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Original

Training cessation in 12 years old and under Age-Group Swimmers

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ABSTRACT

Objective: To verify if three-weeks of training cessation affects 200 m front crawl performance and kinematics in 12 years old and under age-group swimmers controlling for anthropometric changes.
Method: Sixteen age-group swimmers: 11 girls (age 10.0 ± 1.3 y) and 5 boys (age 10.5 ± 1.0 y) performed a 200 m front crawl test (T200) (time trial) PRE- and POST three-weeks (off-season), where performance, kinematics and anthropometrics variables were obtained.
Results: Height and arm span increased (height ~1.0 cm - CI: 0.70 to 1.3 cm; $p < 0.001$; d = 1.22; arm span ~1.0 cm - CI: 0.20 to 1.4 cm; p = 0.007; d = 0.68). Trivial changes were observed for performance (mean diff: 3.3 s CI: -6.7 to 13.9; p = 0.69; d = 0.08) and kinematical variables (p from 0.69 to 0.84; d = 0.04 to 0.17). High intraclass correlations (ICC: 0.69 to 0.84; $p < 0.001$) were observed for all variables after three-weeks, indicating stability over time.
Conclusion: Three-weeks off-season does not impair swimming T200 performance and kinematic variables in 12 years old and under age-group swimmers.
Keywords: Swimming; Detraining; Performance; Kinematics; Anthropometrics

Cese del entrenamiento en nadadores de 12 años y menores

RESUMEN

Objetivo: Verificar si tres semanas de interrupción del entrenamiento afectan el rendimiento y la cinemática de 200 m en nado crol en nadadores de 12 años y menores mientras se controlan los cambios antropométricos.
Método: Dieciséis nadadores de grupos de edad: 11 niñas (edad 10.0 ± 1.3 años) y 5 niños (edad 10.5 ± 1.0 años) realizaron una prueba de 200 m nado crol (contrarreloj) pre y post tres semanas (fuera de temporada), donde se obtuvieron el rendimiento, variables cinemáticas y antropométricas.
Resultados: La altura y la envergadura han aumentado (altura ~ 1.0 cm; IC: 0.70 a 1.3 cm; p <0.001; d = 1.22; envergadura ~ 1.0 cm; IC: 0.2 a 1.4 cm; p <0.001; d = 0.68). Se observaron cambios triviales para el rendimiento (diferencia media: 3.3 s IC: -6.7 a 13.9; p = 0.69; d = 0.08) y las variables cinemáticas (p de 0.69 a 0.84; d = 0.04 a 0.17). Se observaron altas correlaciones intraclase (CCI: 0.69 a 0.84; p <0.001) para todas las variables después de tres semanas, lo que indica estabilidad en el tiempo.
Conclusión: Tres semanas fuera de temporada no afecta el rendimiento en 200 m nado crol ni las variables cinemáticas en nadadores de 12 años y menores.
Palabras clave: Natación; Desentrenamiento; Rendimiento; Cinemática; Antropometría.

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Cessação do treino em nadadores com idade inferior a 12 anos

RESUMO

Objetivo: Verificar se três semanas de interrupção do treinamento afetam o desempenho e a cinemática em 200 m nado crawl de nadadores de até 12 anos de idade, controlando as alterações antropométricas.
Método: Dezesseis nadadores de grupos de idade: 11 meninas (idade 10.0 ± 1.3 anos) e 5 meninos (idade 10.5 ± 1.0 anos) realizaram um teste de 200 m em nado crawl (contrarrelógio) pré e pós três semanas (fora de temporada), quando o desempenho, variáveis cinemáticas e antropométricas foram obtidas.
Resultados: Estatura e envergadura aumentaram (estatura ~ 1.0 cm - IC: 0.70 a 1.3 cm; $p<0.001$; d = 1.22; envergadura ~1.0 cm - CI: 0.20 a 1.4 cm; p = 0.007; d = 0.68). Mudanças triviais foram observadas para desempenho (diferença média: 3,3 s IC: -6,7 a 13,9; p = 0,69; d = 0,08) e variáveis cinemáticas (p de 0.69 a 0.84; d = 0.04 a 0.17). Correlações intraclasse foram elevadas (ICC: 0.69 a 0.84; p <0.001) e observadas para todas as variáveis após três semanas, indicando estabilidade ao longo do tempo.
Conclusão: Três semanas fora da temporada não prejudicam o desempenho de natação em 200 m nado crawl e as variáveis cinemáticas em nadadores de 12 anos e mais novos.
Palavras-chave: Natação; Destreinamento; Performance; Cinemática; Antropometria

Introduction

Regular swimming training leads to quite a lot of physiological and biomechanical adaptations, normally enhancing swimming performance.[1,2] The reverse path of this process is termed detraining,[3] i.e. the cessation or reduction of swimming training can induce in partial or complete reversal of these adaptations, thus impairing swimming performance.[4,5,6] Age-group swimmers training cessation may occur due to injuries, poor health conditions or while enjoying the off-season (e.g. summer break).[6] Studies with adult swimmers indicate an association between training or detraining and impaired physiological and biomechanical responses.[7]

Despite that, the effects of detraining in 12 years old and under age-group swimmers is few explored.[3,5,6] Impaired swimming performance in 11-12 years old swimmers was reported for 100 m front crawl after 11-weeks of training cessation[4,8] and for 400 m front crawl after 4-weeks in older swimmers (14-15 years old).[3] Swimming performance improvements related to growth after a 10-weeks cessation in age-group swimmers (11-13 years old) was also reported,[5] where swimmers were able to swim faster in the 25 m front crawl. In fact, the bigger the swimmer's height, the smaller the hull drag and higher the theoretical hull speed.[9] Also, higher swimming stroke length (SL) have been associated with higher swimming performance.[9,1]

However, detraining effects may be different between distinct swimming events,[3,10] mainly due to their distinct energetic profile.[11]. For instance, the aerobic contribution during a maximal 200-m front crawl effort is ~ 66%[12] when performed by adult elite swimmers. Since prepubertal individuals have less anaerobic capacity compared to adults,[13] the aerobic contribution may be greater in the same event. Besides, the duration of 200 m tests in 11 years old and under age-group swimmers (around 200 s)[14] can be close to the duration of the 400 m test (around 240 s) performed by adults. Furthermore, the 400 m swim test has been pointed out as a valid test for aerobic capacity and power assessment in swimming.[15]

Since it is reasonable to suggest that detraining might be more evident in longer distance events due to higher aerobic impairments,[5,6] the 200 m front crawl event could be assumed as a long- rather than a short-distance event for ~10 years old swimmers.[5] In this study we investigated possible effects on swimming performance and kinematics in 12 years old and under age-group swimmers during a 200 m front crawl test (T200) after three-weeks of training cessation while controlling for anthropometric changes.

Methods

Experimental Approach to the Problem

A longitudinal single cohort study was conducted. Swimmers were tested before (PRE) and after (POST) a three-weeks off-season period. Measures of performance-related kinematic variables, controlling for anthropometrics, were obtained. The experimental testing took place in a 25-m indoor pool (mean water temperature ~26ºC; air temperature ~28ºC). The first experimental testing (PRE) was conducted at the end of the season. Swimmers were then instructed to refrain from training during the whole off-season. The second experimental testing (POST) was conducted three-weeks later, at the beginning of the new season. After 400-m moderate intensity front crawl warm-up, swimmers performed a 200-m maximal effort front crawl swim test (T200) for performance and kinematic assessments (Figure 1). All participants avoided vigorous exercise in the previous 24 h, were well-hydrated for, at least, 3 h before testing and encouraged verbally during the T200. The T200 was chosen since it is a challenging event for young swimmers both in the technical and energetic domains, and because most of the competitive swimming events of this age group have distances up to 200 m.[16]

Subjects

The study included 16 age-group swimmers, 11 girls and 5 boys (10.2 ± 1.2 [9.5 – 10.9] years old), all inserted in competitive swimming training for at least 12 months, pooled in the same group.[17] Swimmers' parents were informed about the benefits and risks of taking part in the current study before signing an informed consent form, which was approved by the Local Ethics Committee and performed according to the Helsinki Declaration (approval number 20416119.5.0000.5347).

Procedures

Anthropometric profile composed by height and arm span was obtained at PRE and POST by the same researcher. A 250cm tape (VONDER®, Brazil) was used. For height, the subjects were

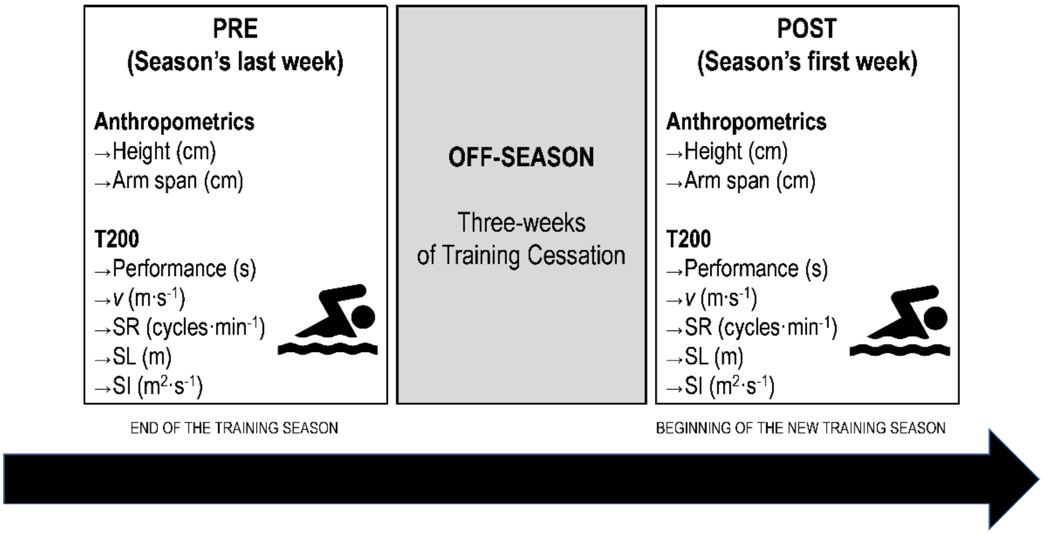

Figure 1. Study design.

Table 1. Effects of three-weeks off-season on age-group swimmers' height, arm span, performance, and kinematics. There are displayed the PRE and POST mean ± SD values, 95% confidence intervals, with respective mean differences and 95% confidence intervals, and comparison p-value and effect size, intraclass correlation coefficients with respective p-value.

	PRE	POST	Diff. PRE-POST	p-value	Cohen's *d*	ICC p-value
Height (cm)	141 ± 8.6 139.9 to 146.0	142.5 ± 8.7 137.8 to 147.1	-1.03 -1.3 to - 0.7	< 0.001	1.22 large	0.99 < 0.001
Arm span (cm)	142.5 ±9.3 137.5 to 147.5	143.4 ± 9.2 138.5 to 148.3	-0.87 -1.4 to -0.2	0.007	0.68 moderate	0.99 < 0.001
Performance (s)	240.8 ± 35.9 221.1 to 259.9	237.5 ± 39.11 216.6 to 258.3	3.3 -6.7 to 13.9	0.69	0.17 trivial	0.93 < 0.001
v ($m \cdot s^{-1}$)	0.77 ± 0.11 0.71 to 0.83	0.78 ± 0.11 0.72 to 0.84	-0.004 -0.05 to 0.04	0.71	0.11 trivial	0.82 < 0.001
SR ($cycles \cdot min^{-1}$)	37.3 ± 5.8 34.2 to 40.2	36.9 ± 6.6 33.0 to 40.2	0.49 -0.4 to 0.06	0.79	0.06 trivial	0.69 < 0.001
SL (m)	1.27 ± 0.25 1.13 to 1.41	1.29 ± 0.18 1.19 to 1.39	-0.01 -0.12 to 0.09	0.76	0.09 trivial	0.72 < 0.001
SI ($m^2 \cdot s^{-1}$)	1.00 ± 0.32 0.83 to 1.17	1.01 ± 0.24 0.88 to 1.14	-0.008 -0.12 to 0.10	1.00*	0.04 trivial	0.84 < 0.001

PRE: the first assessment; POST: the second assessment, ICC: intraclass correlation coefficient; v: swimming velocity; SR: stroke rate; SL: stroke length; SI: stroke index.
* Wilcoxon test

positioned with their backs to the wall with the tape demarcation. For arm span, the subjects remained lying in the supine position with shoulder abduction at 90º. The arm span is considered the distance between the distal extreme points of the middle fingers of both hands.

Soon after, T200 performance (in seconds) and kinematical data were collected manually[1] with stopwatches (CASIO HS-70w, Japan) by the same experienced and previously trained researcher to avoid subjectivity in the measures. To exclude the influence of the turning phase, the 10-m of each 25-m, within two points at 7.5 m from each end of the swimming pool, was used for kinematical assessments,[1] particularly the duration of the passage and the time of three complete stroke cycles (counting the entry of the right hand into the water three times in a row),[1] Thus, kinematics variables were calculated by the following equations:

(1) Swimming speed ($m \cdot s^{-1}$): $v = 10\ m \cdot time^{-1}$
(2) Stroke rate ($cycles \cdot min^{-1}$): $SR = (3\ cycles \cdot time^{-1}) \cdot 60$
(3) Stroke length (m): $SL = v \cdot SR^{-1}$
(4) Stroke index ($m^2 \cdot s^{-1}$): $SI = v \cdot SL$

Mean values from all variables were calculated using all partial values, representing the T200.

Statistical Analyses

Normality was verified and confirmed with the Shapiro–Wilk test, except for the SI. Mean, standard deviation and 95% confidence intervals were calculated for all variables. Student's t test for dependent data (parametric data) and Wilcoxon test (non-parametric data) were used to compare differences between PRE and POST off-season for each variable. Effect sizes (Cohen's *d*) were interpreted as previously proposed:[18]

$$d=\frac{|\acute{m}_1-\acute{m}_2|}{\sqrt{s_1^2+s_s^2-(2rs_1rs_2)}}$$

Where *m*, s, and r are, respectively, the means, standard deviations, and the correlation between the two conditions. Cohen's *d* was interpreted with the following criteria: 0–0.19 trivial, 0.2–0.59 small, 0.6–1.19 moderate, 1.2–1.99 large, 2.0–3.99 very large and >4.0 nearly perfect.[19] Intraclass correlation coefficient (ICC) between PRE and POST was calculated for all variables. Alpha significance level was established at 0.05.

Results

The pre- and post-three-weeks off-season anthropometrics, performance and kinematics results are in Table 1. All the variables, pre- and post-three-weeks off-season had parametric distribution, except the SI. Large and moderate changes were identified, respectively, in height and arm span, although just trivial changes in performance, *v*, SR, SL and SI. High and significant ICC were observed for all variables.

Discussion

This study aimed to investigate effects on swimming performance and kinematics in 12 years old and under age-group swimmers during the 200-m front crawl test after three-weeks of training cessation, while controlling for anthropometric changes. Trivial changes and high intraclass correlations were observed for all variables after three-weeks, suggesting stability over time, i.e., changes occurred in parallel. Specificity and reversibility training principles are widely reported for peripheral skeletal muscles.[20] While specificity denotes that the nature of changes in muscle structure and function relies on the nature of the applied stimulus, reversibility indicates that when physical training is stopped (training cessation), our body readapt in accordance with the reduced physiological demand.[20] Beneficial adaptations may be lost,[3] but in a three-week break it was not enough.

Relevant changes in anthropometry (including increases in height and arm span) can be observed in longer than three weeks break periods.[4,5,8] Some authors observed that fastest swimmers are those with the largest anthropometric dimensions after 10-weeks off-season.[5] In addition, Morais et al.[4] reported that impaired swimming performance after 11-weeks off-season was mitigated by height increase in swimmers, suggesting that anthropometrics may play a major role to changes in technical skills and performance in age-group swimmers. However, the three-week summer break, in the present study, was enough to observe a linear growth that could improve swimming performance. In fact, PRE and POST values for height and arm span values were significant, and effects sizes were, respectively, large, and moderate. In this regard, it is possible that their growth did not allow negative effects in performance that were expected due to reversibility principle.

Higher *v* in 12-15 years old swimmers along time have relation to increases in arm span, which affects SL.[21] When looking for a 4-weeks break (similar to 3-weeks conducted in our study), increases in anthropometrics, related to maturation status - Tanner stage IV to V -, were not sufficient to identify an effect of growth on performance in the 400 m front crawl test (a study carried out with 14-15 y males and females age-group swimmers).[3] In our study, swimmers (10.2 ± 1.2 years old) differ in this aspect, indicating that a late growth spurt would not have arrived yet.[22]

Trivial changes were observed for *v*, SR, SL, and SI in our study (Table 1), suggesting that three-weeks of training cessation was not enough to impair swimming technique. Moreira et al.[5] reported that SR in the 25 m front crawl remained similar after 10 weeks in ~12 years old swimmers, with increase in SL and SI, being explained by physical development. Same behavior was observed by Morais et al.[4] when the 100-m front crawl was studied after 11 weeks with ~12 years old swimmers. It is acceptable to suggest that kinematics may be stable or even increased during long off-season for this age group, being explained by growth.[5] Despite that, it is necessary to highlight that performance may be impaired.[4,8]

Reduction of the "water sensitivity" could also be associated with similar SR values, making the arm stroke less propulsive due to a long pause between seasons.[5] Perhaps, three-weeks training cessation was not enough to demonstrate these effects, but unfortunately, we did not test it. Also, there is an important issue in this discussion which is how active these young athletes were during summer break, including aquatic activities and how this could interfere their physiological and technique adaptations, including the "water sensitivity". However, there is a considerable range between three- and ten-weeks training cessation, making further studies necessary to identify a threshold for technique stabilization. In the light of our results, regardless of the level of performance, technique remained constant and stable, i.e. swimmers with the best performance before the break, continued as the best after the break.

Impaired performance was also observed in other studies,[3,4,8,23] but they diverge from our study by longer breaks,[4,8,23] older swimmers, and longer events tested (e.g. 400 m).[3] In fact, the negative effects of detraining on performance may be more evident over longer distances since there are important losses of aerobic over anaerobic power and capacity.[5] Reduction in cardiorespiratory fitness is the primarily responsible for performance impairment in well-trained athletes.[6] It explains some contradictory responses[5] when testing swimmers in 25 m front crawl efforts. Similar results[10] were observed after six weeks of strength training cessation, which were not enough to impair swimming performance at 25 and 50-m front crawl in ~12 years age-group swimmers. Likewise, strength remained stable after weeks of inactivity,[6] but even so the ability to apply force in the water can be reduced.[24] We investigated the effects of detraining in 200-m front crawl, in which the aerobic contribution reaches ~66% from aerobic, ~14% from anaerobic lactic and ~20% from anaerobic alactic energy sources in adults.[12] There are no data indicating the aerobic contribution for this age group, however, must be more than 66% given that they take more time to complete the distance than adults[25] (130.7 ± 6.5 s *vs.* ~ 140 s in our study).

A study close to the outline followed in this study is of the one from Zacca et al.,[3] despite older swimmers (~ 14 years *vs.* ~10 years). Zacca et al.[3] identified a substantial decrease (-3.8%) in the 400-m front crawl performance after four-weeks of training cessation. However, the differences from this study[3] to the present study (in which there is neither a worsening nor an improvement in performance) can be explained by: (i) one more week of summer break, (ii) the 400-m event instead the 200-m, (iii) the difference in age group, (iv) maturation status and/or (v) non-swimming specific physical activities during off-season (not controlled). Explained by the reversibility principle, the adaptations provided by training stimulus are reversed in losses when the training is stopped.[20] The decrease in maximum oxygen uptake after short detraining periods is greater in experienced athletes when compared to beginners.[6]

Those who work with child athletes usually do not have specific theoretical bases to inform themselves, only general of the individual's motor and maturational development. Nevertheless, the changes and behaviors related to swimming technique are poorly investigated,[3,5,6] requiring coaches to study from bases with post-puberal athletes or even adults. It is important to align the necessary motivation[26] for a child to get involved in a sport in a formal and competitive way with the requirements in sport initiation to mold and not waste promising future in the scenario of elite swimming. Three weeks of summer break after an entire season of regular training possible may not be enough for the child to return with renewed motivation for another year of intense work. However, coaches are concerned with losing physiological and technical gains from training during detraining. Being aware of detraining consequences for this population is necessary to avoid evasion in the sport. The possibility of adaptations due training in young are larger, and they are more sensitive to stimuli than adults, so there is no need to treat them as "miniature adults".[22]

We point out some limitations in our study: (i) the non-measurement of sexual maturation, whereas performance can be influenced by the actual stage; (ii) the non-investigation of the energetics, that provides a wealth of information about the physiological status of swimmers, but can be invasive methods for children; (iii) the relative small sample size (other possible participants, due to the parents' vacation, returned after the stipulated period); and (iv) the non-monitoring of the physical activities during the break, due to the inconsistence of their responses trying to remember the activities. Future research could investigate, either the break effects on the "water sensitivity".

Coaches usually shorten the vacation period as much as possible to avoid substantial losses in the ability of their swimmers. In this study, the three-weeks pause showed no substantial losses in performance and kinematics. Data with age-group swimmers are still scarce, and the majority studies are conducted with longer breaks (>10-weeks). Besides that, our study was the one with the longer distance test for this age-group and the stimulus-characteristics may affect the results of detraining. We presented data that until now were missing in swimming science. Understanding the interaction between growth and technique is important at younger ages, but further studies with this age group are needed to identify possible changes in other abilities beyond the maximum test of 200-m and other periods of detraining, longer than three-weeks and shorter than 10-weeks, with energetic assessments.

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