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A REVISION OF THE CARDIOVASCULAR EFFECTS OF IMMERSION AND AQUATIC EXERCISE : CONTRIBUTION TO THE KNOWLEDGE OF POSSIBLE INDICATIONS AND RISKS OF CRENOBALNEOTHERAPY PROGRAMS

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Introduction

Exercise in aquatic environment has been progressively asserting itself as a common practice in spas. Its prescription must comply with very strict criteria since, in addition to the desirable health benefits that its practice can bring, there is a risk of side effects, sometimes serious, namely at the cardiovascular level. Among many health professionals, there is insufficient knowledge of the cardiovascular effects of immersion. Perhaps for this reason, the enormous potential of aquatic exercise as a mean of prevention, treatment and rehabilitation of numerous pathologies, including cardiovascular ones, is not sufficiently used. We therefore find it useful to recall in this article the physiology of immersion, through a succinct review of these effects, including those that may constitute risk.

Progress in the treatment of heart disease results in a reduction in its mortality across Europe. This increases the number of chronic patients who can benefit from cardiac rehabilitation programs, defined as a multidisciplinary intervention aimed at improving the patient's functional status after an acute cardiac event, or in the context of chronic heart disease. Only a small percentage of these patients enter cardiac rehabilitation programs due to the lack of available offer. Therefore, there is a need to find alternatives for better adherence to healthy lifestyles and control of these cardiovascular risk factors, as well as for a more adequate coverage of the cardiac rehabilitation network.

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The effects of immersion and aquatic exercise have been increasingly investigated, particularly in cardiac patients and their use as a safe environment for carrying out cardiac rehabilitation programs. Thus, conditions are met to consider establishing cardiac rehabilitation programs in spas. For this development, however, it is essential to define rigorous criteria for indications and contraindications, as well as to define the necessary conditions for the establishment of these programs in the spas, namely in terms of facilities, equipment, human resources, capacity to respond urgently to the occurrence of clinical complications.

Cardiovascular effects on hydrotherapy

When we talk about cardiovascular effects on hydrotherapy we must consider separately the physiology of water immersion (in rest) from the physiologic responses during water exercise.

Part I - Physiologic effects of water immersion (rest)

The physiologic effects of water immersion (rest) were early historical described more than 3000 years ago, as we may know from Persian, Hindu, Chinese, Greek or Roman papers. Modern science emphasizes also the mechanisms behind these effects.
A dive reflex occurs as a response to various immersion conditions such as facial immersion, body immersion with the head out of water, during water exercise or hydrokinesitherapy, complete immersion (with or without apnoea) as during underwater swimming or scuba.

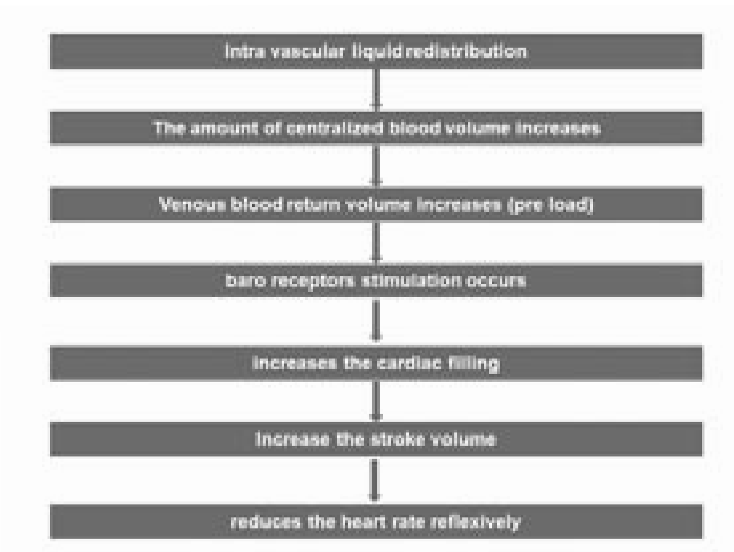

Fig 1 – Circulation changes and heart rate after water immersion

The dive reflex was postulated by Irving in 1963. It is possible that multiple and competitive neural and mechanic factors are involved in human response to immersion. Its interaction perform an important role in all this process.

Bradycardia has a protective role to maintain the body temperature by avoiding heat loss. Secondarily contributes for blood pressure regulation and doesn't reduce the oxygen demand to protect human body from hypoxia or to extend the time of apnoea.

There are several dive reflex mechanisms. As intervenient factors we may consider temperature depth hydrostatic pressure, gravidity, facial wetting, posture / position of the body, apnoea, intra-pleural pressure as well as other factors (anxiety, anticholinergic drugs, etc.).

Regarding temperature different effects may occur depending if the water is very cold, cold, warm or hot. Cold temperature decreases heart rate by two mechanisms : cold receptors distributed on trigeminal area cause neural reflex bradycardia; vasoconstriction originates blood deviation to thoracic area, increasing the venous blood return which elevates the atrial filling, the contractility (Starling law) and the stroke volume. To maintain cardiac outflow the heart rate must than decrease.

Some studies seem to show that the lowest the temperature is the more you get bradycardia. But you probably got a limit of this response. Between 20ºC and 10ºC there is no significant difference in the heart rate. At 10ºC a pressure response elevates the heart rate. Body temperature also seems to interfere with this process. Immersion of the body at 36°C –37ºC, with the head out of water, causes dilatation of peripheral blood vessels and increases the heart rate.

Resume (Tuttle and Corleaux) : cold water immersion reduces heart rate, warm or hot water increases heart rate, neutral temperature doesn't change it.

Gravidity still operates underwater, but has much less influence. The reduced effect of gravidity during immersion causes a deviation of the blood from the lower limbs to the upper part of the body, namely the thoracic segment. This process starts immediately after the immersion but takes several hours to progress.

Factors that may change this mechanism are different levels of immersion, water temperature and depth.

We don't need total body immersion to obtain a bradycardia effect. Facial immersion is enough to cause it. The bradycardic effect is stronger when the whole body (including head) is immersed.

Regarding apnoea we may say that just covering the face of an apnoeic individual with a wet cold towel induces bradycardia. The immersion in apnoea reduces blood flow in the extremities (forearms and legs). Holding your breath diminishes heart rate in the normal atmosphere. Apnoea underwater produces a higher degree of bradycardia than apnoea in the atmosphere. Non apnoeic immersion may reduce this effect or even annul it. Concerning inspiration and expiration we should take in consideration that : the bradycardic effect is enhanced with the immersion after inspiration; apnoeic immersion after expiration elevates heart rate ; during apnoea tachycardia develops independently of intra-horacic pressure ; breathing re-start increases heart rate even if the arterial gas values are maintained.

Apnoea diminishes peripheral blood flow both in air and in water.

In what concerns facial wetting there is some controversy. There are some studies of diving with or without masks with different conclusions. There is a probable role of the cold temperature, a possible individual variation and for sure different thresholds or activity of trigeminal receptors.

Posture is also an aspect to be taken in count. The centralization of liquids during immersion occurs in a similar way independently of the body position (vertical or horizontal). This is of course different from what happens in open air where you may see a decrease in the heart rate when you change from a stand position to a prone one.

In the air the bradycardia that occurs when you bring down your head is caused by a baroreceptor response starting from an augmented venous return.

Part II - Physiologic responses to water exercise

Water represents a unique ambient to perform physical activity. Some physiologic responses to water exercise are different from those we may see on land. Exercise physiology is well studied when physical activity is performed in "open air". Concerning water exercise, there is a considerable amount of information about swimming. This is not the case in other water exercise modalities where less information is available. We will try to resume both the acute physiologic responses to the water exercise and the consequences or adaptation to the long term water training activity. We also want to emphasize the differences between land and water exercise, especially in modalities other than swimming, once they are the most commonly used in Therapy or in Rehabilitation.

Responses during exercise include aerobic energetic metabolism, maximal oxygen uptake, the anaerobic energetic metabolism, circulation, ventilation and temperature regulation.

Regarding Blood pressure we give you the example of the blood pressure response seen in a young man diving in water at two different temperatures :

- 25ºC 130 / 70 mm Hg
- 18ºC 200 / 100 mm Hg

To monitor the blood pressure in pools could be crucial. Often we can see responses such as the example above. As possible causes we may consider an insufficient cool down in the swimming pool after the exercise, circadian effects and alfa-stimulation.

Regarding Temperature we have :

- Between 35 and 37ºC : vasodilatation and higher cardiac rate ;
- Between 27 and 31ºC : mammal's diving reflex (lower cardiac rate) ;
- Between 15 and 20ºC : higher ventricular irritability other with or without apnoea.

Rhythm disturbance

Even in neutral temperatures cardiac rhythm abnormalities can occur. Sudden death is a real risk among coronary patients. As causes, may be that the forces of immersion and the horizontal position of the body increase the central volumes and central pressure. The same sequence may also be responsible for an overload on the left ventricle with a decreased work capability of the patient.

Arms exercise

- The great component of work done by the arms during swimming originates a bigger peripheral vascular resistance than the work of the legs on land with the same load.
- With any given sub-maximal work load arms exercise in coronary ischemic patients results in higher VO_2, systolic BP, heart rate and cardiac outflow.

Explanation : we have here a higher peripheral vascular resistance, because there is less degree of vasodilatation since we have a smaller vascular area in the pectoral and arm muscles. Simultaneously a higher vasoconstriction occurs in the larger vascular structures of the muscles that are not under effort (such as the leg ones).

In the immersion on humans there is no reduction on oxygen demand. In cold water there is an increase in oxygen consumption in conscientious individuals, a variable bradycardia and peripheral vasoconstriction, an acute sensitivity to temperature and more risk of arrhythmias.

The time of apnoea diminishes in cold water when compared with what happens in warm water or in the air. This is due because in cold water oxygen demand are increased.

Pay attention to

- Sudden vasoconstriction
- Bradycardia
- Increase in cardiac volumes
- Abnormal rhythms
- Less tolerated in older people
- Less tolerated in cold water

Suggestions to minimize risk

- Avoid sudden dives
- It’s better to enter the water slowly
- Wet first your hands and your face
- Avoid cold temperatures
- Respect a cool down period before leaving the water

Conclusion

The considerations we presented are crucial to prescribe and perform a safe hydrotherapy program in thermal ambience. Besides this water immersion physiology knowledge it is essential to assess every individual risk level before consider any treatment. Particularly in the case of Aquatic Cardiac Rehabilitation Programs the risk escalation is absolutely mandatory.

Cardiac Rehabilitation Programs (CRP) preconize individually, quantified, safe and independent exercise, to achieve a daily optimal physical activity level and fitness ; better psychological, social, working and emotional conditions, associated to life style chances in patients with Cardiac Disease.
Protocols are based in physical principles and psychological effects of water immersion; acute and chronic physiological and subjective responses to aquatic exercise ; training adaptations ; aquatic protocols for cardiac patients and subjective fatigue, pain and effort scales.
As an example of the results of these programs we mention a study performed in the Centro Hospitalar de Entre Douro e Vouga, conducted by Luis Coimbra and Catarina Branco shows that :

- Individual adaptations to water exercise depend in partial body water immersion, hydrostatic pressure, density, fluctuation, water temperature, deep inspiration, pulmonary volumes and subjective impressions ;
- There was a decrease in blood pressure, heart rate and subjective scales score ;
- There was an increase in respiratory and musculoskeletal performance, during and after effort, comparing to land.

Physical performance improvement associated to patient motivation shows the importance of this reconditioning method in cardiac patients. So let’s think of the possibility of implementing exercise and cardiac rehabilitation programs in our thermal stations. Many patients may benefit from this. We have the concepts and the scientific bases for that purpose. It’s time to get all the others conditions.