# Countermovement jump and pull-up performance before and after a swimming race in preparatory and competitive phases of a swimming season

**Citation for published version:**
Gonzalez Rave, JM, Sorgente, V, Agudo, A, Rodrigo-Carranza, V, Psycharakis, S & Turner, AP 2024, 'Countermovement jump and pull-up performance before and after a swimming race in preparatory and competitive phases of a swimming season', *International Journal of Sports Physiology and Performance*, vol. 19, no. 5, pp. 471-479. https://doi.org/10.1123/ijspp.2023-0329

**Digital Object Identifier (DOI):**
10.1123/ijspp.2023-0329

**Document Version:**
Peer reviewed version

**Published In:**
International Journal of Sports Physiology and Performance

**Type: Original article**

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**Preferred running head:** Jumps and pull-ups at swimming events.

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**Text-only word count: 3759**

**Number of tables and figures: 6**

## Abstract

Purpose: Monitoring performance athletes' training responses can be efficiently completed at competitive events. This study aimed to explore the changes in swimming, countermovement jump (CMJ) and pull-up (PU) performance following training across a competitive phase, as well as immediately before (PRE) and after (POST) each race. Methods: Fourteen well-trained male sprint/middle-distance swimmers (height 179 ± 7 cm; mass 70 ± 8 kg; age: 18 ± 2 years), from 3 regional training groups, completed CMJ and PU tests PRE and POST national competitions in October (PREP phase) and May (COMP), when race performance was also assessed. Results: Swimming race performance was significantly improved from PREP to COMP (1.8 ± 3.2 %, $p = 0.044$, $d = 0.60$, moderate effect). Although there were no significant changes in PU velocity, CMJ performance significantly improved from PREP to COMP (Mean difference 2.29 cm, $p = 0.004$, $d = 3.52$) and showed PRE to POST race decreases (Mean difference -1.64 cm, $p = 0.04$, $d = 2.28$). Conclusion: Swimming performance and CMJ performance improved as the season progressed, although these improvements were not directly correlated. PU performance did not appear to be sensitive to training or race-induced fatigue, in contrast to CMJ, in this group of male swimmers.

**Key words:** fatigue, competition, performance, sprint swimming, middle-distance.

## Introduction

In sprint swimming events, i.e. race distances of 50m and 100m, in all four strokes, the swimmers rely primarily on energy provision from muscle stores of high-energy phosphates (i.e., adenosine triphosphate, adenosine diphosphate, and creatine phosphate). There is evidence that strength, power, and recovery of this energy system can be modified with appropriate training [1-2] . In middle-distance swimming, the 200 m events last around 01:45-2:45 (mm:ss) (depending on stroke and level), and are metabolically supported by a combination of phosphate energy, anaerobic glycolysis, and the aerobic metabolism of carbohydrate, fat, and protein [2] .

Some studies have shown a positive association between upper/lower body strength and swimming success. For example, Keiner et al [3] reported several strong correlations between a range of strength tests (bench press, squats and countermovement jumps, CMJ) and swimming performance for sprints between 15-100m, and particularly for the shorter distances up to 25m. It has also been shown that the maximum velocity and force generated during the pull-up exercise correlates highly with swimming velocity [4-5]. The study by Pérez-Olea et al [4], examined the validity of the CMJ and the pull-up (PU) exercise as predictors of swimming performance. The researchers concluded that a single maximal PU could be used to predict swimming performance in short distances among competitive swimmers, highlighting the importance of upper-limb strength in swimming. Moreover, the inclusion of upper-body strength training into the training regimens appears beneficial in improving performance and the propulsive forces applied in the water [6-8]. Morouço et al. [9] provided some evidence to support the notion that the ability to exert force in the water is a decisive factor, particularly in sprint swimming.

The progressive development of the energy systems involves the design of an effective swimming training plan by coaches, which in turn, represents a complex process underpinning the relationship between training stimulation and recovery [2]. It is well known that correct periodization of swimming and strength training in swimming and the associated physiological and biomechanical adaptations lead to improved race performance in the main events [10-12].

The heavy demands of training for competitive swimming might cause local muscular fatigue and inhibit the development of maximal swimming power during periods of the training cycle. For example, 200 m swimming led to an acute drop in movement execution velocity during the latter stages of a 200m trial due to neuromuscular fatigue, that can also be associated with training overload, and possible muscle failure [13]. Stachowicz and Milde [14] examined the changes in thrust force in five elite swimmers over a season, concluding that all the participants achieved the highest maximum thrust force in the same periods of the training cycle (winter and summer competition period). Yet, there is a scarcity of studies exploring how race-induced neuromuscular fatigue may change over the season in the upper and lower limbs after 50 m, 100 m, and 200 m swimming events. Such research would have the potential to make a contribution to the limited body of knowledge in this field.

The aim of this study was to analyze the performance in pull-up velocity and jump height before and after 50 m, 100 m and 200 m swimming events in two different stages of the season: preparatory and competitive periods of a traditional periodization model. It was hypothesized that swimming performance, jump height and pull-up performance would be improved in the competitive phase compared to the preparation phase. It was also hypothesized that jump height and pull-up velocity would be reduced immediately post-race in both phases, but with potentially less post-race decrement in performance during the competitive phase than in the preparation phase. Finally, it was hypothesized that changes in swimming performance across the season phases would be associated with corresponding changes in jump height and pull-up velocity.

## Materials and Methods

### *Participants*

The study was approved by the local university ethics committee (UNNE-2020-010), and the swimmers and their coach provided written approval for retrospective analysis. This was conducted in accordance with the Helsinki Declaration. The swimmers involved were 16 males (height 179 ± 7 cm; mass 70 ± 8 kg; age: 18 ± 2 years; mean ± SD; 580 ± 107 Fédération Internationale De Natation points of best competitive performance) and all were sprinters/middle-distance specialists (50-100-200m). Unfortunately, we couldn't recruit females from the same squads as the female swimmers were unable to perform the pull-up test satisfactorily. Training for swimmers included general training for 50-200m, with other sessions focused more on sprinting or middle distance. All swimmers were classified as Tier 3 (Tier 3: Highly Trained/National Level) according to the classification framework of McKay et al [15]. Furthermore, the participants reported no physical injuries in the 6 months prior to, and during the study. Between the competitions, two swimmers changed swimming stroke or race distance and were excluded from the analysis the stroke and distance remained the same for the remaining 14 swimmers (Table 1). All swimmers provided written informed consent after a detailed description of the study procedures, and parental/guardian consent was included for those swimmers under 18 eight years old.

### *Data collection*

We collected data at competitive race events for in-water swimming performance, as well as dry-land pull-up and countermovement jump performance. All swimmers were familiarized with both protocols because they were enrolled in a talent identification program carried out by the regional swimming federation. Additionally, two experienced researchers conducted all of the tests and visually checked them in order to ensure reproducibility of technique and protocol application. In our case, each experienced researcher collected data for each test (Pull up and CMJ). We have calculated the ICC for CMJ (pre and post measurements) in the preparatory period as 0.81 and in the competition period as 0.93, while the ICC for pull-ups was 0.78 and 0.47 respectively. Swimming race times were collected during regional swimming races by professional personnel employed by the local swimming federation, using electronic touchpads. To avoid any influence of fatigue developed during the competitions, we only collected data during the first event in which they competed in the heats. The pull-up tests and CMJ were performed in a large, quiet room inside the facility and near the pool. The pull-ups were performed using a standard steel bar of 3.81 cm in diameter (1.5 inches), standing 2.5 m from the ground. Mean Velocity (m/s) during the pull-up was calculated using the Vitruve linear encoder (Speed4Lifts, Madrid, Spain), previously validated [16] and used by our research team [5]. Specifically, this linear encoder comes in the portable form of an 8 $cm^3$ box, equipped with an extensible wire that is attachable via a Velcro strap. The strap was securely attached at the hip level. Moreover, the Vitruve linear encoder is embedded with a smartphone app that allows for insertion of the subject's height and body mass, consequently calculating specific performances in a selected exercise (in this case, the pull-up). Swimmers performed 2 pull-up attempts, selecting the fastest trial. Vertical jump performance was assessed using CMJ height, assessed using an optical measurement system (Optojumpnext, Microgate, Bolzano, Italy). Swimmers performed 2 attempts of each CMJ, selecting the highest jump.

### *Experimental design*

Although a training program was followed by all swimmers, the research design was primarily observational (i.e. we did not intervene in the content of the swimming training), as withholding such training from a control group is neither ethical nor feasible in such trained populations. The training programs were therefore designed and implemented by the coaches. In swimming, such observational studies (research not interfering with training scheduling or regimens) have been often used in the past [17]. The protocol of the programme design is shown in figure 1.

***Figure 1*** around here

### *Procedure*

The data were obtained during the same regional level swimming competition that took place in October, 8 weeks after pre-season training (PREP), and May during the competitive season (COMP), 6 weeks before national swimming championship, and in the same short-course (25 m) swimming pool with similar atmospheric conditions. Between the data collection in October and May (total 28 weeks), all three coaches voluntarily reported training information regarding volume, intensity, dryland sessions and competitions for research purposes only

As shown in Figure 1, the swimmers first executed 30 min of warm-up in the official period set aside for this purpose. Prior to the start of the race, the participants were instructed to perform two maximal explosive PU tests, according to the procedure shown in Sorgente et al [5], and two maximal CMJs in that order. For all tests, participants were fully dried and completed tests barefoot on a dry surface and wearing only swimsuits. Participants were instructed to pull-up "as strong and fast as possible" and to jump "as high as possible" before each repetition. A short recovery was permitted between trials. At 5 minutes after the completion of the race, participants repeated the same two pull-ups and CMJs, performed in the same order. To ensure the procedure for measuring pull-ups 5 min before (PRE) and 5 min after the swimming races (POST), we employed a stopwatch. According to Kraemer and Fleck [18], we used the 5 min rest period to ensure enough recovery pre-competition and to also establish the same rest period after the competition.

### *Periodization*

A traditional periodization model was followed, using three macrocycles covering the winter competition (December), Spring championships (April), and the main competition (June) organized in 2023. Overall, the aim of the first macrocycle was to develop general fitness and specific qualities orientated to the main event for each swimmer. The goals of second and third macrocycles were to develop specific qualities required for the different events (i.e. aerobic power, race speed, lactate production, maximal strength, etc.), culminating in the taper and competition. All training intensity distribution performed in the pool was categorized into five intensity levels [5]. Intensities Z1, Z2, and Z3 represented swimming speeds below (~ 2 $\text{mmol}\cdot\text{l}^{-1}$), equal to (~ 4 $\text{mmol}\cdot\text{l}^{-1}$), and slightly above (~ 6 mmol·l$^{-1}$) the onset of blood lactate accumulation, respectively. High-intensity swimming that elicits blood lactate levels of ~10 mmol·l$^{-1}$ was defined as intensity Z4 and maximal intensity swimming as intensity Z5 [19]. Dryland sessions are included as a part of the preparation involving resistance training. Resistance training sessions focused on maximum strength (i.e. 85 – 90% 1RM), power (i.e. 60 – 75% 1RM) and power endurance (i.e. 50 – 60 % 1RM) with resistance exercises, also including core training to enhance stability and prevent injuries common in swimmers. The regional swimming competitions were targeted by coaches to obtain classification times for the subsequent national championship held in December and main competition in June. The ranges of training volumes and intensities experienced by the swimmers distributed across the season is shown in Table 1.

***Table 1*** around here

### *Statistical analysis*

All data were analysed using IBM SPSS 27 and results are presented as Mean ± SD, with an alpha level of 0.05. Comparison of swimming performance from PREP to COMP was completed using mean race velocity ($v_{mean}$) to normalize between-subject differences in race distance. A paired samples t-test with effect size (Cohen's d) was used, data were normally distributed (Shapiro-Wilk test). CMJ data were analysed to explore effects of race (PRE vs POST) and season phase (PREP vs COMP), using a 2-way repeated measures ANOVA, with normally distributed data. Post-hoc pairwise comparisons were used to calculate effect sizes ($\eta_p^2$). Pull-ups data were analysed to explore effects of race (PRE vs POST) and season phase (PREP vs COMP), using Wilcoxon signed rank tests, as the data were not normally distributed, with effect sizes reported ($r = Z/\sqrt{n}$). Pearson correlations were used to explore relationships between the observed changes in swim performance (PREP to COMP, %) and corresponding changes in CMJ and pull-ups performance (Changes in PRE values from PREP to COMP, %). Effect size interpretations were small, moderate or large as follows (if greater than): $\eta_p^2$ - 0.01, 0.06, 0.14; d - 0.2, 0.5, 0.8, r - 0.1, 0.3, 0.5 [20].Also, the test—retest relative reliability was assessed using the intraclass correlation coefficient (ICC) test and interpreted as follows: as poor (<0.5), moderate (0.5–0.75), good (0.76–0.9), and excellent (>0.9) [21].

## Results

Swimming race performance improved significantly from the preparatory to the competition phase (1.8 ± 3.2 %, $p = 0.044$, $d = 0.60$, moderate effect), as shown in Figure 2. However, performance for two swimmers decreased by approximately ~3-4%. Table 2 shows the race distances, strokes and performance times.

***Figure 2*** around here

***Table 2 *** around here

For the CMJ, there were significant main effects of race (PRE to POST race, $F_{(1,13)} = 5.19$, $p = 0.04$, $\eta_p^2 = 0.29$) and season (PREP to COMP, $F_{(1,13)} = 12.33$, $p = 0.004$, $\eta_p^2 = 0.49$), but no significant interaction effect ($F_{(1,13)} = 1.42$, $p = 0.26$, $\eta_p^2 = 0.10$), as shown in Figure 3. There was a large effect for the decrease in CMJ performance following a competitive race (Mean difference 1.64 cm, $p = 0.04$, $d = 2.28$) and a large effect for the improvement in CMJ performance from the PREP to COMP phases of the season (Mean difference 2.29 cm, $p = 0.004$, $d = 3.52$).

***Figure 3*** around here

For pull-ups, there were no significant changes in pull-ups velocity from PRE to POST race in PREP (0.95 ± 0.05 m/s vs. 0.93 ± 0.06 m/s, $Z = 1.36$, $p = 0.18$, $r = 0.36$, moderate effect) or COMP season phases (0.96 ± 0.05 m/s vs. 0.94 ± 0.05 m/s, $Z = 1.87$, $p = 0.06$, $r = 0.50$, moderate-to-large effect), nor any significant changes from the PREP to COMP season phases for the PRE (0.95 ± 0.05 m/s vs. 0.96 ± 0.05 m/s s, $Z = 0.49$, $p = 0.62$, $r = 0.13$) or POST (0.93 ± 0.06 m/s vs. 0.94 ± 0.05 m/s, $Z = 0.40$, $p = 0.69$, $r = 0.011$) race tests, with considerable inter-individual variation, as shown in Figure 4.

***Figure 4*** around here

Finally, there were no significant correlations between the changes in swimming race velocity from PREP to COMP (% change) and the corresponding changes in CMJ ($r = 0.27$, $p = 0.349$) or pull-ups performance ($r = -0.40$, $p = 0.16$).

## Discussion

This study explored the performance and changes in pull up and countermovement jump tests before and after a swimming race in both early and late competitive phases of the season. There were significant improvements in swimming and CMJ performance between the early and late competitive phases in this group of well-trained swimmers, in support of our hypotheses. There was evidence of a race-induced fatigue effect in CMJ performance in both competition phases, with a similar size of CMJ decrement at both points. In contrast, there were no significant changes in pull-up velocity either between competition phases or from PRE to POST race, despite moderate-to-large effect sizes. Interestingly, the changes in swimming performance and CMJ performance across the season were not significantly associated.

The improved performance times may be attributed to the progressive increases in training load. The correct organization of swim training within a specific periodized mesocycle has been associated with peak performance in elite swimmers [2,17]. However, it should be noted that the training volume prescribed in these previous studies is higher than the volume presented by the coaches analysed in our study, or at least our swimmers were at the lower end of ranges presented. According to our coaches, they reported a monthly training volume ranging from 75 to 153 km (Table 1). This training volume is comparable to the lower range of average weekly training volume (20 – 60 km) reported by Kilen et al. [22] in Swedish elite swimmers. These swimmers were primarily competing in events ranging from 50 to 200 m. Hellard et al. [17] also reported that sprinters had higher weekly training volumes than most of our swimmers, ranging from 29-37km and middle-distance swimmers from 39-42km, depending on the type of macrocycles used.

Our findings align with the commonly used periodization model for endurance events, known as traditional periodization, which involves varying Training Intensity

Distribution (TID) approaches across different training periods [23]. It is evident (Table 1) that coaches allocated a significant portion of the swimming total training volume to lower intensity Z1 and Z2, which typically account for over 80% of the total volume. The remaining volume was dedicated to higher intensity training, as suggested by intervention studies utilizing a five-zone model. It is worth noting that the coaches did not explicitly define the underlying model of periodization they followed, as their primary focus was on achieving specific combinations of workloads rather than emphasizing the specific type of periodization employed; as shown when Gonzalez Rave et al [2] analyzed the main characteristics of endurance training for highly-trained swimmers, volume and periodized models. The data we collected, however, suggests that different types of training were implemented in wave-like cycles throughout the season.

Perhaps surprisingly, a typical tapering approach for peak performance, with a peak in training load approximately six weeks before the competition, followed by a modest decrease in the following two weeks [2,11], was not evident. This may be attributed to the fact that the competition held in May was not the main national competition targeted by the swimmers. The POST test therefore preceded this taper and potential improvements may well therefore be under-represented if anything.

Coaches often prescribe strength and conditioning training programs to improve swimmers' muscle power and strength [24]. This is potentially why both the countermovement jump (CMJ) and performance times may have improved in our study, because all coaches in this study have prescribed dry-land training sessions leading to improvements in both muscle power and strength in swimming and on dry-land conditions. Such dry-land training included strength and power exercises for both the upper and lower body. In this context, strength and power training have been shown to enhance swimmers' ability to apply increased force on the wall during turns, with a shorter period of wall contact [25-26]. However, we did not demonstrate a significant correlation between improvements in CMJ and swimming performance. This is likely explained as although turns and starts represent an important contribution to sprint performance in a short-course pool especially [27], there are many other components that contribute to swimming race performance. The sizes of CMJ improvements observed between PREP and COMP phases (mean 7.6%) are in line with a previous meta-analysis of weight-lifting training effects on CMJ (7.5%) [28].

Secondly, we demonstrated that there was a significant decrement in CMJ performance within 5-minutes of completing the race (POST vs PRE, Figure 3). Monitoring neuromuscular status was aligned to the sensitivity of the CMJ to detect the effects of fatigue and supercompensation on performance as shown the meta-analysis of Claudino et al [29]. We reported larger effect sizes for the CMJ decrement, yet with a mean decrement of 3.8% and a consistent pattern in participants, this emphasises the utility of this measure in our population. In contrast to our hypotheses, the magnitude of the race-induced decrement of CMJ performance was not different between the PRE and COMP phases (no interaction effect). In retrospect, this finding is perhaps not surprising as although training will likely have reduced underpinning mechanisms, the physiological demand of the race has also increased due to the improvements in swimming race performance that were observed. As such, the magnitude of the fatiguing effect remains similar at both time points. Combined, our findings on CMJ and race performance (mean improvement 1.7%) align well with Ribeiro et al.[30], who demonstrated that after eight weeks of training targeted specifically for a 100 m front crawl competition, performance improved by 3.06%., with post-race decreases in measures such as peak force (16.26%) and maximal voluntary contraction force (9.33%). It is noted that 2 of our participants showed large decrements in race performance, which could potentially reflect under-training, over-training, or even a pacing strategy adopted during the heats phase of the competition.

In contrast to our hypotheses, there was no significant change in the corresponding pull-up velocity from PREP to COMP phases. Similarly, we could evidence no consistent change in pull-up velocity from PRE to POST race (Figure 4). The contrast with the CMJ data may suggest differences between upper and lower-body improvements in strength and power, which could reflect different priorities in resistance training. Alternatively, it could relate to the specificity of the tests, with swimmers performing more CMJs than PUs within their resistance training. There is unfortunately insufficient detail in the training programmes provided to further explore this speculation. However, considering the individual variation in the patterns of change in the pull-up velocity (Figure 4) with some improving and others getting worse, it appears more likely that performance in this test was less reliable as shown the results of the ICC for pull-ups compared with the ICC for CMJ. As such, reduced signal-to-noise ratio may have masked any demonstrable changes in upper body strength and power, contributing to the lack of a statistical difference. This is supported with moderate effect sizes and illustrated by a number of swimmers showing improvement being offset by others getting worse, sometimes considerably so. These findings are consistent with the previous study conducted by Sorgente et al. [5], which despite a trend for reduction in both velocity and force generated in the single pull-up test shortly after a swimming competition, the changes were not statistically significant. To the best of our knowledge, we have not found any other studies that specifically compare pre- and post-competition pull-up tests. In future, it is recommended that further familiarisation and reliability testing is conducted with these swimmers to confirm the usefulness and sensitivity of the test with these specific athletes, despite this being demonstrated in our previous work with swimmers.

Finally, there were no significant relationships between the size of season-improvements in swimming performance with changes in CMJ or pull-ups performance. However, in further support of our previous point regarding the multi-factorial nature of competition performance, it is important to note that an increase in strength does not necessarily translate to improved swimming performance, as technical factors also play a crucial role. Swimmers not only need to develop high levels of force but also apply them effectively to maximize propulsion in the water [4]. For example, Hermosilla et al [31] found a lack of correlation between SJ-CMJ, and forces produced in underwater vs. dryland conditions. In this sense coaches and swimmers should perform specific tests in water for evaluating force production in turns and understanding the limitations of the dryland tests. An alternative explanation could be that gains in strength and power have not yet translated to improved swimming performance as there may be a lag between harnessing physiological adaptations through to improved technique and performance. An optimal transfer from training requires a specific exercise program and a dryland general strength training is potentially useful for the purposes of increasing body mass, decreasing the risk of soft-tissue injuries, and developing core stability [32].

This observational study has provided some useful information on pre and post-race measures in early and late season. However, there are some limitations in the present study that should be taken into consideration. Firstly, the population is limited in size and restricted to training approaches of three coaches. This may limit the generalisability of the findings, although will still provide a frame of reference and some suggestions for other coaches and inform other future studies. Secondly, as stated a priori, it was not possible to include a control group across the season. Therefore, it is not possible to conclude a cause-and-effect relationship. However, these are well-trained individuals, very familiar with the protocols and also less-likely to have experienced large changes in growth and maturation. Finally, some more detailed analysis of the dry-land resistance work would have facilitated further exploration of speculated rationales for some of the findings presented.

## Practical applications

This research supports the use of CMJ performance in trained swimmers, easily assessed with only 2 jumps performed pool-side using an optical measurement system, to track both acute alterations in neuromuscular fatigue, as well as longitudinal training improvements. In contrast, use of the explosive pull-up test with a LPT, proved less sensitive to such changes, at least in this population, despite familiarisation. However, further studies with larger sample sizes may further establish these approaches across other trained swimming populations. The lack of association between longitudinal changes in race performance and changes in CMJ performance emphasises the value in monitoring multiple aspects of performance in trained swimmers to evaluate training progress and monitor athlete recovery. Future studies should track individual variation in training load, including resistance training, against the improvements in CMJ and race performance to explore the relative importance of underpinning mechanisms.

## Conclusions

Our study observed that swimming race performance improved from the preparatory phase to the competition phase over the season. Furthermore, there was an improvement in CMJ performance from the PREP to COMP phases of the season. However, there were no significant differences in pull-up velocity from PRE to post-race in either the PREP or COMP season phases, and no significant changes from the PREP to COMP season phases.

Based on these findings, we advise caution in using the pull-ups test as an evaluation tool for in-water performance in similar groups of swimmers. While the CMJ test demonstrated more reliability, particularly when the competition is held in a short course pool, it may be a more suitable option for assessing performance in swimmers.

## Acknowledgments

This study has been partly granted by the UCLM research project (2023-GRIN-34236) entitled “The process of building a high-level swimmer”.

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**Table 1**. Volume and Intensity measured in training zones over a season.

| **Month** | **October** | **November** | **December** | **January** | **February** | **March** | **April** | **May** |
|---|---|---|---|---|---|---|---|---|
| Total volume (Km) | 98,1-129 | 120-139 | 120-129 | 124-130 | 134-140 | 82-154 | 75-87 | 128-153 |
| volume Z1 (km) | 14-50 | 45-63 | 45-55 | 40-52 | 40-66 | 25-62 | 30-43 | 40-64 |
| volume Z2 (km) | 40-55,6 | 40-55 | 40-52 | 50-51 | 47-50 | 30-62 | 25-33 | 27-62 |
| volume Z3 (km) | 15,3-26 | 17-36 | 15-30 | 40-50 | 13-45 | 20-21 | 20-35 | 20-50 |
| volume Z4 (km) | 1,6-3,9 | 1-3,9 | 1-4,5 | 2,5-3,9 | 2,7-3,5 | 2,2-4,5 | 3,1-4,5 | 4,5-4,6 |
| volume Z5 (km) | 0,28-0,4 | 0,4-0,3 | 0,2-0,6 | 0,8-1,2 | 1,3-1,6 | 0,8-2,5 | 1,1-1,5 | 1,4-1,5 |
| Dryland sessions (sessions/week) | 3-8 | 4-6 | 4-6 | 3-4 | 3 | 3-4 | 2-3 | 3 |
| competitions (number per month) | 2 | 1-3 | 1-2 | 1-2 | 0-2 | 1-2 | 1-2 | 1 |

Note: Z1 : <3/mmol [La-]. Z2: ~4/mmol [La-]. Z3: <6/mmol [La-]. Z4 ~10/mmol [La-]. Z5: Max effort. Dryland sessions: weekly sessions. Competitions per month.

**Table 2** – Swimming performance for each participant during competitions in the early (PREP) and late (COMP) season phases.

| Swimming Stroke | Race distance (m) | PREP Race time (mm:ss) | COMP Race time (mm:ss) |
|---|---|---|---|
| Backstroke | 100 | 1:01.56 | 1:00.91 |
| Breaststroke | 50 | 0:34.21 | 0:31.61 |
| Breaststroke | 200 | 2:18.52 | 2:23.15 |
| Butterfly | 200 | 2:41.76 | 2:32.06 |
| Butterfly | 50 | 0:26.23 | 0:25.96 |
| Butterfly | 50 | 0:26.10 | 0:25.54 |
| Freestyle | 100 | 0:53.12 | 0:51.60 |
| Breaststroke | 50 | 0:32.58 | 0:32.49 |
| Breaststroke | 50 | 0:31.34 | 0:30.88 |
| Backstroke | 100 | 1:00.46 | 0:58.79 |
| Butterfly | 50 | 0:28.49 | 0:27.40 |
| Backstroke | 100 | 1:06.95 | 1:06.10 |
| Breaststroke | 200 | 2:39.27 | 2:38.13 |
| Breaststroke | 50 | 0:31.68 | 0:33.01 |

Figure 1

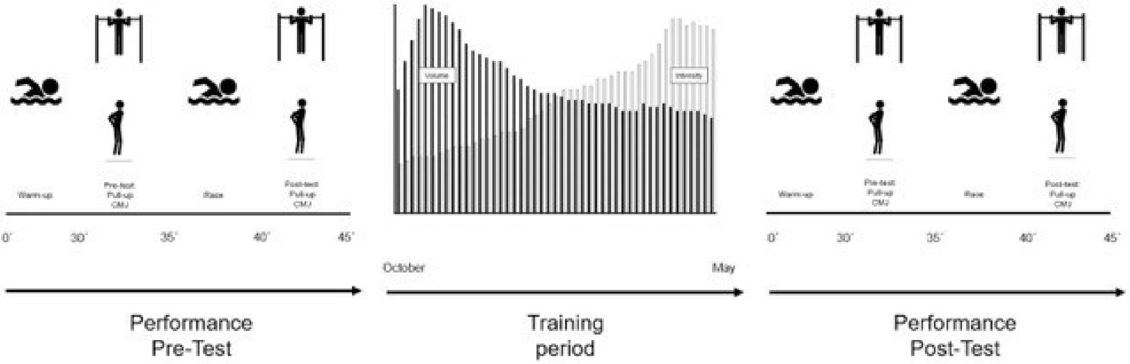

Figure 2

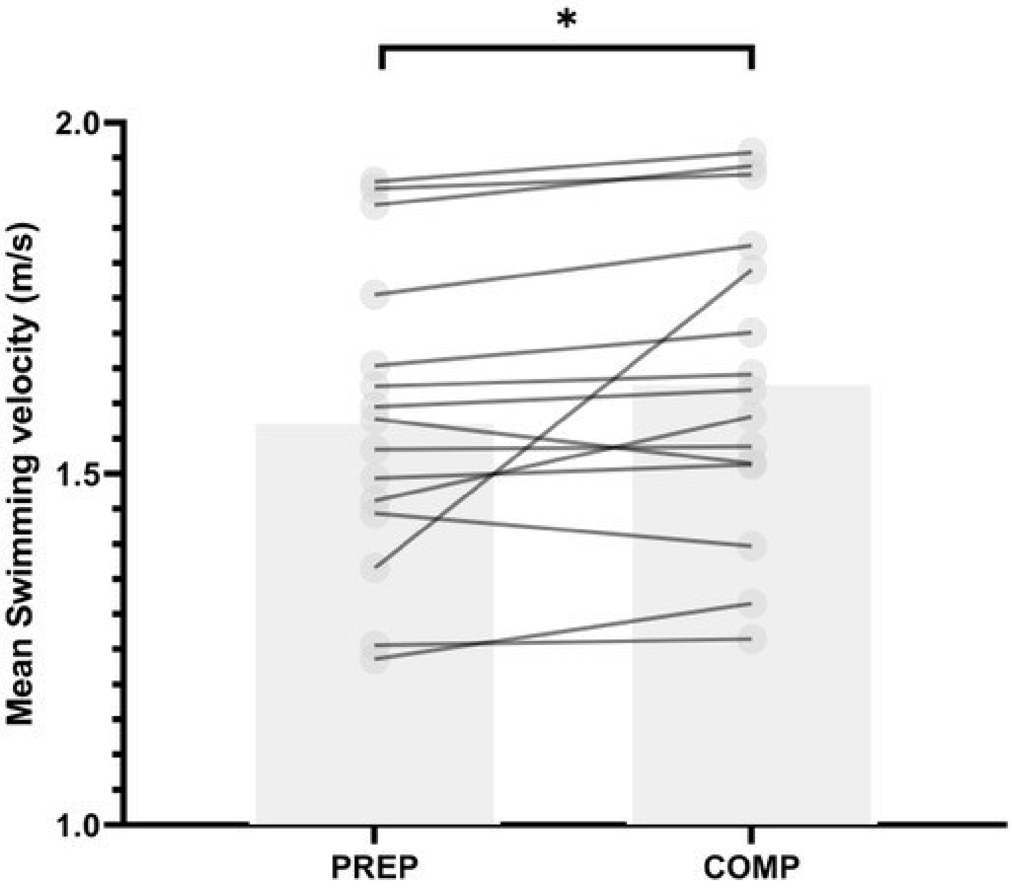

Figure 3

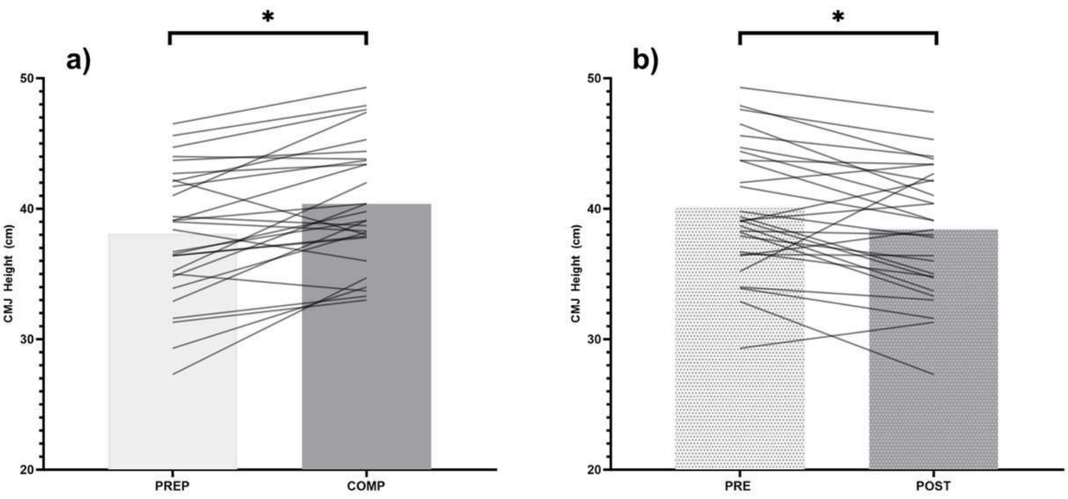

Figure 4