South African Journal for Research in Sport, Physical Education and Recreation, 2013, 35(2): 163-172.
Suid-Afrikaanse Tydskrif vir Navorsing in Sport, Liggaamlike Opvoedkunde en Ontspanning, 2013, 35(2): 163-172.
ISBN: 0379-9069

TRAINING VOLUME AND PERFORMANCE OF YOUNG SPANISH NATIONAL AND INTERNATIONAL LEVEL SWIMMERS

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ABSTRACT

The objective of the present study was to determine the volume of training of young national and international level swimmers, how it evolves and its relationship with performance. The sample comprised of 202 swimmers (11 to 18 years old), selected by the Royal Spanish Swimming Federation. The volumes of pool and dry-land training were evaluated together with the swimmer's performance during the season (LEN score). In general, there was a progression in pool training volume from the youngest swimmers (males 13 to 14 years; females 11 to 12 years), to the next age category (males 15 to 16 years; females 13 to 14 years). Training volume was related to performance only for the youngest swimmers, the possible reason being that, after this age, intensity is the most relevant aspect of the training load.

Key words: Planning; Training load; Swimming.

INTRODUCTION

Training for a sport is a long and difficult process involving many variables, which can influence the sportsperson's performance. Training seeks, by controlling these variables, to optimise performance based on the ability to tolerate high workloads (Faude *et al*., 2008). In swimmers, as in the case of other sportspersons, this process has to be ordered and structured (Villanueva, 2007), to allow swimmers to acquire the skills necessary to achieve their goals in adulthood.

Various factors influence swimming performance (Aspenes & Karlsen, 2012), such as physiological, morphological, biomechanical, technical and psychological factors, among others. Although traditionally swimming training has mainly focused on improving the swimmer's physiological capabilities (Stager & Tanner, 2005), there have been studies examining the relationship of performance with other factors, such as kinanthropometric (Zuniga *et al*., 2011), motor (Coatsworth & Conroy, 2009), psychological (Psycharakis *et al*., 2008) and technical (Jurimae *et al*., 2007).

The improvement produced by training may on occasions be limited by genetics. For example, 45% of the variance in maximal oxygen uptake is genetically determined (Bouchard *et al*., 1997). Training must therefore focus on the remaining percentage, which can indeed be influenced (Richards, 2005). For this purpose, training load is critical for success (Mujika, 1998), and has to be structured according to its nature, orientation, organisation and magnitude (Verjoshanskij, 1990). The nature of the workload can be defined as the work that is actually done and is determined by its specificity and training potential. The orientation is defined by the skill or capacity that is being worked on, and by the source of power that is used. The organisation entails the systematisation and structuring of the load. Finally, the magnitude can be defined as the relationship between the intensity and volume of training, with both high-intensity (but short duration) and low-intensity (but high volume) training being important components of training programs for sportspersons who compete successfully in intense exercise events (Laursen, 2010). Various researchers (Mujika *et al*., 1996; Chatard & Mujika, 1999; Maglischo, 2003; Faude *et al*., 2008; Soultanakis *et al*., 2012), have studied the relationship between volume and intensity in swimming.

An adequate combination of these characteristics is a prerequisite for efficient training. This combination is dependent on the duration and, therefore, on the metabolic requirements of discipline-specific competition (Faude *et al*., 2008). Coaches choose high-volume training at the beginning of the season to build a solid aerobic base for higher intensity training later (Aspenes & Karlsen, 2012). However, the literature in this regard is inconclusive. Some studies point to the importance of intensity for the success of training (Mujika *et al*., 1995, 1996; Chatard & Mujika, 1999), while others suggest that high training volumes do not provide any immediate advantage over lower volumes (with higher intensity) for swimming performance (Faude *et al*., 2008; Aspenes & Karlsen, 2012; Soultanakis *et al*., 2012).

PURPOSE OF THE STUDY

Most studies concur that it is necessary to establish a logical progression in training volume (Faude *et al*., 2008; Issurin, 2010). Most work on this topic has been on adult swimmers (Faude *et al*., 2008; Soultanakis *et al*., 2012), with very few studies on young swimmers. It is of particular importance to analyse how training volume influences performance in young swimmers because their training load is crucial during this formative stage of their sporting careers (Toubekis *et al*., 2011). The objective of the present study was therefore to determine the volume of training, how it evolves and its relationship with performance in young swimmers (11 to 18 years old), who compete at national and international level. The Bio-ethics Committee of the University of Extremadura (Spain) approved this study.

METHODOLOGY

Subjects

The swimmers' parents or legal guardians signed an informed consent form prior to the subjects' participation. The subjects of the study were 215 swimmers between 11 to 18 years old, selected by the Royal Spanish Swimming Federation (RFEN), and belonging to Spain's national teams. They were classified according to their category: ‘Cadet’ – 66 males (13 to 14 years) and 67 females (11 to 12 years); ‘Youth’ – 31 males (15 to 16 years) and 29 females (13 to 14 years); and ‘Junior’ – 10 males (17 to 18 years) and 12 females (15 to 16 years). They had been chosen as participants in the *Detection and Follow-up of Sports Talent Program*, and in the *Future National Selection Program*, both of which are organised by Spain's Sports Council and the RFEN. The respective national team coach responsible for the different categories was responsible for the selection of the swimmers.

In the 'Cadet' category, the top 66 swimmers were selected according to the score attained by applying the following equation:

$$\text{Points} = \frac{\text{LEN} + 2\left[\text{Height} + \text{Span} + (10 \cdot \text{Brocca Index}) + (10 \cdot \text{Span Index}) + (2 \cdot \text{Hand - Foot})\right]}{10}$$

where LEN = performance in points in the LEN table; Height of swimmer (cm); Span of swimmer (cm); Brocca Index = [Height – (Weight kg + 100)]; Span Index = [(Span-Height)/Height]·100, Hand-Foot = sum of the length and width of the hand and foot (LEN, 1996).

In the 'Youth' and 'Junior' categories, the two best swimmers in each event and speciality were selected. A summary of chronological age and body size of the participating swimmers is presented in Table 1.

***TABLE 1*: MEANS AND STANDARD DEVIATIONS FOR AGE AND BODY SIZE CHARACTERISTICS OF SWIMMERS ACCORDING TO GENDER**

	Cadet		**Youth**		**Junior**	
Variables	Males Mean ± SD	Females Mean ± SD	Males Mean ± SD	Females Mean ± SD	Males Mean ± SD	Females Mean ± SD
Age (years)	13.60 ± 0.56	11.51± 0.55	15.65 ± 0.43	13.67± 0.45	17.43 ± 0.52	15.48± 0.50
Height (cm)	171.12 ± 7.50	154.75 ± 7.47	176.80 ± 5.55	165.74 ± 7.19	179.25 ± 4.23	170.20 ± 5.47
Weight (kg)	57.95 ± 8.18	43.96 ± 7.17	69.50 ± 3.69	53.77 ± 5.67	67.80 ± 4.06	61.74 ± 7.10
Sitting height (cm)	80.46 ± 4.14	77.24 ± 4.10	83.78 ± 5.24	90.05 ± 3.21	84.99 ± 2.31	75.41 ± 5.21
Arm span (cm)	177.48 ± 8.77	158.86 ± 8.72	184.01 ± 5.94	170.17 ± 6.64	185.12 ± 3.21	173.43 ± 7.75

Evaluation of training and performance

The subjects completed a questionnaire on the number of hours spent per week on pool and dry-land training and the distance covered in metres per training session. The questionnaire items were the following:

i) *How many hours per week do you normally train in the water?* Possible responses: (a) 5 or less hours; (b) between 5.25 and 7.5 hours; (c) between 7.75 and 10 hours; (d) between 10.25 and 14 hours; and (e) more than 14 hours.

ii) *How many metres in the water do you normally cover in each training session?* Possible responses: (a) 2 500m or less; (b) between 2 501m and 3 500m; (c) between 3 501m and 4 500m; (d) between 4 501m and 5 500m; (e) between 5 501m and 6 500m; and (f) more than 6500m.

iii) *How many hours per week do you normally do dry-land training?* Possible responses:

(a) 0 hours; (b) 2 hours or less; (c) between 2.25 and 4 hours; (d) between 4.25 and 6 hours; and (e) more than 6 hours.

The swimmers completed the questionnaire during training sessions of the National Team. In the ‘Cadet’ category, it was given at the end of the season, and the questions referred to that season. In the ‘Youth’ and ‘Junior’ categories, the questionnaire was given at the beginning of the season, and the questions referred to the previous season's training.

The variable ‘performance’ was calculated as the best score according to the LEN table of competitive performance level. LEN scores measure how close a certain personal best time is to the World Record in each competitive event, allowing times to be compared both within a given event and between different events. Individual performance levels were quantified as the best personal times during the season. This methodological approach is similar to that followed in other studies (Saavedra *et al*., 2010). The performance was evaluated from the most important competition for each category, which in all cases was at the end of the season (June-July).

Data analysis

The normality and homoscedasticity of the distributions were tested using the Kolmogorov-Smirnov and Levene tests, respectively. *Class marks* were used for the value when the response corresponded to a range. For example, “between 10.25 and 14 hours” has a class mark of (10.25+14)/2 = 12.125 hours. A one-way ANOVA with a Tukey *post-hoc* test was used to establish differences by age group. Effect sizes were also calculated (Cohen, 1988). Pearson's simple correlation coefficient was used to examine possible correlations between training volume and performance.

RESULTS

Table 2 lists the basic descriptive statistics of the training and performance variables for each gender and age group category, as well as the results of the one-way ANOVA and Tukey *post-hoc* analyses.

For both gender groups, there were differences between the youngest (Cadet) category and the other 2 categories for both of the in-pool training volumes (hours/week and metres/session), and differences between all 3 categories in performance. For the females, there were also differences between the Youth and Junior categories in hours/week in-pool volume and between the youngest (Cadet) category and the other 2 categories in dry-land training volume.

Table 3 presents the results of the correlation analysis between the season's performance and the training volume variables (same season). For the Cadet category, for both gender groups, performance was positively correlated with the 2 in-pool training volumes (hours/week and metres/session). But in the male Youth category, performance was negatively correlated with the training volume per session.

***TABLE 2*: ONE-WAY ANOVA AND TUKEY POST-HOC TEST OF POOL AND DRY-LAND TRAINING VOLUMES AND PERFORMANCE BETWEEN CATEGORIES ACCORDING TO GENDER**

Variables	Cadet (C) Mean ± SD	Youth (Y) Mean ± SD	Junior (J) Mean ± SD	F-value	p-value	Diff.
Male						
In-pool vol. (hr/wk)	10.3±1.7	14.4±1.4	15.9±2.3	50.852	<0.001	C<Y,J
Session vol. (m)	4520.3±1120.9	5854.9±732.6	5800.1±888.4	25.192	<0.001	C<Y,J
Dry-land vol. (hr/wk)	1.9±1.7	2.8±1.2	3.5±1.7	4.321	0.001	C<Y,J
Performance (LEN)	600.3±89.4	748.7±61.2	825.2±57.6	159.143	<0.001	C<Y<J
Female						
In-pool vol. (hr/wk)	9.9±2.1	12.2±1.8	14.9±2.7	29.184	<0.001	C<Y<J
Session vol. (m)	4111.5±900.5	5655.2±814.0	6208.6±1137.7	47.809	<0.001	C<Y,J
Dry-land vol. (hr/wk)	2.4±1.9	2.5±1.2	3.5±1.0	2.640	0.076	No diff.
Performance (LEN)	574.0±81.3	726.7±55.0	783.7±29.5	183.606	<0.001	C<Y<J

Cadet male (13-14 years) Youth male (15-16 years) Junior male (17-18 years).
Cadet female (11-12 years) Youth female (13-14 years) Junior female (15-16 years)

***TABLE 3*: CORRELATIONS OF THE TRAINING VARIABLES WITH THE SEASON'S PERFORMANCE** (Pearson's *r* and p-value)

Variables	Males Cadet (13-14yrs)	Males Youth (15-16yrs)	Males Junior (17-18yrs)	Females Cadet (11-12yrs)	Females Youth (13-14yrs)	Females Junior (15-16yrs)
In-pool vol. (hr/wk)	0.361**	-0.432**	0.281	0.247**	0.067	-0.200
Session vol. (m)	0.431**	0.154	0.540	0.258**	0.280	0.374
Dry-land vol. (hr/wk)	0.153	0.196	0.298	-0.081	0.028	-0.010

* p<0.05 ** p<0.01

DISCUSSION

This study analysed the training volume, its evolution and its relationship with performance in Spanish swimmers of a national and international level aged 11 to 18 years. To the best of our knowledge, it is the first study of this type with young swimmers. Quantifying the volume of young swimmers' training at this level and establishing its relationship with performance, could assist coaches to understand the relevance of training volume and how it evolves over the successive formative stages in the development of their young swimmers.

The volumes of in-pool training in hours per week were less than those reported in most other studies (Platonov & Fessenko, 1994; Villanueva, 2007; Toubekis *et al.*, 2011), but the volumes per session were similar to those of other studies (Table 4). One study (Villanueva, 2007) recommends somewhat lower session volumes for girls, namely 3 125 to 4 100 metres for the Cadet category (11 to 12 years), 3 333 to 4 286 metres for the Youth category (13 to 14 years), and 4 000 to 5 000 metres for the Junior category (15 to 16 years). Such a low volume of training per session may, however, be one of the commonest mistakes made in the training process, given its recognised importance for the swimmer's metabolic adaptation (Laursen, 2010).

***TABLE 4*: IN-POOL TRAINING: HOURS PER WEEK AND METRES PER SESSION**

	Males			**Females**		
Variables	Cadet (13-14yrs)	Youth (15-16yrs)	Junior (17-18yrs)	Cadet (11-12yrs)	Youth (13-14yrs)	Junior (15-16yrs)
In-pool volume (hr/wk)						
Platonov & Fessenko (1994)	13.0	16.5	20.5	9.5	13.0	16.5
Richards (1996)	7.0	14.5	–	7.0	14.5	–
Villanueva (2007)	9.0	10.0	12.0	9.0	10.0	12.0
Vitor & Böhme (2010)	15.0	–	–	–	–	–
Martínez (2011)	–	12.0	–	–	12.0	–
Toubekis (2011)	12.0	–	–	–	12.0	–
Present study	10.3	14.4	15.9	9.9	12.2	14.9
Session volume (m)						
Richards (1996)	4750	6000	–	4750	6000	–
Chatard & Mújika (1999)	5000	7750	8000	5000	7750	8000
Hellard (2002)	4750	6850	7225	–	–	–
Martínez (2011)	–	6900	–	–	6900	–
Toubekis (2011)	4150	–	–	–	4150	–
Present study	4520	5854	5860	4111	5655	6208

Regarding the differences between categories for both genders there were differences in the in-pool training volumes between the Cadet and the Youth categories (Table 2). In contrast, there were no differences in training volumes between the Youth and Junior categories with the exception of the in-pool weekly hours of training in the female categories. In particular therefore, there was a progression in the volume of training load from the youngest (Cadet) category to the next in age (Youth), but not from this latter category to the oldest category studied (Junior). The principle of progressive training load (Matvéev, 2001), is thus not being adhered to. The reason for the better performance in the female categories (higher LEN scores), may be the increase in volume (hours/week) between the Youth (13 to 14 years) and the Junior (15 to 16 years) categories.

The maturational growth and the motor skill development of young swimmers require an increase in the volume of training that respects this progression (Lätt *et al*., 2009). However, the progression of this increase in training volume is not necessarily linear (Beunen & Malina, 1996). The differences could be less pronounced because most of the swimmers had reached physiological maturity (Beunen *et al*., 1997). Studies on the topic at the senior level, as was mentioned above, indicate that volume is not a determinant of success in competitive swimming (Faude *et al*., 2008; Aspenes & Karlsen, 2012; Soultanakis *et al*., 2012). It is also noteworthy that, while there was no progressive increase by age in the dry-land training volume in the case of the male swimmers, recent studies have highlighted its importance in lower categories (Sadowski *et al*., 2012).

With respect to the relationship between training volume and performance, in-pool training volume (hours/week and metres/session), there was a positive correlation with performance in the Cadet categories for both gender groups. These results are consistent with previous studies of young swimmers where a correlation between performance in 200m and 400m events and the annual volume of in-pool training was reported (Van Tilborgh *et al*., 1984). Similarly, the absence of any relationship between training volume and performance in the oldest age category (Junior – 17 to 18 years and 15 to 16 years in males and females, respectively), is consistent with previous studies indicating that it is intensity, not volume, that is the key to improving results in swimming (Costill *et al*., 1991; Mujika *et al*., 1996; Chatard & Mujika, 1999). Another study (Hellard *et al*., 2002) concluded that it is the frequency of training that is related to performance.

A recent review (Aspenes & Karlsen, 2012), reported that in the short term intensity and volume of training have the same influence on performance, although most of the studies included in that review were on senior category swimmers. Therefore, this may indicate that it is in the younger categories where training volume is a determinant, with it becoming a necessary but not a determining factor in older categories. Surprisingly, no relationship between the number of hours of dry-land training and performance was found, in contrast to previous studies (Van Tilborgh *et al*., 1984). One of the possible causes of this difference is that training methods and content have changed since that earlier study, and that this could affect performance and its relationship with the variables studied (Mouroço *et al*., 2012).

LIMITATIONS OF STUDY

This study had a number of limitations. (i) The questionnaire completed by the swimmers themselves may not have objectively reflected the training they actually were doing, and it might have been more appropriate for it to be completed by the coaches. (ii) The time of the study relative to the season's schedule might have influenced the training volume in terms of hours per session and metres swum, since the different categories held their championships on different dates. (iii) The developmental stage of the swimmers was not evaluated, and such information would be useful for interpreting the observed relationships between kinanthropometric parameters, training and performance. (iv) No evaluation was made of the type and methods of training the swimmers were exposed to (each swimmer belonged to a club, and therefore, had a different trainer within the National Championships program).

PRACTICAL APPLICATION

This study could help coaches understand the relevance of training volume and its evolution over the successive formative stages of their young swimmers. The findings revealed that the training volume was important to performance in young swimmers (males 13 to 14 years; females 11 to 12 years). In older swimmers, training intensity may have more relevance than training volume.

CONCLUSIONS

The results of the present study showed that, in the male swimmers, there was only a progression in the in-pool training volume from the youngest category (13 to 14 years) to the next category (15 to 16 years). This may reflect planning that does not respect the principle of training load progression. There was no progression in the dry-land training volume. In the female swimmers, this progression was observed between all three groups of swimmers (11 to 12 years, 13 to 14 years, and 15 to 16 years). It, therefore, seems necessary for training volume to be more clearly structured when swimmers are young. With respect to a relationship between training volume and performance, this was only present in the youngest categories (Cadets: 13 to 14 years and 11 to 12 years for males and females respectively). This could be because, after this age, intensity is the most relevant aspect of the training load.

Acknowledgements

This study was supported by grants from the Royal Spanish National Swimming Federation (Real Federación Española de Natación) and the Spanish Higher Sports Council (Consejo Superior de Deportes). The author wish to thank all the participants in the study. During completion of this paper, Yolanda Escalante (a co-author) was a visiting researcher at the Cardiff Metropolitan University, Cardiff (UK), supported by a grant awarded by the European Social Funds and the Autonomous Government of Extremadura (Gobierno de Extremadura) (PO10012), who also provided a research grant as support for the study (GR10171).

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(Subject Editor: Prof Ernst Krüger)