RESEARCH DIRECTS in STRENGTH and PERFORMANCE

2023, Volume 3 (Issue 1): 10 OPEN ACCESS

The Influence of a Supervised and Unsupervised Strength and Conditioning Program for Elite Adolescent Freestyle Swimmers

Case Study

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Open Access

Published: November 9, 2023

Research Directs in Strength and Performance: *2023, Volume 3 (Issue 1): 10*

ISSN: 2768-5187

Abstract

Introduction: Adolescent high school swimmers, aged 13-16 years, are an athletic population that can benefit from a strength and conditioning (S&C) program which caters for their developmental and sports-specific needs. The aim of this case study was to analyze the adherence to and subsequent effect of a short-term (12-week) combined supervised and unsupervised S&C program in elite adolescent swimmers during a competitive season.

Methods: Seven elite adolescent swimmers (4 females, 3 males) completed the study (age: 15.2 ± 0.5 years; mass: 64.5 ± 5.1 kg; stature: 1.76 ± 0.07 m). The participants were required to adhere to one supervised S&C session and two unsupervised S&C sessions per week that were performed on non-consecutive days while maintaining their traditional swimming training schedules. The unsupervised component was delivered digitally with participant feedback monitored. The S&C program consisted of upper- and lower limbs exercises with low loads and low volume as well as bodyweight exercise. Adherence to both programs was measured by attendance with correlational analysis conducted from total S&C program adherence to swim performance. The effect of the S&C training protocol was assessed using performance time pre and post the S&C intervention during the 50-m freestyle swim.

Results: The S&C training program intervention resulted in significant improvements in the 50-m freestyle swim ($p < 0.001$, $d = >1$). Total adherence to the supervised and unsupervised parts of the S&C program was 88% while adherence to the digital only component was 76%. Although a correlation was observed between total adherence to the combined supervised and unsupervised S&C program ($r = 0.8$, $p = 0.0243$) and improved 50 m freestyle swim performance, this was not the case when the unsupervised component was compared to swim time performance ($r = 0.4$, $p = 0.679$).

Conclusions: This case study demonstrated that a 12-week S&C intervention has a positive effect on elite adolescents' 50 m freestyle swim performance. Furthermore, swim performance was improved when participant adherence to both formats of the S&C program were met. This study supports the development of S&C interventions to develop these correlates and increase adherence.

Key Words: Adolescent swimmers. Strength and conditioning. Exercise adherence.

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Introduction

Swimming is widely known as a sport that demands a high level of training commitment from a young age. It is common practice for youth (adolescent) swimmers to complete 6–8 sessions, or 11–15 hours of training per week for an entire season[1].

As adolescents are commonly involved in community-based and extracurricular activities, attention is habitually turned towards appropriate training and conditioning to optimize performance, stimulate athletic development, and ensure safety while tolerating the physiological and psychology demands of long-term competition. An age-appropriate strength and conditioning (S&C) program has been suggested as a valuable tool in helping to decrease the likelihood of injury while providing opportunities for adolescents to develop a wide and varied array of movement skills which are seen as vital to long-term engagement in physical activity and sport[2]. Strength training is essential for athletes in sports that require speed, power, and strength[3] while resistance training (RT) is defined as a performance-based methodological approach[4]. Here, adolescent athletes may strength-train because they believe it will improve their athletic performance[5]. Along this line, stronger adolescents are likely to be better prepared for the rigors of sport, and moderate to vigorous physical activity participation. They are also less likely to suffer a preventable injury. Thus, contemporary evidence implies that resistance training amongst adolescents can improve performance[6, 7].

Online (digital) and unsupervised S&C exercise programs can add to existing programs that are delivered in-person by a qualified coach. However, there is a paucity of research into how digitally delivered S&C programs can promote adherence and therefore performance improvements in adolescents. Adherence can be defined as the degree a behavior corresponds with an agreed-on recommendation[8]. Of equal importance in the training prescription is an emphasis on physical literacy instruction. Physically literate adolescents perform exercises with enhanced technical ability, competence, and confidence[7]. Additionally, age-appropriate, qualified, and enthusiastic instruction is needed to tailor needs, goals, and abilities[4], particularly when applied to adolescents. This qualified instruction is necessary to facilitate and ultimately maintain extrinsic motivation for the athletes. The current case study sought to evaluate the feasibility of using a supervised and unsupervised S&C program for adolescent swimmers. Specifically, the case study sought to evaluate if the combined S&C program would positively influence swim performance.

Scientific Methods

Participants

All participants received a plain language statement outlining the research, pre-exercise screening and risk mitigation along with a signed participant and parental consent form. A total of seven elite adolescent swimmers (4 females, 3 males; age: 15.2 ± 0.5 years; mass: 64.5 ± 5.1 kg; stature: 1.76 ± 0.07 m) were selected from one swimming club located in the Northern Territory, Australia. Ethical approval for the study was obtained by the Institutional Review Board (H23027). The participants were excluded from the study if they had any injury (acute or chronic) or illness that prohibited them from exerting maximum effort in both water and dryland activities. The participants were notified that they could withdraw from the study at any time. Parents were given the option of opting their child out of the study. All participants were in physically good condition and reported no injuries or pain prior to the commencement of the study. The participants had been swimming competitively for approximately four years with frequent attendance at swim training approximately three-four times per week for a total of approximately 10 hours per week (10 ± 0.1 hours). All swim (in-water) training sessions were supervised by a swimming Australia accredited swimming coach. All the participants were eligible to compete in an Australian National Tournament ("Nationals") as all had recently qualified based on a timed 50 m freestyle event that was sanctioned by the relevant swimming authority. At the time of this study, ad-hoc S&C activity was self-reported by one participant, although this was not structured and was performed intermittently. All remaining participants had no prior experience of S&C, nor had they previously followed a prescribed S&C program.

S&C program design

Following completion of the pre-exercise screening, a baseline 50 m freestyle swimming test was performed by all of participants in order for suitable comparisons to be made at the conclusion of the 12-week S&C program. All participants completed the 50 m swim on the same day with time manually recorded by the swimming coach and lead researcher using conventional stopwatches. To gauge participant strength, a handheld dynamometer was used as a measure of overall muscle strength. Grip strength has been found to be a reliable instrument to measure hand grip strength in participants aged 7-13 years[9]. Handgrip was chosen due to the participants' unfamiliarity with typical strength testing techniques. The handgrip strength test was supervised by a Level 2 accredited Australian Strength and Conditioning (ASCA) coach.

The participants participated in a progressive 12-week non-randomized S&C program. The main intervention period was 1-6 weeks (training cycle, T1) followed by 6-12 weeks (training cycle, T2) and was based on the participants performing S&C training three days per week. The S&C program was structured into a hybrid format whereby one session was delivered in-person once per week (i.e., each Tuesday at 1530-1615) by the same ASCA S&C coach. The supervised session occurred at the participant's familiar gymnasium, located at the same swimming pool facility that

was used for swim training sessions. This session was supervised by the S&C coach and overseen by the principal researcher. The remaining parts of the program were created so that the participants could perform S&C activities for an additional two days per week (i.e., unsupervised and in their own time), which was to be performed on non-consecutive days. As the participants also swam three times per week, they were advised not to complete any S&C activities on their scheduled swimming days. The S&C program was written by the Level 2 ASCA coach and was subsequently overseen by the principal researcher. All S&C sessions were programmed for participants to complete in approximately 30-45 minutes. The S&C training programs were based on age, maturity, and personal goals and objectives. This program was offered at a beginner level, according to the participant's age, their previous experience with performing S&C exercises, and the level of complexity of the exercises. The program was periodized in 4-week blocks, and the load was prescribed based on the individual's movement competency. All exercises were demonstrated, verbally introduced, and then demonstrated once again by the S&C coach with participants asked to provide an initial demonstration to check for movement and technique errors. The participants were asked to abstain from any additional ad-hoc S&C training and to maintain their normal physical activity schedule during and out of school hours, inclusive of swim training, for the study period.

Program design was made with the individual maturation status of the participants to identify pubescent and post-pubescent individuals in accordance with the Long-Term Athletic Development (LTAD) model[6]. Both the supervised and unsupervised S&C parts of the program included aerobic and bodyweight exercises, such as jumping jacks, squats, push-ups, sit-ups, planks, and dynamic planks and included a 5- to 10-minute warm-up and a 5- to 10-minute cooldown. Warm-up activities help to increase body temperature and blood flow (i.e., to the musculature), whereas cooldown activities help to maintain blood flow to enhance recovery and flexibility[5]. The use of body weight and free weights were included as they provide a full-body movement to challenge major muscle groups and control of body mass in a variety of push, pull, squat and lunge movements to develop foundational strength[10]. To determine the relevance and appropriateness of the selected exercises, all exercises included in the program were selected based on age-suitability, individual requirements and exercises that were sport (swimming) specific. For instance, a swimmer's ability to hold a high hip position in the water is controlled by the core musculature[11, 12] and programs that incorporate an aerobic component are beneficial as they improve overall cardiovascular fitness and stimulate an increase in metabolism[5]. Therefore, a specific focus in the early stages of the S&C program was on enhancements to stability in a fun and interactive way using exercises such as inchworm walks, crab walks, streamline rolls, and plank walks while simultaneously developing aerobic fitness. The range of sets and reps followed the recommendation by the UKSCA for a youth beginner[6]. Despite this, some of the prescribed exercises were based on the availability and the accessibility that the participants had to equipment. Consequently, some of the exercises were recommended based on what weights, free weights, and common gym equipment (i.e., pulley machines, medicine balls) could and could not be assessed. As the adolescents involved in this study did not possess a gym membership and therefore could not access aside from equipment what was located at the swimming pool, exercises were also given based on what could be safely used (both from a supervised and unsupervised perspective); the participants' level of maturation relative to the LTAD, and their competency in performing the exercises. Where applicable, 1RM was estimated using the Brzycki[13] method ($1RM = weight / (1.0278 – 0.0278 \times reps)$). Nevertheless, this was used as a guide only with the final decision made by the strength and conditioning coach. Exercises were then progressed accordingly using are more structured movement pattern progression. The session content is shown in Table 1.

Regarding the unsupervised and digitally produced components of the S&C program, this was created by the S&C coach and provided, via email, to participants using Microsoft Excel (Microsoft Corporation, version 2306 Build 16.0.16529.20226). To support adherence to the unsupervised component of the digital program, all participants received instructional videos, photos, and images (JPEG and GIFs) that provided explanations and examples of how to perform the exercises. The participants were asked to adhere to all training sessions (i.e., the supervised S&C session and the two unsupervised S&C sessions) and report their adherence via a manual section interested onto the Microsoft Excel spreadsheet that enabled participant feedback (Figure 1). At the conclusion of the 12-week S&C program, a brief five-day detraining period (tapering period) commenced as competition neared. Here, the participants performed another 50 m freestyle swim test to assess post S&C swim performance.

Table 1. Initial strength and conditioning protocol (cycle 1) for beginner adolescent swimmers. The program was performed three days per week on non-consecutive days and excluded school-based physical activity.

Training protocol	Weeks 1-6 (Training Cycle T1)	Weeks 7-12 (Training Cycle T2)
Exercises (warm-up)	Bear crawls Crab walks Lizard crawls Zombie crawls Skipping (with rope)	Broad jumps (big, long jumps) Jump into streamline. Arm swings (across body) High stepping Skipping (with rope)
Exercises (main conditioning)	Flutter kicks Medicine ball twists Sit ups (with 5 kg db) Side plank (static) Lunge drops Chin ups Front raise (with db)	Flutter kicks (holding kickboard behind head, arms stretched). Leg lifts Deadlift (with dowel) Squat push press with db Wall angles Inchworms Swiss ball
Exercises (cool down)	Static stretches	Static stretches
Training volume	• 6-week training period with a total of 18 sessions. Each session lasted approximately 30 minutes and excluded a 10-minute warm-up and 10-minute cooldown. • Exercises included 2-3 sets of 8 repetitions with 2-3 seconds rest between repetitions and 2 minutes rest between sets.	• 6-week training period with a total of 18 sessions. Each session lasted approximately 30 minutes and excluded a 10-minute warm-up and 10-minute cooldown. • Exercises included 2-3 sets of 10-12 repetitions with 2-seconds rest between repetitions and 90 seconds rest between sets.
Training frequency	• 3 training sessions a week separated by approximately 48h. • Training completed on non-swimming days. • One session was supervised in person by the S&C Coach with the remaining sessions conducted in the swimmers' own time.	• 3 training sessions a week separated by approximately 48h. • Training completed on non-swimming days. • One session was supervised in person by the S&C Coach with the remaining sessions conducted in the swimmers' own time.
Training intensity	• 30–40% of the 1RM Training intensity was examined for reach participant on a fortnightly basis by means of 1RMtests. If necessary, the training load was adjusted.	• 35–42% of the 1RM Training intensity was examined for reach participant on a fortnightly basis by means of 1RMtests. If necessary, the training load was adjusted.
Method of muscle contraction	• Participants were instructed to perform the exercises using correct technique, as instructed by the S&C coach.	• Participants were instructed to perform the exercises using correct technique, as instructed by the S&C coach.

Session aims: To develop movement skills and improve level 3 to 4 S&C movement pattern competency. Kg = kilogram; db = dumbbell.

**Figure 1. ***See end of manuscript: Copy of Microsoft Excel S&C program that was distributed digitally to participants. Far right column represents section whereby participants recorded comments and feedback.

Feedback session

This case study also used a semi-structured interview guide with five open ended questions. The interview guide was provided to participants at the end of week 4 to explore the participants' experiences and perceptions of the S&C program and to identify potential issues with adherence to the unsupervised component of the program. Thus, the interview guide was administered on three occasions. The interviews were conducted in person with parental supervision and ranged between 15-20 minutes.

Statistical Analysis

Data analysis for the quantitative measures was undertaken using the Statistical Package Analyse-it (Leeds, United Kingdom, version 4.92). All variables were tested for normality using the Kolmogorov-Smirnov and Shapiro-Wilk test and for homogeneity using the Levene's test. All data were reported as mean ± SD. A paired Student's t-test was used to assess the differences between 50 m freestyle performance pre commencement of the S&C program and at the conclusion of the S&C program. In line with de Winter[14] who concluded that there are no principal objections to using a t-test with a small sample size, a paired Student's t test was used as a simple guide to allow for a comparison between pre and post the S&C intervention in the swimmers". Magnitude of effect was determined using Cohen's d[15] effect size (ES) and interpreted based on the following scale: 0.0–0.2 (trivial), 0.2–0.6 (small), 0.6–1.2 (moderate), >1.2 (large), and >2.0 (very large). The Pearson product-moment correlation (*r*) was also used to determine the relation between S&C program adherence and swim time. $p<0.05$ was considered significant.

Results

All participants completed the 12-week S&C training program, and none reported any training-related injury. The participants demonstrated high attendance at the weekly on-site and supervised training session with 88% adherence (attendance). Post S&C 50 m freestyle swim performance resulted in a highly significant improvement, that is – 50 m freestyle swim performance was faster post completion of the S&C program (ES >1, Table 3),

Table 3. Effects of 12 weeks strength and conditioning training and detraining on 50 m freestyle swim performance in high-school student elite swimmers. * Significant at $p<0.05$

	Mean 50 m swim freestyle	Mean SE	SD	CV	Effect Size	*t*	*p*
Pre-S&C	31.36	1.28	3.3	10.8%			
Post S&C	30.25	1.13	3.0	9.9%	>1 (moderate)	-3.46	0.0134*

As shown in Figure 2, while all participants improved 50 m freestyle swim time performance post 12 weeks of the S&C program, the improvements observed varied between the participants. Furthermore, while adherence to the combined supervised and unsupervised forms of the S&C program was 88%, adherence to the digital only component was found to be 76%. Lastly, although a correlation between total adherence to the combined supervised and unsupervised S&C program was found ($r = 0.8$, $p = 0.0243$) along with improved 50 m freestyle swim performance, this was not the case when the unsupervised, digital-only component was compared to swim time performance ($r = 0.4$, $p = 0.679$).

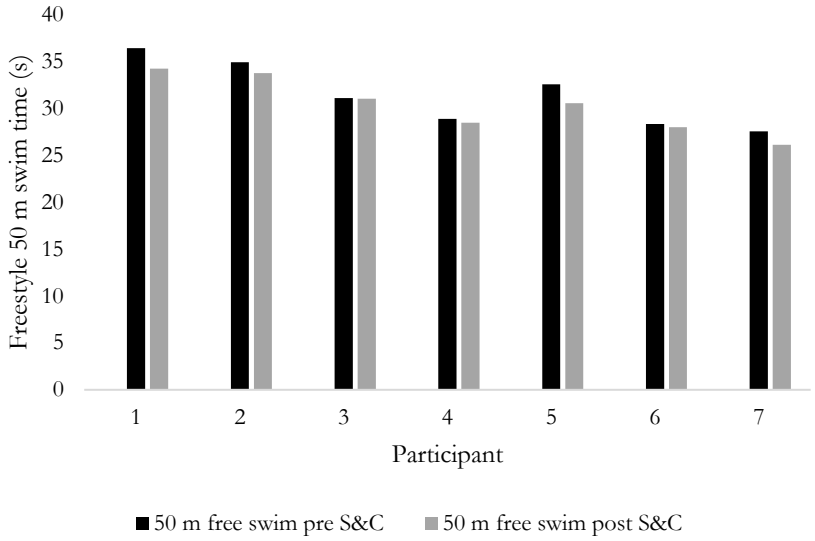

Figure 2. Comparison of individual 50 m freestyle swim time performance pre and post a 12-week combined in-person and digitally delivered S&C program.

Table 4. Individual effects of 12 weeks strength and conditioning training and detraining on 50 m freestyle swim performance in high-school student elite swimmers.

Participant	50 m freestyle swim time pre-S&C (seconds)	50 m freestyle swim time post S&C (seconds)	Difference in 50 m freestyle swim pre v post S&C (seconds)	Effect Size	Adherence to combined S&C program (in-person and digital)	Adherence to digital only S&C program
P1	36.4	34.2	2.18	1.6 (large)	88%	78%
P2	34.9	33.7	1.13	1.1 (moderate)	92%	71%
P3	31.1	31.0	0.09	0.1 (trivial)	88%	71%
P4	28.8	28.4	0.40	0.3 (small)	83%	67%
P5	32.5	30.5	1.98	1.4 (large)	92%	86%
P6	28.3	27.9	0.36	0.3 (small)	81%	64%
P7	27.5	26.1	1.45	1.2 (moderate)	94%	93%

Feedback session

The participants and parents expressed positive changes to both confidence and agency, including a sense of 'feeling positive in order to keep the S&C program going' post the national competition. The participants reported improved confidence to complete the unsupervised digital component of the S&C program. Notably, many participants conveyed a sense of autonomy as they were able to complete the unsupervised program at a time convenient to them despite 'schoolwork getting in the way'. The participants also reported a sense of achievement at the conclusion of the program, the latter is pertinent given the improvements in 50 m freestyle swim performance that were seen. This has previously been described as perceived athletic competency and perceived global self-worth[16]. Along this line, improved self-esteem and self-confidence were also mentioned by five of the participants in the current study. Additional comments were made that might support regular adherence to S&C programs with one female participant stating that she was encouraged to keep going with the program (I would like to challenge myself to see how fast I can

swim in future). Two male participants acknowledged that they had believed that they had gained strength which had made swimming 'easier and faster'. Interestingly, all the participants spoke of being supported in both the supervised and unsupervised programs. This support came from parents, the swimming coach, the S&C coach and peer-to-peer support. Again, this finding is consistent with others. For example, Jonsson et al.[17] note that a supportive environment is mainly built from encouragement, help from family, friends, trainers, and coaches as both encouragement and support can help adolescents to overcome psychological barriers such as low self-esteem and lack of motivation to exercise. Therefore, future studies are needed to determine the processes by which social support influences various performing promoting behaviours.

Discussion

Maglischo's theory of resistance training in swimming posited that there are two types of resistance training that can improve swimming performance: training conducted in water and on land (dryland)[11]. The current case study sought to evaluate the feasibility of using a supervised and unsupervised S&C program for adolescent swimmers. Specifically, the study sought to evaluate if the combined S&C program would positively influence swim performance. That the S&C program was purposely delivered in a hybrid format, that is – with one S&C session delivered in person and supervised by a qualified S&C coach with all participants training as a group, with the remaining parts of the program delivered digitally and unsupervised for participants to complete in their own time, represents the novelty of this case study. Consequently, a secondary aim of this study was to consider the adherence of participant engagement in both the supervised and unsupervised S&C programs while assessing 50 m freestyle swim performance pre and post the S&C intervention. Firstly, there was a statistically significant effect when assessing pre S&C 50 m freestyle swim time performance against post S&C freestyle swim performance with all participants swimming faster after completion of the 12-week program. This is in accordance with Maglischo[11] and others who concluded that dry-land strength training can improve swimming performance[18, 19,] particularly the auxiliary effect of kicking in improving swimming speed[20]. However, as kicking speed was not measured in the current study, caution should be exercised when considering these findings as data collection was from a relatively small sample of participants and results cannot be generalized to a wider population.

In general, the dryland S&C training included basic body weight and resistance training exercises. The basic resistance training comprised of exercises to improve the pectoralis major, triceps and forearm muscles, dumbbell exercises to develop the strength of the latissimus dorsi, and Swiss ball and medicine ball to build local muscle development. However, it must be noted that although the participants reported their progress and responded to the feedback provided by the S&C coach during both the supervised and unsupervised components of the program, the reports and updates provided by the participants were subjective and open to interpretation given the unsupervised nature and focus on participant autonomy. Along this line, different theories and models have been purported from different disciplines to explain adherence to exercise[21.] Spring et al[22] suggested the need for an equivalent psychological intervention, in addition to the exercise program, to aid in behavior change. Others have proposed the benefits of increasing participants' motivation towards exercise by paying more attention to the three basic psychological needs: autonomy, competence, and relatedness[23]. To address the issue of increasing motivation towards exercise, in the current study autonomy was stipulated that minimal restrictions were placed on how and when the unsupervised S&C component of the program could be completed by participants. That a proportion of the S&C program was unsupervised and therefore not directly monitored is both a strength and limitation of this case study. For those participants who self-reported high adherence to the unsupervised program, significant improvements in 50 m freestyle swim performance were observed post the 12-week S&C intervention (e.g., participants 5 and 7). The outlier here is participant 1 who demonstrated a lower adherence to the unsupervised program yet recorded the largest improvement in swim performance (i.e., 2.18 seconds improvement). In this instance, while the S&C training may have positively influenced athletic performance, other variables that were out of scope of this case study need consideration.

While a spreadsheet format was selected as the unsupervised and digital means of providing the S&C program in current study, there are many forms of digital technology; from mobile applications to websites to simple phone calls, that could also assist participants to adhere to a structured physical activity program. These technologies can provide education, advice, information, feedback, and communication from S&C coaches, which can in turn enhance motivation. Although the intervention was 12 weeks in duration, it took a significant amount of time for some of the participants to learn the exercises and, therefore, a familiarization period would be recommended in future studies. Additionally, while the participants were asked to maintain their normal physical activity and dietary patterns over the study period, it is not possible to ascertain if this was the case.

There are both strengths and limitations in this study. One asset is the use of a recognized theoretical lens to evaluate the feasibility of using a supervised and unsupervised S&C program. A limitation might be the possibility of generalization as all participants were from the same swimming club. One limitation of this study is the small sample size and limited qualitative data, which could shed more light on the adolescents' experiences, especially, between males and females. Although this case study sample (both female and male) may suffice given the convenient sample research design, future research could perhaps extend the sample. This study did not include a long-term follow-up and it is therefore unknown whether any changes in performance persisted when the training stimulus was withdrawn. Consequently, longer-term studies are needed to determine if any benefits from S&C are maintained, if the participants remain engaged and/or have increased sets, loadings or changed exercises. Despite this, the idea of the hybrid program was to provide opportunities and flexibility for long-term development. This was somewhat apparent in the feedback provided by both adolescent and parents. However, more research is needed to substantiate this.

Numerous myths concerning strength training in children deserve discussion. One misunderstanding concerns strength training and growth plate injuries. A well-supervised strength training program has no greater inherent risk than that of any other youth sport or activity[24]. Thus, a well-structured and age-appropriate S&C program can be a valuable tool in improving movement skills and enhancing performance in adolescent swimmers. This is vital to ensuring long-term engagement in physical activity and sport. S&C coaches who work with youth athletes should strive to provide fun, interactive, and challenging S&C programs that suit the developmental and sports-specific needs of their athlete(s).

Conclusion

Adherence to 12 weeks of strength and conditioning training was observed to result in improved performance in the 50 m freestyle swim in adolescent swimmers. The results from this case study suggest adherence to both a supervised and non-supervised (digital) strength and conditioning program are beneficial to performance. Although a correlation was seen between total adherence to the combined supervised and unsupervised S&C program, this was not the case when the unsupervised component was compared to swim time performance. Future research should aim to address other strategies to encourage adherence to unsupervised strength and conditioning programs in adolescent swimmers.

Acknowledgments

The authors thank the participants and the S&C coach for their commitment to the study.

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WEEK: 31/07/2023 to 6 weeks NAME

GOALS: General conditioning

Record fatigue levels, responses to exercise,

WARM UP: SPEED AND AGILITY						DAYS: Tuesday 4pm	
ACTIVITY	SETS	REPS	TIME	DIST	INTENSITY**	NOTES	
Arm circles (clockwise/anti-clockwise)	1	10-12	-	-	Low	Warm up should be performed at moderate intensity	Repeat x 2. Allow 60 seconds rest after set 1
Star jumps	1	10		-	Low		
Broad jumps (big, long jumps)	3	3	60 seconds				
Jump with streamline	1	10		-	Low		
Arm swings (across body)	1	10	-	-	Low		
High-stepping	1	10	-	-	Low		
Skipping (with rope)	60 seconds						

STRENGTH TRAINING	SETS	REPS	WEIGHT		REST TIME	NOTES
Flutter kicks	3	30 seconds				Keep shoulders on ground; flutter slowly and keep legs low
Medicine ball twists	3	10-12	Boys: use 10 kg weight	-	-	
Deadlift with dowel	3	20			45 seconds between sets	
Squat push press with DB	3	10-12				Seated position. Use dumbbells or weight and push weight above head, keeping arms straight
Inchworms			2-3 sets			

COOL DOWN: MOBILITY	SETS	REPS	TIME	DIST	INTENSITY**	NOTES
Wall Angles	2-3	10	2 kg in each hand		Moderate	https://www.youtube.com/watch?v=ywYi4rBhRBQ