise. However, the IRB requested modifications to the terminology in the proposal since some wording, mainly the wording of "all out sprint" for the 50 freestyles in the pre and post trials, did not make the studies exercise seem mild. After changing the wording and ensuring that all swimmers would have as much time as needed between the three attempts in each trial I received approval from the IRB. The IRB number assigned to this study is #1559519-2. Also the approval letter is provided in Appendix D of this document.

Analyses

The results that I had expected for this study was to find support for alternative hypothesis 2, that swim training augmented with weighted training would produce faster 50 yard times and a lower arm stroke index than swim training only over a 4-week period.

The results of this study could have been important to swim coaches. Coaches have debated how to best utilize the time that they have during the week with their swimmers. Some have elected to spend all of the time inside of the water since that is where the racing takes place. This decision would be supported by the motor learning principle called "specificity of training," or practicing what you are going to do. Having efficient and effective technique and form can save seconds in the water. On the other hand, other coaches believe that it is better to augment the swimming training during the week with weight training as well. The belief by this second group of coaches is that while the technique training is important, swimmers also benefit from having greater strength and power in their arms to pull their body, their shoulders to balance the rotator cuff muscles and prevent injuries, their core to be able to help with rotation in order to keep the streamline tight, and their legs in order to have greater power to push off the wall during turns as well as off the blocks during the starts. The expected results of this study could have helped new as well as experienced coaches to better determine how they want to schedule their workouts to best improve the performance of their swimmers. In turn this could also help the swimmers to get more efficient and effective training and receive faster times.

Proposed Original Timeline



Discussion

I originally identified a null hypothesis and four different alternative hypothesis earlier in the paper under the hypothesis section (see Table 1). If the study had been completed with enough participants and followed the proposed methodology, then any of these hypotheses could have occurred. The following paragraphs are my reasoning behind why each hypothesis might have occurred and what that finding might mean for future research and swim training. It is important to note that the dependent variables of time and efficiency mostly have been collapsed in this discussion for simplicity and clarity purposes. They would have been presented and analyzed separately if the study had been completed.

The first potential outcomes of swimmers who did not improve (or even got worse) during both of the 4-week sessions, regardless of whether they did swim only training or swim training with weights would have represented the null hypothesis. The main reason that comes to mind is that the study also had a dependent variable of the swimmers Arm Stroke Index (ASI). If the swimmer was using a large amount of strokes and covering a small of amount of distance per stroke pull used then the training would have taught them to expand their reach and do more pulling. A change from one neuromuscular memory to another can take a significant amount of time and a month might not be enough to see a benefit as far as time is involved. However, in that case the ASI would have greatly improved (i.e., gotten smaller) for the swimmers and benefitted their time later on if they continued with the workouts for more than a month.

Another reason that this could occur was that swimmers can sometimes get stuck at a certain time, especially in a short distance event like the 50 freestyle (sometimes called a plateau). It can take a long amount of time before experienced swimmers make even gradual improvements in their time. In this case it would be important to look at things outside of the training component of swimming such as their diet and/or amount of sleep per night because these can have effects on how they swim as well.

The second potential outcomes of swimmers (representing alternative hypothesis 1) is also possible. In this case the swimmers would improve during the weeks that they were doing pure swim training and not improve (or even get worse) during the weeks that they were doing swim training with weights. One potential reason for this would be that the pure swimming was only focused on the specific swimming movement that would be conducted when the swimmer swims the 50 freestyle. By doing this, the nervous system would create a neuromuscular memory that would limit the amount of time it takes to move to the next movement of the stroke in order to improve the time further. Taking the swimmer out of the pool for the weight training period might stop this improvement of neuromuscular memory.

The third potential outcome (alternative hypothesis 2) of swimmers improving during their weeks of swim training + weights and not improving (or even getting worse) during their weeks of pure swim training could happen for a few different reasons as well. One potential reason for this was because the weight training could be increasing the strength in the muscles that are used for the 50 freestyle. Increase in shoulder and arm strength will increase the power and distance of the swimmers' pull while the increase in the leg muscles' strength will help with the distance gained on the kick as well as the push off of the wall during start and turn.

Along with all of these potential outcomes we would also have been able to tell if the order of the conditions mattered by comparing the two final post-tests of the two groups. If the fourth potential outcome (alternative hypothesis 3) would have been supported, then we would have seen the group that started with swim training and then went to swim + weight training have significantly better results (i.e., faster swim times/ lower arm stroke index) than the group that started with swim + weight training and then moved on to just swim training. One potential reason for this would be the fact that the swimmers were able to focus solely on perfecting the stroke and then once they had the movements down for the stroke they were able to gain muscle strength and power in order to produce momentum while still maintaining that stroke form whereas the swimmers who started with weight training and swimming before doing only swimming were not able to increase their muscles after having the time to perfect the stroke.

The fifth potential outcome (alternative hypothesis 4) could also have been supported. If this was indeed found to be the case then we would have seen the group that started with swim training + weights and then went to just swim training have significantly better results (i.e., faster swim times/ lower arm stroke index) than the group that started with just swim training and then moved on to swim training + weights. One potential reason for this would be the fact that weight training can cause fatigue within the muscles. As a result the muscles of the swimmers who were doing swimming and weight training during the final four weeks wouldn't have been able to improve as much as the swimmers who did just swimming during the final four weeks. If this was found to be the case I would suggest that coaches make sure not to schedule lifting practices around the time that their swimmers would have to race.

Reflection

The best parts of this honors project were working with Dr. Langendorfer on the essay in his office every week. He helped me take an idea to look at something we both cared very passionately about and make it a reality. There were definitely some setbacks and ultimately with COVID-19 pandemic causing the closure of the University and all the swimming pools, I could not complete the actual intervention and data collection part of my project, but I would not have changed a single moment of the experience I have had with this study over the course of the past year. It taught me how much goes into writing a study and getting it approved by the IRB to become reality. I learned that setbacks in any project, especially research, are to be expected but it's how you finish that ultimately matters. Furthermore, due to these setbacks I had to really learn how to critically think about every possible outcome of a situation. With the study not being able to take place I had to analyze and critically think of all the hypotheses and the potential outcomes that could come from each and what those findings would have meant for the culture of swim training as a whole for the discussion portion of this research. I also learned that it takes time to make something good; many revisions are necessary. I think ultimately that is what I will take with me to the future. The memories of how to persevere. If I would try this project again, I would use that perseverance I have learned through this experience. I would try to find strategies for recruiting a lot more participants who are generally interested in solving the question of this study. I would try to make it fun for everyone involved and ultimately find the answer to the proposed question.

Appendix A

Annotated Bibliographies

In this appendix, I have reviewed 15 studies I identified through a systematic review of the literature. I provide a citation for each study and then an annotated bibliography comprised of the article abstract as well as information I gleaned from reading the paper itself that included the intended audience..

Batalha, N., Raimundo, A., Tomas-Carus, P., Paulo, J., Simão, R., & Silva, A. J. (2015). Does a land-based compensatory strength-training programme influences the rotator cuff balance of young competitive swimmers? European Journal of Sport Science, 15(8), 764–772. Retrieved from http://search.ebscohost.com.ezproxy.bgsu.edu/login.aspx?direct=true&db=s3h&AN=111799735&site=ehost-live&scope=site

"During the repeated execution of the swimming strokes, the shoulder adductor and internal rotator muscles have a tendency to become proportionally stronger when compared to their antagonist group. This can lead to muscle imbalances. The aim of this study was to examine the effects of a compensatory training programme on the strength and balance of shoulder rotator muscles in young swimmers. A randomized controlled trial design was used. Forty male swimmers took part in the study and were randomly divided into two groups: an experimental group (n = 20) and a training group (n = 20). A control group (n = 16) of young sedentary male students was also evaluated. The experimental group subjects participated in a 16-week shoulder-strength programme with Thera-Band® elastic bands; the training group was restricted to aquatic training. Peak torque of shoulder internal rotator and external rotator (ER) was measured at baseline and after 16 weeks. Concentric action at 1.04 rad s−1 (3 reps) and 3.14 rad s−1 (20 reps) was measured using an isokinetic dynamometer. The strength training programme led to an improvement of the ER strength and shoulder rotator balance in the experimental group (data from both shoulders at 1.04 rad s−1). Moreover, concentric action at 3.14 rad s−1 presented significant differences only for the dominant shoulder. Findings suggest that the prescribed shoulder-strengthening exercises could be a useful training option for young competitive swimmers. They can produce an increase in absolute strength values and greater muscle balance in shoulder rotators".

The intended audience of this article were swimmers who want to protect their shoulders as well as coaching staff. This article helps to inform my proposed Honors topic by showing the benefits of certain shoulder exercises on the overall shoulder health of swimmers by strengthening the rotator cuff and keeping a balance among and across the shoulder girdle complex of muscles. Unlike my proposed study, this research used a between-groups research design and the dependent measures were direct measures of muscle strength and not swimming performance.

Baumrtová, S., Jebavý, R., & Hojka, V. (2017). The influence of explosive power on the performance of an elite swimmer in 25 and 50 metre pools. Acta Universitatis Carolinae: Kinanthropologica, 53(2), 107–115. http://search.ebscohost.com.ezproxy.bgsu.edu/login.aspx?direct=true&db=s3h&AN=126503673&site=ehost-live&scope=site

“Each swimming stroke, and each distance, requires a different approach to strength training. For sprinters in swimming the most essential part is explosive power. The goal of this case study was to find out how explosive training can influence the performance in both long course and short course meters swimming pools. This study was conducted with the cooperation of an elite swimmer over a time period of 6 years. Tests were performed twice a year (June and November) during the years of 2010–2016. The Myotest device was used to measure countermovement jump height. Swimming performance was evaluated by FINA points in the swimmer’s three main disciplines. ANOVA, Cohen’s d and regression equation were used for statistical analysis. The results showed that explosive power does not influence performance in the 50m swimming pool ($p = 0.25$; $r2 = 0.08$). However the performance in the 25m pool is directly linked to the level of explosive power of the lower limbs ($p < 0.001$; $r2 = 0.85$). The results of the swimmer in the 25m pool are closely related to the level of explosive power of the lower limbs. Performance in the 50m pool might not be affected by level of lower limb power”.

The intended audience of this article were sprint swimmers and their coaches looking to increase the power for their flip turns and starts. This study was a single case study following the swimmer over 6 years and comparing their explosive power, which was trained through dry-land workouts, with their performances (measured as points earned). No direct measure of performance (e.g., times or arm stroke index) were measured in this study.

Bertoleti E., Aidar, F. J., de Souza, R. F., de Matos, D. G., Camara, M. B., Gomes, A. A. B., … Garrido, N. D. (2016). Swimming performance evaluation in athletes submitted to different types of strength training. *Journal of Exercise Physiology Online*, *19*(6), 1–9. http://ezproxy.bgsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=120375680&site=ehost-live&scope=site

“The purpose of this study was to compare the effects of a traditional strength training exercise, a training tether made of rubber attached to a belt around the swimmer’s waist in the water, and training only in the water without additional strength training on the performance of the 25 m and 50 m freestyle in young athletes. The subjects consisted of 24 male athletes 15 to 16 yrs of age. They were 2 divided into 3 groups: (a) 7 swimmers tethered by a rubber device while in the water (RW); (b) 7 swimmers who did strength training (ST) program; and (c) 7 swimmers who comprised the control group (CG). The findings indicate that there was no difference in the post-test responses between the group that trained while tethered to the rubber device and the group that engaged in a traditional strength training program. But, there were differences in both groups that engaged in strength training compared to the control group at both time points (pre- and post-test). Hence, it is reasonable to conclude that both strength training methods used in this study tended to promote improvements in speed, especially for shorter distances.”

The intended audience was coaches who were designing conditioning programs for swimmers. This article contributed to my Honors topic since it looked at different types of resistance and weight training and compared it to swimming-only training. In this article the authors found that weight training did indeed promote improvements in short distance swimming speed. This experiment also compared different types of weight training including in-water resistance used by swimmers had the full swimming workout as well as the extra workouts which can create the question if the extra time training is the actual factor that caused the faster time instead of the type of training being used.

Dalamitros, A. A., Vagios, A., Toubekis, A. G., Tsalis, G., Clemente-Suarez, V. J., & Manou, V. (2018). The Effect of Two Additional Dry-Land Active Warm-Up Protocols on the 50-M Front-Crawl Swimming Performance. Human Movement, 19(3), 75–81. Retrieved from http://search.ebscohost.com.ezproxy.bgsu.edu/login.aspx?direct=true&db=s3h&AN=131062941&site=ehost-live&scope=site

"The purpose of the study was to compare the effectiveness of 2 different dry-land active warm-up protocols on 50-m front-crawl swimming performance, biomechanical variables (stroke rate, stroke length, and stroke index), rate of perceived exertion, and exercise heart rate in swimmers of both genders. Method. The total of 10 male and 9 female national-level swimmers completed a standardized 1000-m in-water warm-up protocol followed by a 30-min transition phase and a 50-m front-crawl time-trial. During this 30-min period, each swimmer executed, on different occasions, a protocol consisting of either a dynamic stretching routine (stretch) or a power exercise circuit (power) of equal duration (~ 5 min) in a randomized sequence. A control condition (control) including a passive recovery strategy after the in-water warm-up protocol was also analyzed. Results. An improvement in 50-m time-trial performance was demonstrated in male swimmers after executing the power protocol ($p = 0.034$), while in female swimmers a trend towards faster performance times was revealed after the stretch protocol ($p = 0.064$). Stroke index was improved after the stretch routine only in female swimmers ($p = 0.010$). Stroke rate, stroke length, rate of perceived exertion, and exercise heart rate showed no differences among all the 3 conditions in either gender ($p > 0.05$). Conclusions. Male and female swimmers respond differently to a power or a dynamic stretching protocol. In addition, the variation in responses to different warm-up conditions highlights the importance of individualizing the dry-land warm-up procedure to promote maximum performance during 50-m front-crawl swimming events".

The intended audience of this article were coaches. This article did not contribute directly to my study since it focused on warm up procedures rather than weight training itself, but it did measure both time and stroke index as dependent measures.

García-Ramos, A., Tomazin, K., Feriche, B., Strojnik, V., de la Fuente, B., Argüelles-Cienfuegos, J., … Štirn, I. (2016). The relationship between the lower-body muscular profile and swimming start performance. Journal of Human Kinetics, 50(1), 157–165. Retrieved from http://search.ebscohost.com.ezproxy.bgsu.edu/login.aspx?direct=true&db=s3h&AN=114707910&site=ehost-live&scope=site

"This study aimed to examine the correlation of different dry land strength and power tests with swimming start performance. Twenty international level female swimmers (age 15.3 ± 1.6 years, FINA point score 709.6 ± 71.1) performed the track freestyle start. Additionally, dry land tests were conducted: a) squat (SJ) and countermovement jumps (CMJ), b) squat jumps with additional resistance equivalent to 25, 50, 75 and 100% of swimmers' body weight [BW]), and c) leg extension and leg flexion maximal voluntary isometric contractions. Correlations between dry land tests and start times at 5, 10 and 15 m were quantified through Pearson's linear correlation coefficients (r). The peak bar velocity reached during the jumps with additional resistance was the variable most correlated to swimming start performance (r = -0.57 to -0.66 at 25%BW; r = -0.57 to -0.72 at 50%BW; r = -0.59 to -0.68 at 75%BW; r = -0.50 to - 0.64 at 100%BW). A few significant correlations between the parameters of the SJ and the CMJ with times of 5 and 10 m were found, and none with the isometric variables. The peak velocity reached during jumps with external loads relative to BW was found a good indicator of swimming start performance".

The intended audience of this article were swimmers looking to increase the performance of their racing starts as well as coaches looking to help their athletes. This study contributed less to my study since it was mostly focused on the racing start rather than a full race performance. The weight measures may serve to help design the weight training portion of my study by showing how lower body workouts can help swimming performance.

Garrido, N., Marinho, D. A., Barbosa, T. M., Costa, A. M., Silva, A. J., Pérez-Turpin, J. A., & Marques, M. C. (2010). Relationships between dry land strength, power variables and short sprint performance in young competitive swimmers. *Journal of Human Sport & Exercise*, *5*(2), 240–249. Retrieved from http://ezproxy.bgsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=51232762&site=ehost-live&scope=site

"The aim of this study was to identify the dry land strength and power tests that can better relate with sprint swimming performance in young competitive swimmers. Twenty-eight (16 boys and 12 girls) young competitive swimmers of national level (12.01 ± 0.56 years-old, Tanner stage 1-2) volunteered to participate in this study. Swimming performance (25 m and 50 m freestyle sprint tests), muscle strength (bench press and leg extension) and muscle power (throwing medicine ball and countermovement jump) performances were tested. Spearman ranking correlation coefficient were computed to verify the association between strength and power variables with sprint swimming performance. Regarding strength tests, the bench press and leg extension exercises were moderate but significantly associated with 25 m and 50 m tests ($-0.69 \leq \rho \leq -0.58$). The sprint tests were only associated with throwing power tests ($-0.74 \leq \rho \leq -0.54$) and not with vertical jump height. The main results suggested that, simple dry land strength and power tests although moderate are significantly associated with sprint swimming performance in young competitive swimmers".

The intended audience of this article are sprint swimmers and people who are questioning the use of dry land activities in swimming performance. This article should help contribute to my Honors topic because it looked at the same short distance that will be utilized within this study and examined the correlation between the bench press and leg extension on the performance of sprint swimmers. Unfortunately, the results of this study showed that sprint test results were only associated with the throwing power test and not bench press or vertical jump performance. The results should give guidance to designing the weight training portion of my study.

Manske, R. C., Lewis, S., Wolff, S., & Smith, B. (2015). Effects of a dry-land strengthening program in competitive adolescent swimmers. *International Journal of Sports Physical Therapy*, *10*(6), 858–867. Retrieved from http://ezproxy.bgsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=119252097&site=ehost-live&scope=site

"Background: Shoulder pain is common in competitive young swimmers. A relationship between shoulder strength and shoulder soreness in competitive young swimmers may indicate need for strengthening. Purpose: To determine if a shoulder exercise program will improve shoulder strength and decrease pain in competitive young swimmers. Study Design: Randomized control Methods: Participants (10 control, 11 experimental), randomly assigned to a control or experiment group, completed the 12 week program. Strength was measured prior to the study for shoulder flexion, abduction, external rotation, internal rotation, and extension on the dominant arm using handheld dynamometry. The experimental group was then assigned exercises to be performed three times per week. The control group was instructed not to perform the exercises. All participants were re-tested at six and twelve weeks following initiation of the study. Results: The changes in strength for each muscle group and pain were compared between groups using a mixed design two-way ANOVA. The experimental group significantly increased external rotation strength compared to the control group. Shoulder soreness was not significantly different between groups. Conclusion: Adolescents who perform shoulder strengthening significantly increased their external rotation strength compared to adolescents who only participated in a regular swimming regimen".

The intended audience of this article was coaches and swimmers, especially those at high risk of a shoulder injury. This article may contribute to my Honors topic by identifying five easy-to-perform shoulder warmups that can help to increase shoulder rotation and prevent injury. The research did use pain as a comparable however since pain is a subjective measure and each person has a varying degree of pain tolerance this measurement may not be as valid as others used within this study. The study also did not measure swimming performance directly so it may not be as apropos to my study as other articles.

Marinho, D. A., Silva, A. J., Reis, V. M., Costa, A. M., Brito, J. P., Ferraz, R., & Marques, M. C. (2009). Changes in critical velocity and critical stroke rate during a 12 week swimming training period: A Case Study. *Journal of Human Sport & Exercise*, *4*(1), 48–56. Retrieved from http://ezproxy.bgsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=38591893&site=ehost-live&scope=site

"The aim of this study was to analyze the evolution of critical velocity and critical stroke rate during 12 weeks of training in age group swimmers. Fourteen age group male swimmers took part in this investigation. The evaluation took place in two different trials. The first one was conducted at the beginning of the season and the second one after 12 weeks of training. For each subject the critical velocity and the critical stroke rate were determined in both trials. The main result was that critical velocity increased, whereas critical stroke rate decreased between the first and second trials. It seems that technical ability was improved during the 12 weeks of training. The swimmers were able to perform at the same physiological intensity at higher velocities and with less stroke rate. This information could help swimming coaches monitoring their training without expensive instruments."

The intended audience was swimming coaches. The study may contribute to my Honors topic through its use of critical velocity and critical stroke rate performance measures (dependent variables), but it doesn't involve weight training specifically so it may not provide important insights.

Ortiz, E. M., & Colomina, R. A. (2019). Regression analysis model applied to age-group swimmers: 50m race component times analysis. *Journal of Human Sport & Exercise*, *14*(2), 315–324. Retrieved from http://ezproxy.bgsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=136877236&site=ehost-live&scope=site

"This investigation aimed to develop a regression model of the Race Component evolution in a large sample of regional age-group Spanish swimmers in 50 m freestyle. Subjects were 280 regional swimmers selected of different club (with an age range of 9 to 22 year) and the swimmers were divided into five competitive categories. The time spent starting (ST), the time spent stroking (STT1 - STT2), the time spent turning (TT) and the time spent finishing (FT) were used for analysis. Inverse function approximation of the partials times by aging and was carried out. Furthermore, the analysis regression of partials times and event time for age and genders were calculated respectively. It seems that the times of swimmers studied have a tendency to resemble of internationals swimmer´s times. The estimation formula applied was different time according to gender. The crossing age in the swimming partials times were about 12-14 years old. At this age begin to differentiate the performed and swim times between boys and girls."

The intended audience was the coaches who handle post-competitive performance workouts. This study may help with my Honors topic by showing different forms of component time analysis as well as bringing in consideration to the ages of the swimmers. My proposed study does not anticipate using a race component times analysis and it doesn't deal with weight training so it probably has little relevance to my study except that it is looking at sprint training.

Perna, S., Bologna, C., Degli Agosti, I., & Rondanelli, M. (2018). High intensity Crossfit training compared to high intensity swimming: A pre-post trial to assess the impact on body composition, muscle strength and resting energy expenditure. *Asian Journal of Sports Medicine*, *9*(1), 1–5. Retrieved from http://ezproxy.bgsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=129125663&site=ehost-live&scope=site

"Objectives: The aim of this study was to evaluate the impact of two different forms of high intensity training i.e. power CrossFit and intermittent swimming, on body composition markers, max strength and resting energy expenditure. Methods: This pre-post trial was conducted on twenty three subjects (14 female, 9 male; mean age = 31.74 ± 7.46 years; BMI = 23.665 ± 2.994 kg/m2). They were assigned into interventions of CrossFit training or swimming (CrossFit/Swimming: 10/13) for 8-weeks (60 min, 3 times per week). Using dual X-ray energy absorptiometry (DXA), we measured body mass composition markers such as body weight, total free fat mass, total fat mass, arms and legs free fat mass, and percentage of android and gynoid fat mass. Also muscle strength and resting energy expenditure were measured at baseline and immediately after 8 weeks of training intervention. Feasibility measures of recruitment and injury were also assessed. These variables were measured at baseline and after 8 weeks and compared within and between groups, using paired t-tests and linear regression models, to detect significant changes. Results: Between groups, data comparisons (pre-post intervention training) demonstrated a significant effect of CrossFit on gynoid fat (β = -1.42%; CI 95% -2.81; -0.03; P = 0.047), and suggestive but not significant variations in decreasing for total fat mass (β -1427 g, CI 95%: -2861, 7, 31; P = 0.051) and android fat (β = -2.64%, CI 95%: -5.36, 0.08; P = 0.056). Conclusions: This study showed the potential benefits of high intensity training in improvement of body composition markers. In particular, CrossFit is more effective than swimming in losses of total fat mass, specifically of gynoid and android fat mass. Further research is needed to understand the potential of CrossFit training on health."

The intended audience of this article would be coaches, swimmers, Crossfit users, or people trying to lose weight. This work has limited usefulness to my Honors topic because it only focused on Crossfit training versus pure swimming exercises. Since the only dependent variables were BMI, DXA, muscle strength, and resting energy expenditure, it does not have any direct swimming performance measures.

Pešić, M., Okičić, T., Madić, D., Dopsaj, M., Djurovic, M., & Djordjevic, S. (2015). The effects of additional strength training on specific motor abilities in young swimmers. / Uticaj Dodatnog Treninga Snage Na Specifične Motoričke Sposobnosti Mladih Plivača. *Facta Universitatis: Series Physical Education & Sport*, *13*(2), 291–301. Retrieved from http://ezproxy.bgsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=113892399&site=ehost-live&scope=site

"The aim of this study was to determine the effects of dry-land strength training on motor abilities specific for swimming among young swimmers aged 10-14 years. The participant sample comprised 60 swimmers, aged 10-12 and 13-14, divided into two experimental and two control groups. The measures included 16 variables for assessing specific motor abilities in the disciplines of the 100m freestyle and breaststroke. The experimental exercise program lasted 12 weeks. Compared to the control groups, the experimental groups had additional dry-land strength training targeting large muscle groups of the entire body. After the applied experimental program, statistically significant effects were identified in the form of improvements to the following variables: start time for the 10m breaststroke, stroke length in the breaststroke, and turn length in the breaststroke for swimmers aged 10-12, whereas for swimmers aged 13-14 there was an improvement in the variable stroke efficiency in the freestyle. Based on the total analysis, we conclude that the applied experimental program would require modification in the further training process with a view to achieving more considerable training effects which would in turn lead to a more significant transformation of the swimming results in the categories of swimmers aged 10-12 and 13-14".

The intended audience for this article was coaches for young competitive swimmers, specifically those between the ages of 10-14. This article helped identify how the weight training section of the study might be designed. The authors noted at the end of their study that it would be more beneficial to have increased the strength workouts from twice a week to four times weekly as well as progressed the strength training instead of keeping it constant throughout the whole experiment.

Richmond, T., Buell, J., Pfeil, S., & Crowderd, M. W. (2015). Evidence-based recommendations for maximizing competitive swimming performance. Journal of Swimming Research, 23, 1–14. Retrieved from http://search.ebscohost.com.ezproxy.bgsu.edu/login.aspx?direct=true&db=s3h&AN=102706544&site=ehost-live&scope=site

"The current dogma of swimming training programs promotes high-distance, high volume workouts requiring a considerable time investment and high risk of injury to swimmers striving to achieve elite level swimming performance. In this paper, the current literature in exercise physiology, swimming performance, and nutrition is reviewed in order to provide evidence-based training guidelines to maximize performance and minimize risk of overuse injury. Suggested practices for day-of-competition exercise and nutrition are also offered. This work aims to provide training recommendations for coaches and swimmers, and to aid the work of physicians and dietitians involved in the care of swimmers. Narrative review encompassing studies done on the topic of elite swimmers and performance, metabolism, nutrition, stroke technique, tapering, and injury. Studies done in athletes of other sports regarding muscle metabolism and nutrition are also taken into consideration, as necessary, when there is a paucity of work in swimmers. This evidence-based approach to swimming training challenges current popular coaching principles, i.e. long-distance workouts, by offering a more focused and individualized training regimen that may improve performance and decrease workout-related injury risk. Specifically, inclusion of high intensity training, stroke technique improvement, limited total distance and water time spent per week, optimized nutrition, strategic tapering, and a personalized day of-event warm-up routine appear to be key factors for success in a swimming competition. Specific guidelines in each of these areas are reviewed or synthesized, and means of implementation are suggested. This multidisciplinary approach to swimming training that optimizes each stage of training and competition will likely improve the performance of many competitive swimmers".

The intended audience were swimmers who are trying to maximize their performance, coaches who are trying to help their swimmer, and parents who want to make sure their swimmers are healthy. This will contribute to my Honors topic by showing the proper workload that the swimmers should experience. Unfortunately, little emphasis on weight training was mentioned.

Sadowski, J., Mastalerz, A., Gromisz, W., Jówko, E., & Buszta, M. (2015). The effects of swimming and dry-land resistance training programme on non-swimmers. *Polish Journal of Sport & Tourism*, *22*(1), 35–40. Retrieved from http://ezproxy.bgsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=103339880&site=ehost-live&scope=site

"Introduction. The aim of the study was to estimate the influence of combined swimming and dry-land resistance training on swimming force, swimming performance and strength in non-swimmers. Material and methods. Thirty male non-swimmers took part in the research. They were randomly assigned to one of the two groups: experimental (n=17) and control (n=13). The experimental group took part in combined swimming and dry-land resistance training. The control group took part in swimming training only. The swimming and dry-land resistance training programme lasted twelve weeks (48 training sessions of swimming and 36 sessions of dry-land resistance training). Average training volume and intensity were the same for all swimmers throughout the study protocol. The training programme included dominant aerobic work in front crawl. Results. Dry-land resistance training applied in the experimental group significantly improved the upper body strength. In spite of the theory that dry-land strength training is probably not specific enough to improve the sprint swim performance, the experimental group tended to demonstrate greater improvement in sprint performance. The imitation of the underwater phase of shoulder work during front crawl provided by the ergometer can be a useful training method in non-swimmers".

The intended audience of this article was non-swimmers who wish to start swimming as well as swimmers and coaches who prepare workouts for themselves or players. This article likely will not contribute to my Honors topic because I am focusing on current swimmers, not non-swimmers. This research only focused on upper body strength solely instead of focusing on upper body for arm rotation as well as lower body for power and stability provided through kicking.

Tate, A., Harrington, S., Buness, M., Murray, S., Trout, C., & Meisel, C. (2015). Investigation of in-water and dry-land training programs for competitive swimmers in the United States. *Journal of Sport Rehabilitation*, *24*(4), 353–362. Retrieved from http://ezproxy.bgsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=111742597&site=ehost-live&scope=site

"Context: Youth- through masters-level competitive swimmers incur significant shoulder pain. Risk factors associated with shoulder pain include high swimming yardage, a lack of cross-training, decreased shoulder strength and reduced core endurance, and limited posterior shoulder and pectoral length. Since training, swimming exposure, and physical-performance measures have all been associated with shoulder pain, the methods used to train swimmers may influence the development of shoulder pain, yet studies delineating training methods are lacking. Objectives: To identify in-water and dry-land practices among youth- through masters-level swimmers in the United States (US) and describe the potential effects of training practices on swimmers' shoulders. Design: A Web-based survey was developed to identify common training practices in 5 areas: quantification of swimming and dry-land training and in-water techniques such as kicking drills, upper-body stretching, shoulder and core strengthening, and cross-training. Participants: 156 swim-team coaches or captains of youth, high school, and college swim teams and 196 masters swimmers participated (N = 352). There was geographic representation from across the US. Results: Responses indicated diverse training practices. However, most respondents used kicking drills, which may provoke shoulder pain due to prolonged poor positioning. High yardage swum by high school and college teams increases their risk of shoulder tendinopathy. Stretching and strengthening exercises and dosages commonly used were inconsistent with current research recommendations and lacked specificity in terms of addressing typical mobility restrictions and muscle weaknesses described in the swimming literature. Core strengthening and cross-training are frequently performed. Conclusions: Several areas of in-water and dry-land practice were identified that may put swimmers' shoulders at risk for injury. Further research regarding the safety and efficacy of training programs is recommended to determine optimal methods of injury prevention and performance enhancement."

The intended audience of this article was coaches, medical staff, and swimmers. This illuminated the bibliography topic because it showed the benefits of using weight training in tandem with swimming to help reduce the risk of injury, specifically the shoulder, to swimmers. This research was done by a web-based survey instead of an experimental study. The exercises used in the study could also help in the design of the weight training for this study

Weston, M., Hibbs, A. E., Thompson, K. G., & Spears, lain R. (2015). Isolated Core Training Improves Sprint Performance in National-Level Junior Swimmers. *International Journal of Sports Physiology & Performance*, *10*(2), 204–210. Retrieved from http://ezproxy.bgsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=101439199&site=ehost-live&scope=site

"Purpose: To quantify the effects of a 12-wk isolated core-training program on 50-m front-crawl swim time and measures of core musculature functionally relevant to swimming. Methods: Twenty national-level junior swimmers (10 male and 10 female, 16 ± 1 y, 171 ± 5 cm, 63 ± 4 kg) participated in the study. Group allocation (intervention [n = 10], control [n = 10]) was based on 2 preexisting swim-training groups who were part of the same swimming club but trained in different groups. The intervention group completed the core training, incorporating exercises targeting the lumbo-pelvic complex and upper region extending to the scapula, 3 times/wk for 12 wk. While the training was performed in addition to the normal pool-based swimming program, the control group maintained their usual pool-based swimming program. The authors made probabilistic magnitude-based inferences about the effect of the core training on 50-m swim time and functionally relevant measures of core function. Results: Compared with the control group, the core-training intervention group had a possibly large beneficial effect on 50-m swim time (-2.0%; 90% confidence interval -3.8 to -0.2%). Moreover, it showed small to moderate improvements on a timed prone-bridge test (9.0%; 2.1-16.4%) and asymmetric straight-arm pull-down test (23.1 %; 13.7-33.4%), and there were moderate to large increases in peak EMG activity of core musculature during isolated tests of maximal voluntary contraction. Conclusion: This is the first study to demonstrate a clear beneficial effect of isolated core training on 50-m front-crawl swim performance".

This article is intended for swimmers of all ages as well as their coaches and personal trainers. This article helped illuminate the bibliography topic by showing the importance of using weight techniques that engage the core muscle while also stretching and fortifying the other body parts. However, this study was done using national-level junior swimmers instead of moderate level swimmers making it possible for the results to significantly vary when studying swimmers who are not at such an elite level.

Appendix B
Swimming workouts

Workout A
Warm-Up
200 Freestyle
5-5-5 (5 flip turns; 5 wall kicks for 5 sec; 5 back streamlines off wall w/turn to front) 250
Set 1
3*100: (80% effort) with 30-second rest after each interval swim
50 EZ active rest
3*100: (Negative split within set – descend 1-3) using 30-second rest interval
50 EZ active rest
3*100: (build effort: 50%, 75%, 100%) using 30-second rest interval
100 EZ active rest
1200
Set 2
4*25: (focus on lowering stroke count) 10-second-rest
50 EZ active rest
1*50: (race speed) 30-second rest
50 EZ active rest
1*25 w/ flip turn: (race speed)
25 EZ active rest
1*25 w/ flip turn: (race speed)
25 EZ active rest 350
Cool Down
100 free Total = 1900

Workout B
Warm-Up
200 Freestyle
5-5-5 (5 flip turns; 5 wall kicks for 5 sec; 5 back streamlines off wall w/turn to front)
250
Main Set
8*50: 75% effort (on 60 second interval)
8*50: 90% effort (on 75 second interval)
50 EZ active rest
3*100: Freestyle (descend 1-4) (on 2 min interval)
3*100: 75 fast, rest 10 seconds, then 25 sprint with 30 second rest between swims
50 EZ active rest
8*50: 25 medium, rest 10 seconds, 25 sprint 10 second rest 1900
Cool Down
100 free Total = 2250

Workout C

Warmup

2*200 (50 drill, 100 swim. 50 drill) 400

Set 1

3*400

First 400: 100 build, 200 fast, 100 EZ

Second 400: 100 EZ, 50 fast, 50 EZ, 50 fast, 150 EZ

Third 400: 200 build, 100 fast, 100 EZ 1200

Set 2

3*200

First 200: Pull, build by 50

Second 200: Kick, build by 50

Third 200: Broken 200 at 50 (10 sec rest) – shoot for race pace 600

Cool Down

100 free Total =

2300

Workout D

Warm up

200 free

5-5-5 250

Set 1 – even pace across distances

1*400: 30-second rest

1*300: 30-second rest

1*200: 30-second rest

1*100: 30- second rest 1000

Set 2

8*50 kick

200 Pull 600

Cool Down

100 Free Total = 1950

Workout E

<u>Warm-Up</u>

200 Freestyle

5-5-5 250

<u>Set 1</u>

8*75: (swim/drill/swim)

3*200: pull 1200

<u>Set 2</u>

3*100: swim

100 EZ

3*100: Pull

4*25 (odds = 100% effort; evens = EZ) 800

<u>Cool Down</u>

100 free

Total = 2350

Workout F

<u>Warm-Up</u>

200 Freestyle

5-5-5 250

<u>Workout 1</u>

4*150 (kick/drill/swim) @ 20-second rest

2*50 Drill Free

2*50 Free

2*50 Drill Non-free

2*50 Non-free 1000

<u>Workout 2</u> – sprint ladder

14*50 Free

- 1 fast, 1 EZ
- 2 fast, 1 EZ
- 3 fast, 1 EZ
- 4 fast, 1 EZ 700

<u>Cool Down</u>

100 free

Total = 2150

Workout Alternate
<u>Warm-Up</u>
200 Freestyle
5-5-5

250

<u>Workout</u>
3x
[6*25 @ :30
4*50 @ :60
2*75 @ 1:30
1*100 @ 2:00]

1800

<u>Cool Down</u>
100 free

Total = 2150

Appendix C
Weight Training workouts

Lift #1 **Dates** ______________ ______________ ______________ ______________
Russian Twists 1*25 (each side)
Bench Press 4*12
Box Jumps 3*10
Weighted Lunges 4*12 (each side)
Weighted Fly 4*12
1 minute plank

Lift #2 **Dates** ______________ ______________ ______________ ______________
Slam Ball 4*12
Pull Ups 4*Max
Leg Press 4*12
Lat Pull Down 4*12
Seated Row 4*12
Leg Raises 2*10

Lift #3 **Dates** ______________ ______________ ______________ ______________
Superman 4*12
Shoulder Press 4*12
Tricep Pull Down 4*12
Tricep Kickback 4*12
Bicep Curl 4*8-8-8
Flutter Kicks 4*12

Appendix D

BGSU Institutional Review Board Approval Letter

BGSU.

BOWLING GREEN STATE UNIVERSITY

Office of Research Compliance

DATE:	February 26, 2020
TO:	Griffin Patterson
FROM:	Bowling Green State University Institutional Review Board
PROJECT TITLE:	[1559519-2] Impact of weight training on sprint swimming
SUBMISSION TYPE:	Revision
ACTION:	APPROVED
APPROVAL DATE:	February 25, 2020
EXPIRATION DATE:	February 13, 2021
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category #4

Thank you for your submission of Revision materials for this project. The Bowling Green State University Institutional Review Board has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

The final approved version of the consent document(s) is available as a published Board Document in the Review Details page. You must use the approved version of the consent document when obtaining consent from participants. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that you are responsible to conduct the study as approved by the IRB. If you seek to make any changes in your project activities or procedures, those modifications must be approved by this committee prior to initiation. Please use the modification request form for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. All NON-COMPLIANCE issues or COMPLAINTS regarding this project must also be reported promptly to this office.

This approval expires on February 13, 2021. You will receive a continuing review notice before your project expires. If you wish to continue your work after the expiration date, your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date.

Good luck with your work. If you have any questions, please contact the Office of Research Compliance at 419-372-7716 or orc@bgsu.edu. Please include your project title and reference number in all correspondence regarding this project.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Bowling Green State University Institutional Review Board's records.