Descriptive analysis of the water balance in swimmers of the club orcas Tuluá

LUIS HEBERT PALMA PULIDO
Education of deparment
Central unit of the Cauca Valley
Kra 27a No 48-144 Tulua
Colombia
lpalma@uceva.edu.co

JOCELYN PORTELA ARÉVALO.
Education of deparment
Central unit of the Cauca Valley
Kra 27a No 48-144 Tulua
Colombia
jocelynportelaa@hotmail.com

RUBEN DARÍO LERMA PIEDRAHITA
Education of deparment
Central unit of the Cauca Valley
Kra 27a No 48-144 Tulua
Colombia
bencho_94@hotmail.com.

CARLOS HERNÁN MÉNDEZ DÍAZ
Education of deparment
Central unit of the Cauca Valley
Kra 27a No 48-144 Tulua
Colombia
cmendez@uceva.edu.co

DIEGO BONILLA OCAMPO
Department of biochemistry and molecular biology
Francisco José de Caldas University
Kra 7 No 40b-53 Bogotá
Colombia
dabonilla@g-se.com

Abstract: **Problem**: Hydration is considered as one of the most important nutritional ergogenic aids. However, there are very few coaches and athletes in Colombia who really focus on fulfill this requirement. Actually, those who know or were instructed about the importance of being well hydrated, only try to accomplish the fluid intake during competitions or training sessions, disregarding the moment before and after each sports / training event. **Objective**: The aim of this research was to describe the water balance levels of swimmers belonging to the *Club Orcas Tuluá*, Colombia. **Methodology**: Eight young swimmers (men = 6; women = 2; age = 13.8 ± 1.4 years) participated in this descriptive study. After being advised of the experiment and asked to sign an informed consent form (parent/guardian), the following variables were measured in all subjects during 7 days: pre- and post-training weight, length of training, volume of fluid intake during exercise, and self-perceived hydration was assessed using the urine color eight-point Armstrong scale at four time points. **Results**: Our results showed a mean pre-exercise body mass of 58.0 kg while mean post-exercise value was 56.8 kg, which lead to a 2.06% hypohydration status in the group of young swimmers. After calculation mean body water loss and sweat rate was 1.88 $L \cdot h^{-1}$ and 0.73 $L \cdot h^{-1}$, respectively. The athletes were placed at a level 4 of hydration classification, which corresponds to not sufficiently hydrated. Interestingly, hypohydration status and post-exercise body mass change were less in female athletes in comparison to male. **Conclusion**: Even though studied athletes consumed water or isotonic drinks during exercise, they do not hydrate properly throughout the day.

Based on these results we establish some easy-to-understand and practical recommendations for coaches, family and young athletes to improve hydration status in Colombian population.

Keywords: Hydration, swimming, Armstrong scale, sweat rate and sports performance.

1. Introduction

Swimming is a sport featured by higher energy expenditure than other disciplines. Barret, Barman, Boitano and Brokks (1) indicated that this is due to the decrease in body temperature and as a defense mechanism; where the body activates heat conductors that generate what is commonly known as "shivers". This response of the organism increases the metabolic rate, which leads to a greater use of energy and rise body temperature in order to keep the vital organs functioning correctly.

In fact, liquids and minerals fulfill specific roles in the cell during sports activity, especially when the energy requirement and the rate of sweating increases as the length and intensity do. Thus, their replacement plays a key rol in sports performance. Athletes become dehydrated more easily and this condition causes a large loss of electrolytes, especially the essential salts (2). Actually, in environments with high humidity or very hot conditions, the relative intake of 2-3 $L \cdot day^{-1}$ can be very little, being necessary up to more than 4 $L \cdot day^{-1}$ (3). In this sense, optimal hydration will minimize a state of early fatigue, by suppressing the lack of fluid and electrolytes (4).

Several studies demonstrate variations in sweating rate, hydration status, and fluid intake according to training intensity and length (5,6), which promote good hydration practices in athletes, especially by means of sport drinks. Even though hydration is important, athletes should take care of falling in hyperhydration, since this last can decrease sports performance as previous studies have reported (7). Indeed, not only sports professionals but also athletes must know the basic concepts of hydration protocols; however, most of them do not realize the importance of this and its relationship with performance (8).

2. Problem: Keeping a water balance is very important in all people, even more in athletes. Replacement of liquids, electrolytes and glycogen is of great importance in the sports; in which training is carried out under high temperatures, or the competitions are strenuous. Unfortunately, some athletes and some coaches do not know exactly the state of hydration in which they are or the methodology used for keeping it adequate. The Orca Swimming Club in Tuluá- Colombia is no stranger to this situation, since a survey was carried out both to the swimmers and to the coach; it was evident that the coach has the knowledge and knows the importance of keeping swimmers well hydrated and how to do it. However, in athletes, although they are aware of it, there is little knowledge about how to do it or what methods to use to know if they are well or poorly hydrated.

3. Solution to the problem: An assessment was carried out for 7 days, taking into account the variables of pre and post weight, training time and liquids consumed. In addition, urine samples were taken 4 times a day in order to know changes in the pigmentation of it at different times. The variables used, although they do not yield direct results in terms of electrolytes and body water, are widely used as tools to determine the water balance in athletes.

4. Hydric balance

Actually, there are several important factors to obtain a clear diagnosis with respect to the hydration of an athlete. For example, urine color, weight before and after training, sweat loss, the rate of sweating and the level of dehydration to mention some practical and easy indicators. Hereunder, there will be an explanation about each of them.

4.1. Urine color

Rivera et al. (8) mentioned in their publication that "Armstrong has shown that the urine color is directly proportional to the level of hydration presented by each person, this is why a scale has been established including color ranges from pale yellow to dark brown, which can be compared with a sample of urine and thus know the state of hydration of the person (p.242)".

It should be taken into account that the urine color after training can come out in a crystalline or clear color, which can generate a misinterpretation of the results, this happens as Adms *et al.* (9) explained, by a suppression of antidiuretic hormone secretion and reduced perception of thirst and besides that, the hydrostatic pressure exerted by water in the human body expands the volume of plasma and suppresses the accumulation of peripheral blood, resulting in hypervolaemia and load of the central baroreceptor and this change in blood volume may increase the production of diluted urine.

Figure 1 show the Armstrong scale, which corresponds to the different colors of urine ranging from 1 to 8. A color of urine between 1, 2 or 3, indicate a good state of hydration. However, the following numbers demonstrate dehydration from minor to major (mild, moderate and severe).

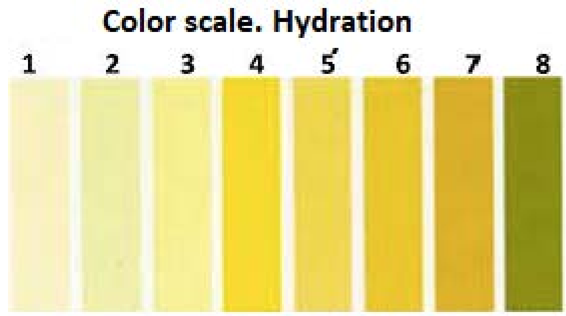


Figure 1. Armstrong scale. Modified from (10)

4.2. Athlete's Body Mass

Swimmers have a great absolute aerobic capacity, although when expressed per kilogram of muscle mass, it is lower than the one of other endurance athletes. In general, swimmers are taller, stronger and heavier than their sedentary counterparts, or than resistance-trained athletes. Some studies have shown an increase in height and lean mass averages of elite competitors in recent decades, and a difference between the winners of the competitions and those who do not reach the finals (11). In this sense, Burke (12) stated that these studies showing an increase in the size and lean mass of swimmers involve generally elite level and also well-trained swimmers.

Hence, body composition has a close relationship to dehydration status, since an athlete with greater muscle mass will have a greater amount of total body water (60-65% body water) and viceversa. Thus, the pre- and post-training body mass have became a good reference point to know how much fluid the athlete has lost, for this reason, 150% of the lost weight should be consumed after training in order to cover the sweat losses plus the production of urine (13).

4.3 Sweating rate

According to Velasquez (14) the sweating rate is the amount of fluid lost during training per unit of time, which is generally expressed in milliliters per hour or liters per hour.

Several factors that would influence the rate of sweating encompass individual characteristics such as sex, age, body mass, genetic predisposition, heat-conditioning status, among others. Diuretic efficiency may be lower in men and higher in women, because women have a faster exchange of water than men (15). The following equation taken from Velasquez (14) represents the rate of sweating.

$$\frac{Body\ mass\ lost\ (g)\ +\ Fluid\ intake\ (mL)}{Training\ Lenght}$$

4.5 Fluid loss

Body water is distributed in two compartments, either intracellular or extracellular; i) the first contain approximately 65% of the total body water, ii) while the second has 35% (this compartment is divided into the interstitial and plasma spaces). To understand the term "fluid loss", concepts such as dehydration, euhydration and hyperhydration must be known. The first one refers to the excess loss of body fluid, which leads to the reduction of working capacity and decrease in resistance to fatigue (16); euhydrations refers to the normal contentof body water (17); and the latter indicates the excesses of the body water, beyond normal fluctuations.

During physical activity, there are important physiological changes that modulate fluid and electrolytes homeostasis, which in turn can cause dehydration. Electrolytes participate in vital functions such as transmission of nerve impulse, muscle contraction, increase of cardiac output and pH regulation (18). For this reason, attention should not only be paid to the consumption of water, but also to electrolytes and even sugars when necessary, considering intensity and length of training mainly.

In general terms, during competition the goal is to avoid excessive dehydration (>2% of body weight loss due to water deficit) or significant changes of electrolytes, although this value can be higher with no side effects according to individual responses. As a result, many factors affect hydration status at the pre-, peri- and post-exercise level. For this reason, the athlete must know step by step what to do, and carry it out daily by him in order to turn this into a habit and look for the euhydration.

5. Methodology

5.1 Population

This study represents a quantitative approach, with a non-experimental design and descriptive scope. Young athlete population was between 12 and 16 years old from the *Club Orcas Tuluá*. The descriptive analysis was performed in 8 swimmers (2 female and 6 male) using non-probabilistic sampling at convenience). The group was subjected to 7 days of data collection to know the level of water balance, remaining with their usual planned training program.

5.2 Measurements

The first step of this study was to hold a meeting with the adolescents, the coach and parents, in order to make the objectives of the research known, and the importance of this for the athlete’s life and club performance. Signature of the informed consent from each parent was requested. After consent from parents, research group explained the variables measurement for 7 days. It was specified that the urine sample would be made by the young athletes alone but under parental supervision and control of the schedules. For sampling, each young athlete was in charge of 28 containers, which were picked just after they urinated. Next, taking photographs and categorization according to Armstrong scale was performed. The process was carried out in the following way: 4 daily doses of urine, the first shot was taken in the morning hours at 6:00 am, the second intake at 9:00 am, the third one pre-workout, at 3:30 pm and the last intake post training at 6:30 pm. The body mass was measured with a portable Scale Health O'meter Model 1302014. Fluid mass of the sport dring or water was measured with a 5 kg digital scale Adir® brand. These masses were taken before and immediately after the training session. Training specialists control the exercise time of each session.

5.3 Statistical Analysis

Descriptive and inferential statistics were performed using the Statistical Package for the Social Sciences (SPSS) software (SPSS 21.0, SPSS Inc., Chicago, USA).

6. Results

Data obtained from the swimmer group is displayed in table 1. The highest ranking on the Armstrong scale is urine 1 presented when getting up (5:00 am), urine 2 during the morning (9:00 am) and urine 3 pre-workout (3:30 pm). These correspond to the numerical classification of 4, which means athletes are not sufficiently hydrated. On the other hand, the post-training sample (urine 4 at 6:30 p.m.) corresponds to the numerical classification 3, which showed a well hydrated status in the individuals.

Table 1. Armstrong scale results

		Urine 1	Urine 2	Urine 3	Urine 4
N	Valid	8	8	8	8
Half		4	4	4	3

Source: the authors

Table 2 shows the weight data before and after exercise. As it is appreciated, the mean body mass before workout was 58.0 kg, while the one after exercise was registered at 56.8 kg. Change between pre and post body mass measurement was 1.2 kg. In addition, the average of sweat loss was 1.88 L, while the sweating rate was 0.73 $L{\cdot}h^{-1}$ with a hypohydration level of 2.06%.

Gender			pre weight kg	post test weight kg	sweat loss (L)	sweating rate (L)	level of dehydration %
Female	N	Valid	2	2	2	2	2
	Media		62,05	60,95	1,95 (L)	,75 (L)	1,75 %
	Desv. típ.		7,141	7,141	,21213	,0707	,2121
Male	N	Valid	6	6	0	0	0
	Media		56,66	55,43	1,86 (L)	0,73 (L)	2,15 %
	Desv. Típ.		7,463	7,438	,26	,10	,150

Table 2. Results after Rate of Sweating Calculation

		initial weight kg	**final weight kg**	**sweat loss (L)**	**sweating rate (L)**	**level of dehydration %**
N	Válid	8	8	8	8	8
Half		58,0	56,8	1,88 (L)	0,73 (L)	2,06%

Source: the authors

Pre and post data of the athletes' body mass are observed in Table 3. In here, $p<0.05$ indicates significant change in body mass before and after the training session.

Table 3. Differences in Body Mass before and after Training

Source the authors

The average body mass in women before and after training was 62.0 kg and 60.9 kg, respectively (difference of 1.1 kg). In these female athletes the average of sweat loss was 1.9 L, the sweating rate was found in 0.7 $L{\cdot}h^{-1}$, and the hypohydration level in 1.7%. Conversely, the average body mass in men before and after training session was 56.6 kg and 55.4 kg, respectively (difference of 1.2 kg). Male athletes had an average sweat loss of 1.8 L, sweating rate of 0.7 $L{\cdot}h^{-1}$, and hypohydration level of 2.15%. Then, there was a higher level of dehydration in men compared to women.

Table 4. Differences of Sweat Rate at the Gender Level

		Related differences					**Sig**
		Half	Desviación típ.	Typ error of the average	95% Inferior Confidence interval for the difference	higher	
Par 1	Weight pre-post	1,20	,0925	,03273	1,12260	1,27	**,000**

Source: Authors

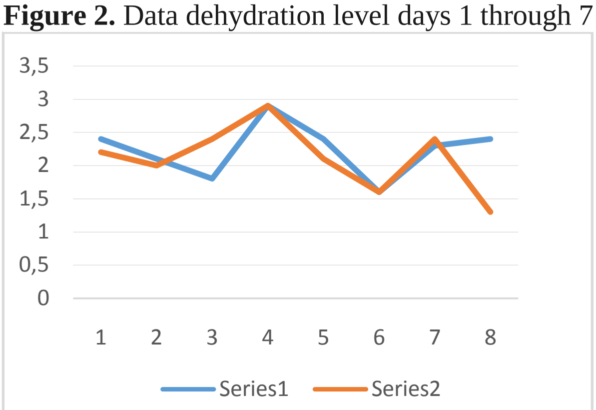
Table 5. Day 1 and 7 of ratings

Day 1								
Athlete	**Pre weight**	**post weight**	**Volumen of fluid consumed in exersice**	**Duration of the exercise**	**Fluit déficit**	**Total, loss of sweat**	**Sweating rate**	**Hypohydration level**
1.	45,4	44,3	0,7	2.5	1,1kg	1,8L	0,7	2,4%
2.	59,3	58,0	0,8	2.5	1,3kg	2.1L	0,8	2,1%
3.	59,6	58,5	1,3	2.5	1,1kg	2,4	0,9	1,8%
4.	51,4	49,9	0,5	2.5	1,5kg	2L	0,8	2,9%
5.	57,2	55,8	1.0	2,5	1,4 kg	2,4L	1	2,4%
6.	67,0	65,9	0,6	2,5	1,1 kg	1,7L	0,7	1,6%
7.	57,5	56,2	1,1	2.5	1,3 kg	2,4	0,9	2,3%
8.	67,5	65,9	0,4	2,5	1,1 kg	1,5	0,6	2,4%
Day 7								
Athlete	**Pre weight**	**post weight**	**Volumen of fluid consumed in exersice**	**Duration of the exercise**	**Fluit déficit**	**Total, loss of sweat**	**Sweating rate**	**Hypohydration level**
1.	45,2	44,2	0,6	2.5	1,0kg	1,6L	0,7	2,2%
2.	59,4	58,2	0,4	2.5	1,2kg	1,6L	0,7	2,0%
3.	59,5	58,1	0,9	2.5	1,4kg	2,3L	0,9	2,4%
4.	51,5	50,0	0,5	2.5	1,5kg	2,0L	0,6	2,9%
5.	56,9	55,7	0,8	2,5	1,2kg	2,2L	0,4	2,1%
6.	67,2	66,1	0,6	2,5	1,3kg	1,9L	0,8	1,6%
7.	57,4	56,0	0,8	2.5	1,4kg	2,2L	0,9	2,4%
8.	66,9	66,0	0,4	2,5	0,2kg	1,6L	0,7	1,3%

Source: Authors

In the tables above the data obtained is observed. It helped to determine the water balance of each athlete, from the first day through the seventh. There is a constant in some variables such as ingested fluid, duration of training and sweating rate. However, the hypohydration level obtained a more favorable result on the last day of assessmen

Figure 2. Data dehydration level days 1 through 7



Source: Authors

Figure 2 shows the constant level of dehydration of athletes from the first day through the seventh. It can be seen that this level was lower than the others on the last day, it was likely the result of a more conscious hydration on the part of the athletes, since they had been subjected to the evaluations for several days.

7. Discussion

The methods used in this research were characterized by being subjective; however, by taking into account various variables, a reliable description can be obtained regarding the water balance of the athletes. Actually, the variables measured in this study were body mass, hypohydration level, urine color and sweating rate.

Regarding body mass, Del Rosso (11) argues that this variable, although subjective, can be a good predictor for dehydration. In this study we evidenced an average loss of 1.2 kg, after calculating the difference of body mass pre- and post-training. In a study carried out by Adms, *et al*. (9), no statistically significant changes ($p > 0.05$) were observed with regard to body mass, since the loss of fluids was only 300 grams between the pre- and post-training. Something similar happened in the study carried out by Maughan, Dargavel, Hares, & Shirreffs, (19), where the losses of body weight were only between 100 and 500 grams. Notwithstanding, Castagna *et al.* (20), found similar results to our data, since these authors showed that the body mass was reduced by 989 grams ($p < 0.05$) after diving two hours at three meters deep. In line with this, Costa & Petrucceli (21) reported in a previous study a decrease in body mass of 1% in swimmers after training sessions between 80% and 100% of the intensity. Also, in this study the hypohydration level, with direct relationship to body mass, corresponded to 2.06% for the general group; but, analysis by gender showed a hypohydration level of 1.75% and 2.15% for women and men respectively. This can be due to the fact that women can not afford to lose as many fluids as men because they have a smaller reserve of body fluids.

Results slightly higher were found in the research carried out by Soler, *et al*. (22), in which nine men presented a hypohydration level of 2.5% after swimming 9 km for 3 hours. It should be noted that a 2% loss of body mass can worsen the cardiovascular and thermoregulatory response, thus reducing the ability to perform the exercise (8,21).

Another important variable when it comes to predicting the level of hydration of athletes is the urine color, where according to the Armstrong scale (8) the classification for the group of young athletes analyzed in this study was level 4, which means "not sufficiently hydrated". Even so, Macaluso (23) did not find significant differences between pre- and post-swimming training in urine sampling that was taken at various temperatures (23°, 27° and 32°). Guadalupe (5) obtained results in 3 of 11 assessed swimmers, as minimal dehydration, while 7 were very dehydrated. However, Adms, *et al*. (9) concluded after analyzed 46 swimmers participating in the study, that the decrease in urine hydration markers after swimming could reflect the state of this variable with less precision. The urine color after training can result in a crystalline or clear color, which can generate a misinterpretation of the results, as mentioned Adms et al. (9), who argue that a change in the volume of blood can increase the production of diluted urine. This point is very important, since our young individuals presented a classification of 3 (well hydrated) in the post-training urine color, while the other three samples before training were classified to category 4 (not sufficiently hydrated). This indicates that these young athletes were not really well hydrated during the day and participated in training sessions with fluid deficits, which in turn might interfere with sports performance. One important variable to be considered was the athletes' drink selection, taking into account that some of the analyzed individuals ingested water as the only source of fluids, but it has been shown that sport drinks may improve performance by means of better fluid replenishment (6).

The general sweating rate in this study was 0.73 $L \cdot h^{-1}$, with similar values when analyzed by gender. These results are lower than those found by Guadalupe (5), in which the swimmers finished with a rate of 1.3 $L \cdot h^{-1}$ for men and 1.7 $L \cdot h^{-1}$ for women. Similarly, Sellés et al, (24) reported higher sweating rates in women when compared to men during different training protocols in young triathletes. Conversely, our data was similar to those obtained by Henkin, Sehi, and Meyer (25), in which their swimmers ended up with a sweating rate of 0.9 $L \cdot h^{-1}$.

8. Conclusion

After descriptive analysis of the hydration status of young athletes belonging to the *Club Orcas Tuluá*, we identified certain levels of hypohydration (above normal) and a constant state of fluid deficit during the day, after urine color analysis. Even though these results are not extremely bad, this study serves as a call to action across sports professionals to improve and develop a more precise hydration assessment in young Colombian athletes. Moreover, since the geographic location of these young swimmers presents an average high temperature (max 36°), it is necessary to establish nutritional education strategies in order to augment good fluid replenishment practices throughout the day. Finally, these educational and promotional activities of public awareness of hydration requirements are not only important for athletes but also for parents, coaches and sport team members.

References

1. Barret, K., Barman , S., Boitano, S., & Brokks, H. (2010). *Gangong Fisiología Médica.* México D.F. : Mac Graw Hill.

2. Palacios, N., Manonelles, P., Manuz, B., & Villegas , J. (2008). Consenso sobre bebidas para el deportista . *Archivos de medicina del deporte.*

3. Bankhead, C. (2012). Too much water bigger thread than too little . *Medpagetoday* .

4. Willians, C., & Blackwell, J. (2012). Hydrations status, fluid intake and electrolyte losses in soccer players. *International journal of sports physiology and performance*.

5. Guadalupe, X. (2014). *Correlación de la tasa de sudoración, nivel de hidratación, consumo de líquidos según la intensidad y duración del entrenamiento de resistencia y velocidad.* Universidad Rafael Landivar .

6. Prado, E., Da Silva B.; Oliveira Góis., H & Reinert, T. (2009). Estado de hidratación en nadadores tras tres diferentes formas de reemplazo hídrico en la ciudad de aracaju - se - brasil. Journal, Fitness and Performance.

7. Glulet, E. (2015). Efecto de la Deshidratación Inducida por el Ejercicio sobre el Rendimiento de Resistencia: Evaluación del Impacto de los Protocolos de Ejercicio sobre los Resultados Mediante un Procedimiento de Meta-Análisis. Journal PubliCE grupo g-se.

8. Rivera, A., Sánchez, J., Escalante, X., & Lambert, O. (2008). Utilidad de la densidad Urinaria en la evaluación del rendimiento físico. Revista Patología Clínica.

9. Adms, J., Kavouras, S., Robillard, J., Bardis, C., Johnson, E., Genio, M., y otros. (2016). Fluid balance of adolescent swimmers during training. *Journal of strenght and conditions research* .

10. Aranceta, J. (2017). XVII encontro Nacional de salud y medicina de la mujer. *Nutrición y dieta: necesidad de educar y conocer.* Madrid.

11. Andrea, K. (2016). Nutrición en el deporte. *elheraldo* .

12. Burke, L. (2007). *Nutrición en el deporte.* Madrid: Médica Panamericana.

13. Del Rosso , S. (2008). *Termorregulación, hidratación y ejercicio.* grupo sobreentrenamiento.

14. Velasquez, X. G. (2014). *Correlación de la tasa de sudoaración, nivel de hidratación, consumo de liquidos según la intensidad y duración del entrenamiento en atletas de resistencia y velocidad.* Universidad Rafael Lndivar , Guatemala de la asunción.

15. Sawka, M., Burke , L., Eichner, R., Maughan, R., Montain, S., & Stachenfeld, N. (2007). Ejericicio y reposición de líquidos. *Medicine & acience in sports & exercise* .

16. Serra, J. (2000). *Salud integral del deportista.* España: Springer.

17. Bellagarde, R. (2013). Euhidratación. *g-se* .

18. Olivos, C., Cuevas, A., Álvarez, V., & Jorquera, C. (2012). Butrición para el entrenamiento y la competición. *Rev Med Clic CONDES* .

19. Maughan, R., Dargavel, L., Hares, R., & Shirreffs, S. (2009). Water and salt balance of well-trained swimmers in training. *International Journal of Sports Nutrition and Exercise Metabolism* .

20. Castagna, O., Desruelle, A., Blatteau, J., Schmid, B., Domoulin, G., & Regnard, J. (2015). Alterations in body fluid balance during fin swimming in29º water in a population of special forces divers. *International journal of sports medicine* .

21. Costa, I., & Petrucceli, F. (2005). La deshdratación en los deportes aeróbicos de natación . *G-se* .

22. Soler, R., Echegaray, M., & Rivera, M. (2003). Thermal responses and body fluid balance of competitive male swimmers durong a training sessionng . *Jounal Strength conditioning research.*

23. Macaluso, F., Di Felice, V., Boscaino, G., Bonsignore, G., Stampone, T., Farina, F., & Morici, G. (2011). Effects of three different water temperatures on dehydration in competitive swimmers. *Science & Sports*, *26*(5), 265-271.

24. Sellés López de Castro, M. C., Martínez-Sanz, J. M., Mielgo-Ayuso, J., Selles, S.,

Norte-Navarro, A., Ortiz-Moncada, R., & Cejuela, R. (2015). Evaluación de la ingesta de líquido, pérdida de peso y tasa de sudoración en jóvenes triatletas. *Revista Española de Nutrición Humana y Dietética*, *19*(3), 132-139.

25. Henkin, S., Sehi, P., & Meyer, F. (2010). Sweat rate and electrolyte concentration in swimmer, runners and nonathletes. *International Journal of Sports Physiology and Performance*