Journal of Physical Education an Sport Vol 23, no 2, June, 2009
e – ISSN: 2066-2483

Online Publication Date: 01 June 2009

ORIENTATION ARTICLE

WATER IMMERSION AS A POST-EFFORT RECOVERY FACTOR. A SYSTEMATIC REVIEW

Chulvi-Medrano. I. [1], *LLana-Belloch. S. 1, Pérez-Soriano, P.* [1]

[1] *Department of Sport and Physical Education. University of Valencia (Valencia, Spain).*

In physical preparation is well established the importance of recovery processes in order to achieve high levels of performance. Therefore, and due to the high demands required in the current sports competitions, to enhance recovery processes play an important role in the final performance. Water immersions have been used as a recovery agent by coaches for long. However, only in recent years have been published scientific papers which investigate this topic. The purpose of this work was to establish a theoretic framework based on these publications. It has conducted a thorough bibliographical review in databases Pubmed and SportDiscus, using the keywords "Post-exercise recovery "," water immersion "," thermal responses" and "cryotherapy". After purifying the papers retrieved, 39 papers were obtained, of which 33 are original research work and 6 are reviews. We must highlight a limiting factor in the extraction of general conclusions: the absence of standard protocols. Therefore, sometimes it is difficult to compare results from different studies. However, two conclusions can be drawn: (1) Hot water (> 33º C) is not a good regenerating agent post-effort, and (2) immersion in cold water (15ºC) for 1o minutes, split into periods, facilitates regenerative processes post-effort. About contrasts (alternate cold and hot water) there is less information and results are sometimes contradictory.

Key words: cryotherapy, performance, recovery, contrast therapy, baths.

Introduction

In physical training for sport performance, recovery processes of functional and structural systems of the organism after the physical effort, must be programmed as an important component of sport training process (Siff & Verhoshansky, 1998; Fleck, 1999, Bompa, 2000; Barnett, 2006). Post-effort recovery is a heterogenous process that happens after interrupting the physical activity and restitutes the internal balance (homeostasis) and the capacity to develop an efficient effort (Cochrane, 2004).

The biological regeneration of the organism after the physical effort is not linear in all components, but these presents a very noticeable heterocronism. In addition, this heterocronism is very affected by diverse factors, among which stands out: (1) the internal load caused by the effort, (2) the individual adaptive capacity, (3) nutritional status of the athlete and (4) the used recovery methods.

A correct post-effort recovery produces improvements in two of the most important organic systems: muscular (Fleck, 1999) and cardiovascular (Bosquet et al., 2007). For this reason, Bompa (2000) affirms that approximately the 50% of the athlete peak performance depends on their recovery capacity. Among diverse recovery methods, aquatic immersions are one of the most extended. This is not a nowadays innovation because on Roman Empire days was developed the concept of "salus per aquam" (SPA), that is to say, the health through water (Llana & Perez, 2007). But the scientific interest on thermoregulatory and metabolic responses to water immersion dates from the 1960 decade, and initially, the interest was oriented to the effects on the specific performance on swimming (Craig & Dvorak, 1966; Holmér & Bergh, 1974). From the 1990 decade (Terrados & Padilla, 2004) interest has extended to the society, rising up a great number of SPAs all over the developed countries (van Tubergen & van der Linden, 2002).

Coaches and therapists have paid attention on water exercises at least by the next effects: a) for injuries prevention and for physical rehabilitation (Peyré-Tartaruga & Martins 2006), b) to improve muscular strength (Martel et al., 2005; Tsourlou et al., 2006); c) as a therapy in populations with specific requirements as subjects with fibromialgia (Take et al., 2007; Takeshima et al., 2002) d) flexibility improvement (Burke et al., 2001), e) VO2máx improvement in sedentary subjects (Reilly et al., 2003), f) to reduce joint compression and to improve venous return (Llana & Perez, 2008).

Regards the recovery effect of aquatic immersions Vaile et al. (2008) indicate that water immersions triggers organic alterations and responses that can be intuited as positive for the post-effort recovery. According to Wilcock et al (2006[a]), there are four recognized methods for water immersions to allow this:

a) Thermoterapy, which means water immersion to increases body temperature. So water must be up to 36ºC.
c) Cryotherapy. Immersion in water bellow 16ºC.
c) Water immersion "per se". Not hot neither cold water (16ºC to 36ºC)
d) Contrasts therapy. Hot (> 36ºC) and cold (< 16ºC) water alternation.

Among these four options, Wilcock et al (2006b) claims that only cryotherapy and contrast therapy are useful as a post-effort recovery method.

Material and method

The articles location for this systematic review was realised in the two data bases computerized online more important in the scope of the areas of Health and Physical Education:

- PubMed (http://www.ncbi.nlm.nih.gov/pubmed/): it is the most important data base regards medicine. It depends on the National Bookstore of the United States of America and the National Institutes of Health.
- SportsDiscus: (http://www.sirc.ca/products/sportsdiscus.cfm): it is the data base of Sport Information Resource Centre (SIRC) realised by the Coaching Association of Canada.

Key words used for the search were: "water immersion", "post-exercise" and "post-effort" "recovery", "thermal responses", "cryotherapy", "contrast therapy". No limits (publication dates, human or animals, gender, type of article or ages) were applied. 56 possible papers were located, among which a selection was made in order to fit the study objectives. After filter all located papers, 39 were elected: 33 are research articles and 6 reviews. To manage this papers, 5 were located online, 30 in the libraries of the University of Valencia and 4 were send by email by the authors after request for them.

Results

Following Wilcock et all (2006b) results of our systematic review will present in two blocks: the first one dedicated to the cryotherapy and, the second one, to the contrast therapy.

1. Cryotherapy

Cryotherapy is defined as the curative and recovery method based on the application of cold on a damaged corporal zone. Water is usually the way used. Also exists the therapy based on "extreme cold " (- 110º C) applied in air chambers (Westerlund et al., 2003), but a little number of this chambers exist all over the world. So, as Wilcock et al. (2006a) indicate, consensus exists that cryotherapy is based on cold water (< 15ºC) immersions.

Body responses to cryotherapy are based on the thermal homeostasis break down: (1) to limit heat loss, peripheral blood vessel constrict (Srámek et al., 2000; Guyton &Hall, 2006) and, (2) to increasing heat generation (thermogenia), tiroxin and catecholamines secretion increases (Guyton & Hall, 2006; Lopez, 2006) and, if this is not enough, involuntary muscular spasms will happen. This can increase until 5 times the muscular heat generation (Wilmore & Costill, 2004; McArdle et al., 2004). Diuresis increase until 163% (Srámek et al., 2000) is another remarkable effect.

These responses, that represent the way the organism defend itself to a so important thermal aggression, are independent on gender, age or physical fitness conditions (Tikuisis et al., 2000; Glickman-Weiss et al., 2000; Wilmore & Costill, 2004). Anthropometry and body composition affect these responses in the way that as small the fatty tissue percentage and the greater the corporal surface, the greater loss of corporal temperature will be (Wilmore & Costill, 2004; Xu el al,. 2007) and the greater the body responses will be.

Body benefits associated to this thermal situation can be grouped in to kind of effects:

1) Cold effects "per se". Temperature reduction slow down all chemical reactions (Zumdahl & Zumdahl, 2006) and specially reactions mediated by enzymes (Nelson & Cox (2004) Nervous system is very affected by this biochemical effect, thus nervous impulse speed can be reduced by 10 times at 12.5ºC (Knight, 1976). This effect diminishes muscular tone and pain perception (Cochrane, 2004; Wilcock et al., 2006a; Enwemeka et al., 2002). Also it seems to be the cause of intracellular pH increase detected in this type of immersions (Yanagisawa et al., 2003), because key enzymes catalysis of the glycolysis are reduced. Moreover, some authors (Morton, 2006; Hugh, 2007) indicate that lactate cleanliness increases, which could be another explanatory mechanism of the cryotherapy regenerative effects, although Cheung et all. (2003) indicate that investigations are inconclusive. Terrados & Padilla (2004) recommends cryotherapy as one of the best recovery

agents after maximum intensity exercises, due these are the kind of exercises which generates higher lactate levels.

2) Biological reactions effects (Enwemeka et al., 2002; Yanagisawa et al., 2003; Wilcock et al., 2006a). The main body defence to a great temperature fall is peripheral vessel constriction. As a consecuence, the metabolism in those body areas diminishes. Tissue inflammation and edema post-exercise reduces at a great extend, and this, cushions the tissue injury and reduces pain sensation. Also, perspiration diminishes because there is no heat to eliminate.

These two kind of effects are the bases of cryotherapy as a post-effort regenerative method. To these effects must be added one more: water immersion "per se" effects. It is well known that water immersion until hip level provides a degree of hydrostatic pressure enough to generate fluid displacement on the lower limbs (Wilcok et al., 2006a; Llana & Pérez 2008; Goodal & Howatson, 2008) facilitating, therefore the venous return of the legs.

Cryotherapy regenerative effects seem to be especially remarkable when physical work has implied eccentric muscular actions. Thus, reductions on muscular rigidity and on the amount of muscle damages post-exercise have been registered on upper extremities (Eston &Peters, 1999) and on lower estremities (Lane & Wenger, 2004; Yanagisawa et al., 2003). Ruiz et al. (1993) indicated that to enhance post-effort cryotherapy regeneration effects, it is very important to realize exercise of moderate-low intensity after cold water immersions. Nevertheless, Sellwood et al. (2007) didn't find a reduction on muscle damage by using cryotherapy after eccentric efforts in a group of untrained subjects.

On the other hand, Nosaka et al. (2004) applied cryotherapy before an eccentric exercise, and did not find reduction on muscular damage or an increase on muscular performance. Bolster et al. (1999) find an impairment of aerobic capacities immediately after cryotherapy. So, it is concluded that cryotherapy benefits are only achieved when it is used after exercise.

Cryotherapy analgesic effect is reached very fast in time and its effect tends to be transitory since it dissipates gradually after 60 minutes of the immersion (Washington et al., 2000, Wilcock et al., 2006a).Due to the regenerative effects of cryotherapy, muscular and cardiovascular performance increases (Yeargin et al. 2006; Vaile et al. 2007; Peiffer et al. 2008;Vaile et al. 2008) but these exceeds the objectives of the present paper.

Associated risks and contraindications of cryotherapy.

Although the above results are encouraging, cold water immersion is not free of possible associate risks. Although in few individuals, tachycardia and hyperventilation associated to cryotherapy have been reported (Wilcock et al., 2006a). On the other hand, it is not recommended to perform high intensity exercises immediately after cryotherathy because performance is impaired, especially muscular strength and speed movements (Douris et al., 2003; Howard et al., 1994) and the possibility of suffering an injury increases. This is due for three mean reasons. First, cold have a negative effect on the miotatic reflex (Cross et al., 1996) which is a musculoesqueletical protector reflex. Second, muscular, tendinose and ligamentose tissues increase their rigidity (stiffnes), so flexibility decreases (Evans et al., 1995). Third, anaerobic metabolism is declined due to enzymatic speed reduction (Schniepp et al., 2002).

This reduction in the maximum functional capacity of muscle is transitory and can extend over 15 minutes (Douris et al., 2003) to 20 minutes (Ruiz et al., 1993). In this sense, Patterson et al. (2008) indicated that power will be reduced until 32 minutes, muscular strength until 12 minutes and agility and speed will be reduced until 22 minutes.

Finally it must be considered that few individuals may feel something of pain or discomfort during cryotherapy. Nevertheless, discomfort and pain dissipates gradually after repeated cryotherapy sessions (Carman and Knight, 1992).

Basic criteria to consider on cryotherapy

In order to obtain the cryothepaphy positive effects and to diminish the possible negative effects, it is very important to take into account a correct protocol. But this is not so simple, because there is not a universal protocol accepted for all researchers. So, we present a possible a guide (table 1) based on the most coincident criteria used Wilcock et al. (2006a), Cochrane (2004) y Srámek et al. (2000).

Table 1. Cryotherapy guide based on the most coincident criteria used in literature (Wilcock et al. 2006a; Cochrane, 2004; Srámek et al. 2000).

Temperature	**Total immersion time**	**Immersion time per stance**	**Considerations**
≤15º.	10 minutes	≈30 seg or athlete´s capacity to maintain disconfort.	Be careful with subjects with hypertension, hyperventilatory and/or tachycardia.

2. Contrast therapy.

Contrast therapy implies alternative immersions on hot (> 36ºC) and cold (< 15ºC) water (Wilcock et al., 2006a). The biological basis of contrast bath therapy are the “vaso-pumping”, this means an increase of blood flow due to temperature changes (French et al., 2008;). Morton (2006), Wilcocket et al. (2006a) and French et al. (2008) reported significant reductions on blood lactate after an anaerobic intense exercise. These authors indicate tha “vaso-pumping” is the responsible of this effect. Vaile et al. (2007) demonstrated that muscular recovery is faster using contrast bath therapy instead passive recovery. Wilcock et al. (2006a) summarize the benefits as follow: blood flow increase, muscular stiffness reduction, increase on movement amplitude and inflammation and edema reduction.

Criteria to apply contrast bath therapy are very vague. Wilcock et al. (2006a) recommend the next: one session may long from 4 to 30 minutes. Each hot or cold immersion may long from 30 seconds to 300 seconds. Cochrane (2004) indicate that if injury exist, is better to finalize with cold water immersion. Table 2 summarizes criteria (Wilcock et al. 2006a; Cochrane, 2004; Brukner & Khan, 2006).

Table 2. Contrast method summary. From Wilcock et al. (2006a), Cochrane (2004) and Brukner & Khan (2006).

Temperature	Total immersion time	Contrast Time	Considerations
Hot: 37-43ºC Cold: 12-15ºC	4-30 min	3-4 min warm water 30-60 seconds in cold water	Be careful with subjects with hypertension, hyperventilatory and/or tachycardia There is not consensus about the recovery effects of this method.

Discussion

The results show to an evident recovey response post-effort of the biological systems after the cryothery without negative effects for the health (Eston & Peters, 1999; Lane & Wenger, 2004; Yanegisawa et al., 2003). Nevertheless, in some protocols of intervention where it is applied the cold water immersion immediately after an effort seems to negatively affect the performance of the athlete when it confronts another period of brief effort of high intensity (Schniepp et al., 2002 Crowe et al., 2007). On the neuromuscular capacity after a period of effort and cold water immersion has not been any text on the matter. Nevertheless, it has been reported reductions of manifestations of speed and power when is preceded of cold water immersions (Howard et al., 1994) or reductions of maximal hand-grip strength (Douris et al., 2003).

A noticeable variability in the achieved effects by the cold water immersions exists. These differences in the results can have to the disparity of applied protocols, the two more important are different water temperatures and different immersion time, but different level of water immersion, different modalities of exercise pre-immersion and others. Nevertheless, after this systematic review, it seems to be consensus for cryotherapy to be at 15ªC during 10 minutes facilitates post-effort recovery. Regards contrast bath therapy, less information is available and criteria are quite vague.

Van Tubergen and van der Linden (2002), Wilcock et al. (2006a and b) and Srámek et al. (2000) agrees with the potential of immersions as a very effective recovery method. Nevertheless, all they indicated the lack of current research and the necessity to increase it in order to establish good criteria to maximize the positive effects of aquatic immersions. Regards ports-effort recovery, it seems to be a tendency towards a greater effectiveness due to water cryotherapy than contrast baths method (Ingram et al., 2008), whereas both methods seem to have equal effectiveness alleviating (milding) muscular stiffness symptoms (Kuligowski et al.,1998).

References.

Barnett A. Using modalities between training sessions in elite athletes. Does it help? Sports Med 2006; 36(9):781-796.

Bolster DR, Trappe SW and Short KR, Scheffield-Moore M, Parcell AC, Schulze KM, Costill DL. Effects of precooling on thermoregulation during subsequent exercise. Med Sci Sports Exerc 1999; 31 (2):251-257.

Bompa T and Carrera (2005) Periodization training of sports. Ed. Human Kinetics.

Bosquet L, Montpetit J, Arvisais D and Mujika I. Effects of tapering on performance: a meta-analysis. Med Sci Sports Exerc 2007; 39 (8):1358-1365.

Brukner P and Khan K. Clinical Sports Medicine. Australia: McGraw-Hill; 2007.

Burke DG, Holt LE, Rasmussen R, MacKinnon NC, Vossen JF, Pelham TW. Effects of hot or cold water immersion and modified proprioceptive neuromuscular facilitation flexibility exercise on hamstring length. J Athl Train 2001; 36(1):16-19.

Carman KW and Knight KL. Habituation to cold-pain during repeated cryokinetic session. J Athletic Training 1992; 27 (3):223-230.

Cochrane DJ. Alternating hot and cold water immersion for athlete recovery: a review. Physical Therapy in Sport 2004; 5:26-32.

Craig AB and Dvorak M. Thermal regulation during water immersion. J Appl Physiol 1966; 21 (5):1577-1585.

Cross KM, Wilson RW and Perrin DH. Funtional performance following an ice immersion to the lower extremity. J Athletic Training 1996; 31 (2):113-116.

Crowe MJ, O'Connor D and Rudd D. Cold water recovery reduces anaerobic performance. Int J Sports Med 2007; Doi 10.1055/s-2007-965118.

Cheung K, Hume PA and Maxwell L. Delayed onset muscle soreness: treatment strategies and performance factors. Sports Med 2003; 33: 145-164.

Douris P, McKenna R, Madigan K, Cesarski B, Costiera R and Lu M. Recovery of maximal isometric grip strength following cold immersion. J Strength Cond Res 2003; 17 (3):509-513.

Enwemeka CS, Allen C, Avila P, Bina J, Konrade J and Munns S. Soft tissue thermodynamics before during and after cold pack therapy. Med Sci Sports Exercise 2002; 34 (1):45-50.

Eston R and Peters D. Effects of cold water immersion on the symptoms of exercise-induced muscle damage. J of Sports Sciences 1999; 17 (3):231-238.

Evans TA, Ingersoll Ch, Knight KL and Worrell T. Agility following the application of cold therapy. J Athletic Training 1995; 30 (3):231-234.

Fleck SJ. Periodized Strength Training: A Critical Review. J. Strength Cond. Res. 1999; 13(1):82-89.

French DN, Thompson KG, Garland SW, Barnes Ch A, Portas MD, Hood PE and Wilkes G. The effects of contrast bathing and compression therapy on muscular performance. Med Sci Sports Exerc 2008; 40 (7):1297-1306.

Glickman-Weiss EL, Cheatham C, Caine N, Blegen M, Marcinkiewicz J and Mittleman KD. The influence of gender and menstrual phase on thermosensitivity during cold water immersion. Aviat Space Environ Med 2000; 71 (7):715-22.

Goodall S and Howatson G. The effects of multiple cold water immersions on indices of muscle damage. J Sports Sci Med 2008; 7, 235-241.

Guyton and Hall (2005) Textbook of Medical Physiology. Ed. Saunders.

Holmér I and Bergh U. Metabolic and thermal response to swimming in water at varying temperatures. J Appl Physiol 1974; 37 (5):702-705.

Howard RL, Kraemer WJ, Stanley DC, Armstrong LE and Maresh CM. The effects of cold immersion on muscle strength. J Strength Cond Res 1994; 8 (3):129-133.

Hugh R. Contrast water immersion hastens plasma lactate decrease after intense anaerobic exercise. J Sci Med Sport 2007; 10:467-470.

Ingram J, Dawson B, Goodman C, Wallman K and Bilby J. Effect of water immersion methods on post-exercise recovery from simulated team sport exercise J Sci Med Sport 2008; doi:10.1016/j.jsams.2007.12.011.

Knight KL. Effects of hypothermia on inflammation and swelling. J Athl train 1976; 11:7-10.

Kuligowski LA, Lephart SM, Giannantonio FP and Blanc RO. Effect of whirlpool therapy on the signs and symptoms of delayed-onset muscle soreness. J Athletic Training 1998; 33(3):222-228.

Lane KN and Wenger HA. Effect of selected recovery conditions on performance of repeated bouts of intermittent cycling separated by 24 hours. J Strength Cond Res 2004; 18 (4):855-860.

López J. Estrés térmico y ejercicio físico en López J and Fernández A (coord). Fisiología del ejercicio. 3 edición. Madrid: Panamericana; 2006.

Llana S y Pérez P. Biomecánica de la natación. En Izquierdo M. (ed) Biomecánica y bases neuromusculares de la actividad física y el deporte. Madrid: Panamericana; 2008.

Llana S y Pérez, P. Historia de la natación. En Llana S y Pérez P (de) Natación y actividades acuáticas. Alcoy: Marfil: 2007.

Martel GF, Harmer ML, Logan JM, Parker CB. (2005) Aquatic plyometric training increases vertical jump in female volleyball players. Med Sci Sports Exerc. Oct;37(10):1814-9.

McMaster WC. Cryotherapy. The Physician and Sportsmedicine 1982; 10 (11):112-119.

Morton RH. Contrast water immersion hastens plasma lactate decrease after intense anaerobic exercise 2006;20 doi 10.1016/j.jsams.2006.09.004.

Nosaka K, Sakamoto K, Newton M and Sacco P. Influence of pre-exercise muscle temperature on responses to eccentric exercise. J Ath Training 2004; 39 (2):132-137.

Patterson SM, Udermann BE, Doberstein ST and Reineke DM. The effects of cold whirlpool on power, speed, agility, and range of motion. J Sports Science Medicine 2008; 7: 387-394.

Peiffer JJ, Abbiss CR, Nosaka K, Peake JM and Laursen PB. Effect of cold water immersion after exercise in the heat on muscle function body temperatura, and vessel diameter. J Sci Med Sport 2008; doi 10.1016/j.jsams.2007. 10.011.

Peyré-Tartaruga LA and Martins LF. Deep water running: limits and possibilities for high performance. Rev Bras Med Esporte 2006; 12 (5): 257e-261e.

Reilly T, Dowzer CN, Cable NT. The physiology of deep-water running. J Sports Sciencies 2003; 21 (12):959-972.

Ruiz DH, Myrer JW, Durrant E and Fellingham GW. Cryotherapy and sequential exercise bouts following cryotherapy on concentric and eccentric strength in the quadriceps. J Athletic Training 1993; 28 (4): 320-323.

Schniepp J, Campbell TS, Powell KL and Pincivero DM. The effects of cold-water immersion on power output and heart rate in elite cyclists. J strength Cond Res 2002; 16 (4):561-566.

Sellwood KL, Brukner P, Williams D, Nicol A and Hinman R. Ice-water immersion and delayed-onset muscle soreness: a randomised controlled trial. Br J Sports Med 2007; 41:392-397.

Siff MC and Verkhoshansky Y. Superentrenamiento. Barcelona: Paidotribo; 2000.

Srámek P, Simecková M, Janský L, Savlíková J and Vybíral S. Human physiological responses to immersion into water of different temperatures. Eur J Appl Physiol 2000; 81 (5):436-442.

Terrados N and Padilla S. (2004) Medios y métodos de recuperación físicos y fisioterapéuticos. In Terrados N, Mora R, Padilla S. (Eds) La recuperación de la fatiga del deportista. Gymnos.

Tikuisis P, Jacobs I, Moroz D, Vallerand AL and Martineau L. Comparison of thermoregulatory responses between men and women immersed in cold water. J Appl Physiol 2000; 89:1403-1411.

Tomas-Carus P, Häkkinen A, Gusi N, Leal A, Häkkinen K, Ortega-Alonso A. Aquatic training and detraining on fitness and quality of life in fibromyalgia. Med Sci Sports Exerc 2007; 39 (7):1044-1050.

Vaile J, Gill N and Blazevich AJ. The effect of contrast water therapy on symptoms of delayed onset muscle sorenees (DOMS) and explosive athletic performance. J Strength Cond Res 2007; 21 (3): 697-702.

Vaile J, Halson S, Gill N and Dawson B. Effect of hydrotherapy on recovery from fatigue. Int J Sports Med 2008; 29 (7):539-544.

van Tubergen A and van der Linden S. A brief history of spa therapy. Ann Rheum Dis 2002; 61:273-275.

Washington LL, Gibson SJ and Helme RD. Age-related differences in the endogenous analgesic response to repeated cold water immersion in human volunteers. Pain 2000; 89 (1):89-96.

Westerlund T, Oksa J, Smolander J, Mikkelson M. Thermal responses during and after whole-body cryotherapy (-110ºC). J Thermal Biology 2003; 28 (8): 601-608.

Takeshima N, Rogers ME, Watanabe E, Brechue WF, Okada A, Yamada T, Islam MM, Hayano J. (2002) Water-based exercise improves health-related aspects of fitness in older women.Med Sci Sports Exerc. Mar;34(3):544-51.

Tsourlou T, Benik A, Dipla K, Zafeiridis A, Kellis S. (2006) The effects of a twenty-four-week aquatic training program on muscular strength performance in healthy elderly women. J Strength Cond Res. Nov;20(4):811-8.

Zumdahl and Zumdahl (2006) Chemistry. Ed. Brooks Cole.

Nelson and Cox (2004) Lehninger Principles of Biochemistry. Ed. W. H. Freeman.

Wilmore and Costill (2007) Physiology of Sport and Exercise. Ed. Human Kinetics.

McArdle, W. D., Katch, F. I., Katch, V. L. (2006) Exercise physiology. Energy, nutrition, and human performance. Ed. Lippincott Williams and Wilins .

Journal of Physical Education an Sport Vol 23, no 2, June, 2009
e – ISSN: 2066-2483

SHORT PERSONAL PRESENTATION

***MANUSCRIPT:* WATER IMMERSION AS A POST-EFFORT RECOVERY FACTOR. A SYSTEMATIC REVIEW**

D. Ivan Chulvi Medrano.

(1) Qualifications
BSc – Physical Education (2007)
PhD candidate – Physical Activity and Sport Sciences (2009)
Personal trainer (1999).
NSCA Fellow
ACSM Fellow
(2) Research Interests
Physical activity and health.
Stregnth training.
Personal training.
(3) Professional data
PhD studente on Department of Sport and Physical Education (University of Valencia).
Faculty of Physical Activity and Sport Sciences.
Department of Physical Education and Sports.
University of Valencia.
c/Gascó Oliag,3 - 46010 - Valencia (Spain).
Tel. +34 96 3864352 // Fax. +34 96 3864353
Email: ichulme@alumniuv.es

Journal of Physical Education an Sport Vol 23, no 2, June, 2009
e – ISSN: 2066-2483

Dr. Salvador Llana Belloch

(1) Qualifications
BSc – Physical Education (1994)
PhD – Physical Activity and Sport Sciences (1998)
National Coach: Track and Field (1993), swimming (1995).
(2) Teaching subjects
Performance on individual sports – Athletics and Swimming,
Biomechanics of Physical activity.
(3) Research Interests
Analysis of sports performance (Biomechanical analysis of sport techniques and sport equipment).
Swimming biomechanics and Gait plantar pressure.
(4) Professional data
Teaching staff on Faculty of Physical Activity and Sport Science.
Faculty of Physical Activity and Sport Sciences.
Department of Physical Education and Sports.
University of Valencia.
c/Gascó Oliag,3 - 46010 - Valencia (Spain).
Tel. +34 96 3864352 // Fax. +34 96 3864347

Journal of Physical Education an Sport Vol 23, no 2, June, 2009
e – ISSN: 2066-2483

Dr. Pedro Pérez Soriano

(1) Qualifications
BSc – Physical Education (2000)
PhD – Physical Activity and Sport Sciences (2004)
Postgraduate in sport management (2003)
National Coach: Triathlon (1999).
(2) Teaching subjects
Performance on individual sports – Athletics and Swimming,
Biomechanics of Physical activity.
(3) Research Interests
Analysis of sports performance (Biomechanical analysis of sport techniques and sport equipment).
Swimming biomechanics and Gait plantar pressure.
(4) Professional data
Assistant Doctor on Department of Sport and Physical Education (University of Valencia).
Faculty of Physical Activity and Sport Sciences.
Department of Physical Education and Sports.
University of Valencia.
c/Gascó Oliag,3 - 46010 - Valencia (Spain).
Tel. +34 96 3864352 // Fax. +34 96 3864353
Email: pedro.perez-soriano@uv.es