**EFFECTS OF TRAINING CESSATION ON ANTHROPOMETRICS, BODY COMPOSITION AND SOMATOTYPE IN ADOLESCENT SWIMMERS**

**INTRODUCTION**

Anthropometric measurements are important aspects in the early identification of talented swimmers (Rejman et al., 2018). Both anthropometrics and body composition changes may affect swimming performance, including the longitudinal variations during maturational growth (Oliveira et al., 2021; Zacca et al., 2019). Hence, the anthropometric assessment plays an important role in the swimming area (Alves et al., 2022).

Based on the sport or physical activity practiced, the somatotypes defined differs for each athlete (Raković et al., 2015). In young swimmers, the mesomorph has been identified as the most common somatotype (46.1%), followed by the ecto-mesomorph (30.8%) and the meso-ectomorph (23.1%) (Stanković et al. 2018). Understanding that training programs of young swimmers are usually planned to achieve two or three performance peaks over a 10-11 months season (Morais et al., 2018), which are characterized by a temporary break known as detraining (Mujika & Padilla, 2000), the anthropometric changes may occur also as a process of training.

The detraining period after a season, may lead to the partial or total loss of training, inducing anatomical, physiological and performance adaptations (Mujika & Padilla, 2000; Ruiz-Navarro et al., 2022). These detraining periods are influenced by the duration of training break, obtaining different adaptations in shorter or longer breaks than four weeks (Mujika & Padilla, 2000). For high-level swimmers, four weeks of season break are the typical detraining period (Mujika & Padilla, 2000), while age-group swimmers generally recover 4-6 weeks, depending of each national swimming calendar (Zacca et al., 2019). During the seasons’ break, anthropometric changes are also influenced by the level of physical activity performed (Zacca et al., 2019), which should be considered to understand its possible effects. Therefore, the aim of the current study was to analyse the effects of five weeks of training cessation on anthropometric measurements and its influence on swimming performance.

**METHODS**

 Twelve males and eight females (17.0 ± 2 and 17.3 ± 2.4 years old) volunteered to participate in the current study. The swimmers performed six training sessions weekly under the guidance of the same coach. The protocol was approved by the University of Granada Ethics Committee and each participant signed an informed-consent form. This data is part of a cross-sectional study performed before (PRE) and after (POST) five-weeks off-season period (Ruiz-Navarro et al., 2022). The PRE test was performed at the end of the week prior the last peak-performance of the competitive season. The POST test was performed before the beginning of the first week of training of the following competitive season.

Anthropometric variables were performed following standardized measurement techniques adopted by the International Society for the Advancement of Kinanthropometry (ISAK) (Ross et al., 1991). Body height, body mass and arm span; thickness of eight skinfolds (biceps, triceps, subscapular, suprailiac, supraspinal, abdominal, thigh and calf); and four girths (relaxed upper arm, flexed and tensed upper arm, thigh and maximum calf) were measured in the same conditions. Body height, body mass, and the sitting height of participants were measured using a stadiometer/scale (Seca 799, Hamburg, Germany). Skinfold thickness was measured using a caliper calibrated (Holtain Ltd, Crymych, UK) and girths measurements were performed using a flexible anthropometric steel tape (Holtain Ltd, Crymych, UK). Body mass index (BMI) was calculated as body mass (kg)/height(cm)2. Body density was estimated using the equations of Durnin & Womersley (1974) and it was transformed to body fat (%) applying Siri’s formula (Siri, 1961). Muscle mass (kg) was calculated using the methods of Lee at al. (2000) and converted in percentage by subtracting body mass. Somatotype was determined using the Heath-Carter anthropometric method (Carter & Heath, 1990). Following anthropometric measurements, the swimmers performed a 1200 m standardized warm-up (Ruiz-Navarro et al., 2022). Both in the PRE and POST tests, after 10 min of rest, the swimmers performed 50 m all out front-crawl with dive start. Swimming performance was determined according to the time obtained in the 50 m. All test were recorded with a Sony FDR-AX53 (Sony electronics Inc., Tokyo, Japan) and the videos were analyzed by one expert evaluator to obtain the swimmers’ time accurately. Non-swimming specific training during the training cessation was evaluated by a weekly self-reported questionnaire: International Physical Activity Questionnaire (IPAQ) and summarized based on the physical activities recorded (low, moderate and vigorous intensities) (Craig et al., 2003). The results of the swimmers’ questionnaires were transformed into units of metabolic equivalent of task (METs) following the IPAQ conditions (Craig et al., 2003). Swimmers were instructed to record their daily activities for their own control.

**Statistical Analysis**

Descriptive statistics (mean and standard deviation [SD]) for all variables studied were obtained. The normality of the distribution was checked with Shapiro-Wilk. The paired samples t-test was conducted to verify differences between PRE and POST in the anthropometric measurements and swimming performance. Effect sizes (d) were calculated and interpreted as follow: small if 0 ≤ |d| ≤ 0.5, medium if 0.5 < |d| ≤ 0.8 and large if |d| > 0.8. Pearson correlation coefficients were calculated to assess the association between anthropometric and swimming performance changes. Partial correlations, controlling for total physical activity values, were used to quantify the degree of association between anthropometric changes and the variation in swimming performance. Statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS 25.0, IBM Corporation Chicago, IL, USA) being the level of statistical significance set at p < 0.05.

**RESULTS**

The mean difference in anthropometric measurements between PRE and POST and effect sizes are reported in Table 1.

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| **Table 1.** Mean and standard deviation (SD) for anthropometric measurements, body composition and swimming performance for male and female swimmers before (PRE) and after (POST) the five weeks of training cessation and comparison between both periods. |
|  Male swimmers (n = 12) Female swimmers (n = 8) |
| Variables | PRE | POST | *p*-value (d) | PRE | POST | *p*-value (d) |
| Body height (cm) | 175.7 ± 8.2 | 175.9 ± 8.0 | 0.060 (0.02) | 165.6 ± 3.3 | 166.0 ± 3.5 | 0.012 (0.12) |
| Body mass (kg) | 65.8 ± 9.4 | 67.1 ± 9.3 | 0.008 (0.14) | 58.1 ± 6.2 | 59.2 ± 5.5 | 0.065 (0.19) |
| Arm span (cm) | 180.8 ± 10.3 | 181.1 ± 10.3 | 0.061 (0.03) | 169.9 ± 4.7 | 170.0 ± 4.2 | 0.698 (0.02) |
| Body mass index (kg/m2) | 21.3 ± 2.4 | 21.7 ± 2.6 | 0.012 (0.16) | 21.2 ± 2.4 | 21.5 ± 2.2 | 0.204 (0.13) |
| Body fat (%) | 15.4 ± 4.1 | 17.9 ± 3.7 | <0.001 (0.64) | 20.1 ± 6.3 | 22.8 ± 4.9 | 0.018 (0.48) |
| Muscle mass (%) | 45.7 ± 4.8 | 39.2 ± 3.8 |  0.003 (1.50) | 41.4 ± 6.3 | 32.6 ± 1.5 |  0.002 (1.92) |
| **Skinfolds thickness** |  |  |  |  |  |  |
| Triceps (mm) | 8.6 ± 3.6 | 9.6 ± 3.9 |  0.040 (0.27) | 15.0 ± 6.8 | 17.9 ± 6.1 |  0.001 (0.45) |
| Biceps (mm) | 4.4 ± 2.0 | 4.4 ± 1.4 | 0.936 (0) | 7.8 ± 4.0 | 8.0 ± 3.9 | 0.731 (0.05) |
| Subscapular (mm) | 8.2 ± 1.6 | 9.2 ± 1.6 | 0.002 (0.63) | 10.2 ± 4.3 | 11.4 ± 4.2 | 0.096 (0.28) |
| Suprailiac (mm) | 12.9 ± 4.8 | 17.2 ± 5.7 | <0.001 (0.82) | 16.1 ± 7.0 | 19.2 ± 6.3 | 0.036 (0.47) |
| Supraespinale (mm) | 7.9 ± 2.5 | 9.5 ± 2.9 | 0.002 (0.59) | 11.4 ± 6.9 | 13.2 ± 5.6 | 0.107 (0.29) |
| Abdominal (mm) | 10.8 ± 4.3 | 13.0 ± 5.1 |  0.003 (0.47) | 15.2 ± 6.1 | 17.9 ± 5.6 |  0.009 (0.46) |
| Thigh (mm) | 12.9 ± 5.4 | 13.7 ± 4.6 | 0.288 (0.16) | 23.0 ± 9.6 | 24.3 ± 9.4 | 0.462 (0.14) |
| Calf (mm) | 10.0 ± 2.6 | 9.8 ± 3.3 | 0.640 (0.07) | 14.4 ± 6.8 | 15.6 ± 7.3 | 0.017 (0.17) |
| Sum of 3 (mm) | 24.7 ± 6.7 | 28.4 ± 6.8 |  0.001 (0.55) | 36.6 ± 17.0 | 42.5 ± 15.5 |  0.015 (0.36) |
| Sum of 6 (mm) | 61.3 ± 19.8 | 72.4 ± 20.2 |  0.001 (0.55) | 90.9 ± 38.7 | 103.9 ± 34.4 |  0.034 (0.35) |
| Sum of 8 (mm) | 75.7 ± 23.4 | 86.6 ± 24.0 |  0.002 (0.46) | 113.1 ± 49.0 | 127.5 ± 44.0 |  0.027 (0.31) |
| Sum of upper limb (mm) | 52.8 ± 16.7 | 63.0 ± 17.6 | <0.001 (0.59) | 75.7 ± 33.6 | 87.6 ± 29.9 | 0.018 (0.37) |
| Sum of lower limb (mm) | 23.0 ± 7.9 | 23.5 ± 7.6 | 0.627 (0.06) | 37.4 ± 15.9 | 39.9 ± 14.7 | 0.121 (0.16) |
| **Girths** |  |  |  |  |  |  |
| Relaxed upper arm (cm) | 29.1 ± 3.1 | 29.4 ± 3.2 | 0.310 (0.09) | 27.9 ± 2.4 | 27.9 ± 2.1 | 0.836 (0) |
| Flexed and tensed arm (cm) | 31.8 ± 2.9 | 31.4 ± 3.2 | 0.187 (0.13) | 29.3 ± 2.0 | 28.7 ± 2.0 | 0.028 (0.30) |
| Thigh (cm) | 51.1 ± 4.2 | 51.9 ± 4.5 | 0.108 (0.18) | 50.8 ± 3.9 | 51.4 ± 3.9 | 0.229 (0.15) |
| Calf (maximum) (cm) | 33.3 ± 2.8 | 34.4 ± 2.6 | <0.001 (0.41) | 32.7 ± 1.8 | 33.7 ± 1.9 | 0.032 (0.54) |
| **Somatotype** |  |  |  |  |  |  |
| Endomorphy | 2.9 ± 0.9 | 3.5 ± 1.0 | <0.001 (0.63) | 4.2 ± 1.7 | 5.1 ± 1.6 | 0.019 (0.55) |
| Mesomorphy | 3.9 ± 1.5 | 4.2 ± 1.2 | 0.110 (0.22) | 3.7 ± 0.7 | 3.3 ± 0.7 | 0.222 (0.57) |
| Ectomorphy | 3.4 ± 1.3 | 3.2 ± 1.3 | <0.001 (0.15) | 2.8 ± 1.2 | 2.7 ± 1.1 | 0.143 (0.08) |
| **Swimming performance**  |  |  |  |  |  |  |
| 50 m front crawl time (s) | 27.9 ± 1.7 | 28.4 ± 2.1 | 0.014 (0.26) | 31.0 ± 2.5 | 31.9 ± 2.2 | 0.033 (0.38) |
| Sum of 3 = triceps, subscapular and supraespinale; Sum of 6 = sum of 3, suprailiac, abdominal and thigh; Sum of 8 = sum of 6, biceps and calf.  |

The somatotypes of each swimmer, before and after the five weeks off-season period, are shown in Figure 1. Males’ mean somatotype was ecto-mesomorph (2.9-3.9-3.4 of endomorphy, mosomorphy and ectomorphy, respectively) in the PRE while it changed to endo-mesomorph (3.5-3.9-3.4) in the POST. Females’ mean somatotype was meso-endomorph in the PRE (4.2-3.7-2.8) and endomorph in the POST (5.1-3.3-2.7).

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Figure 1. Somatotype distribution observed in male (left panel) and female (right panel) swimmers. Each participant is represented by the same number before (PRE = ○) and after (POST = ▲) the five week of training cessation on its corresponding panel. The mean somatotypes for each sex in the PRE (●) and in the POST (▲) are represented.

In male swimmers, the body height changes showed positive correlation with 50 m front-crawl performance changes (r = 0.66; p = 0.010). In female swimmers, the 50 m front-crawl performance changes were negatively correlated with the changes in girth of tensed arm (r = -0.64; p = 0.043) and muscle mass (r = -0.66; p = 0.037). The total physical activity during the off-season (Table 2) was not associated with the variation in 50 m front-crawl performance. Moreover, when conducting partial correlations, controlling for total physical activity values, the male and female swimmers exhibited the same associations as the Pearson’s.

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| **Table 2.** Physical activity levels for male (n = 12) and female swimmers (n = 8) during the five weeks of training cessation. |
| **Physical activity** |  | **Male swimmers** |  | **Female swimmers** |
| Low intensity (MET-min·wk−1) |  | 943.4 ± 711.2 |  | 817.2 ± 165.8 |
| Moderate intensity (MET-min·wk−1) |  | 1111.2 ± 1592.3 |  | 322.5 ± 233.9 |
| Vigorous intensity (MET-min·wk−1) |  | 1352.0 ± 1435.1 |  | 213.0 ± 281.8 |
| Total (MET-min·wk−1) |  | 3404.5 ± 1473.7 |  | 1306.7 ± 558.3 |
| MET = metabolic equivalent of task |

**DISCUSSION**

The aim of the current study was to analyse the effects of five weeks of training cessation on anthropometric measurements and its influence on the possible changes in swimming performance. After the five weeks, the anthropometric measurements and body composition deteriorated in both sexes. However, most of anthropometric changes were not associated to swimming performance impairments, either when conducting Pearson’s or partial correlation controlling for the non-swimming specific training conducted during the off-season. The increase in body height was the only variable that presented a positive correlation with changes in swimming performance in males. Regarding females, the changes in girth of tensed arm and muscle mass were the anthropometric measures directly related with performance maintenance. The non-specific swimming activity conducted during the off-season was not related with swimming performance.

A large number of studies have focused on analyzing some anthropometric and body composition changes (Zacca et al., 2019; Roelofs et al., 2017), although few research compared the skinfolds variation after a period of detraining and its influence on swimming performance. Among the off-season effects, increases of 62.5% and 50% of skinfolds measurements were observed in males and females, respectively (Table 1). Moreover, body fat increases and muscle mass reductions were found in both sexes, agreeing with other studies in swimmers (Roelofs et al., 2017). Although the muscle mass has been related with swimming performance (Cochrane et al., 2015), body fat percentages would not be as relevant as in other sports, as it could contribute to increase buoyancy in the water environment (Lowensteyn et al., 1994). Regarding the swimmers’ somatotype, the endomorph component increased in both sexes and the ectomorphy decreased in males only (Table 1 and Figure 1). It may be due to different reasons, such as the assessment moment of anthropometric measurements, different levels of performance, or the specialty (i.e., swimming strokes or distance) of each swimmer (Stanković et al. 2018). In line with previous studies (Zacca et al., 2019; Roelofs et al., 2017), body fat increments and muscle mass declines after the training cessation explain the change from ecto-mesomorphic to endo-mesomorphic in males and from meso-endomorph to endomorphic somatotype in females.

The anthropometric measures have been related to changes in swimming performance, being the arm span and the body height the most influential variables in young and adolescent front-crawl swimmers (Alves et al., 2022). The changes obtained after the detraining period showed only a positive correlation between body height and 50 m swimming performance in males. It could be explained by the effect of body mass on wave drag since larger bodies present lower wave drag, hence, taller swimmers present a lower wave-making resistance than shorter swimmers (Trujiens & Toussaint, 2005).Regarding female swimmers, 50 m swimming performance changes were related to the girth of tensed arm (i.e., biceps contracted) and muscle mass impairments. Indeed, the girth of tensed arm has been recently associated to muscle mass, since higher values of the arm girth may be indicative of the upper limbs strength and, probably, greater arm propulsion (Alves et al., 2022). Hence, swimmers that maintained their strength level during the off-season period would be able to reduce the negative effects of detraining on swimming performance.

The non-swimming physical activity intensities showed no correlation with swimming performance in both sexes in the current study. In addition, swimming performance impaired after five weeks of detraining in both males (1.7%) and females (2.8%) in the 50 m front-crawl. Slight differences were observed after 11 weeks of break in 100 m front-crawl in young male swimmers (2.1%), while lower impairments were observed in females (1.9%) (Morais et al., 2020). In this case, despite a longer period of detraining (i.e., 11 vs. 5 weeks), the different performance decrements (1.9% vs. 2.8%) could be explained by the age differences in female swimmers (11.9 vs. 17.3 years). Physical activity declines over the years during childhood and adolescence (Farooq et al., 2020); hence, the greater non-specific activity performed by female children during the off-season compared to older swimmers (i.e., between 16 and 20 years) may explain the smaller reductions in swimming performance.

The current study showed interesting information about the anthropometric measurements and the changes produced after a period of detraining in swimmers. The limitation of the study was not controlling for the type of physical activity performed by the swimmers during the off-season. Future research should consider the anthropometric changes after different periods of detraining and testing how performance is affected in other swimming distances.

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