Abstract

This study compared the differences in spatial relation, spatial ability and reasoning ability between female swimmers and sedentary people. Fifty-eight participants (24 swimmers and 34 sedentary females) were recruited to complete the PMA E & R tests (Primary Mental Ability Test) and the DAT-SR test (Differential Aptitude Test). Findings indicated that swimmers scored higher in spatial relations, spatial ability, and reasoning ability. The practice of competitive swimming appears to have a positive relationship with the spatial relation, spatial ability and reasoning ability.

Keywords: intelligence; spatial ability; spatial relationship; reasoning ability; swimming

Nowadays, the importance of physical / psychological balance is increasing in prominence and recognition in the world of sports. There are many athletes with high physical ability, but low psychological abilities. To recognize and to identify certain cognitive abilities in athletes can help us to focus on those factors inherent in sport.

Intelligence is a complex cognitive construct, particularly when applied to physical abilities, but the question is whether or not motor performance requires intelligence. Many researchers have discovered positive associations between sport experience and certain psychological variables. Many papers in the literature have tried to answer the question about whether physical activity is associated with the appearance of certain cognitive abilities. To answer this question, recent studies have observed a positive relationship between experience playing sports and high levels of spatial and reasoning

ability (García & Burgos, 2012; Shalar, Strikalenko & Ivaschenko, 2013). Other authors have suggested that aerobic exercise promotes cognitive development (Davis, Tomporowski, Boyle, Waller, Miller, Naglieri & Gregoski, 2007; Ellemberg & Deschenes, 2010; Hillman, Buck, Themanson, Pontifex & Castelli, 2009).

Physical activities have a positive impact on cognitive processes (Budde, Voelcker- Rehage, Pietraßyk-Kendziorra, Ribeiro & Tidow, 2008; Pesce, Crova, Cereatti, Casella & Bellucci, 2009). A positive relationship has been observed between sport experience and cognitive abilities in various sports including team sports, such as volleyball (Alves et al., 2013) and team handball (Zwierko, Florkiewicz, Fogtman & Kszak-Krzyżanowska, 2014) and individual sports like tennis table (Feng, 2014) and track and field athletics (Miranda & Pytel, 2014). We found studies that observed how swimming significantly promoted the development of intelligence in children. Certain studies of school children showed that those who performed water practices from babies, showed a higher on intelligence quotient than those who could not swim (Diem, Bresges & Hellmich, 1978; Wen, Sun, Luo & Wang, 2011). Diem (1979), reported similar findings on high levels of intelligence among early swimmers. He observed that children who learned to swim at an early age, demonstrated advanced development in reaction time, power of concentration and intelligence. Along the same line, Zatońl, Chrobotl, Kwaśnal & Zysiak (2013) found a positive correlation between levels of intelligence (abstract reasoning) in nine years old children and aims accomplished by them during subsequent lessons in the swimming teaching – learning process. Del Pino, Milán, Ríos, García & Pérez

(2009) observed that swimmers had a positive relationship with mathematics, visual and interpersonal intelligence.

Although there are studies interested in relating swim practice and development of intelligence in children, there is lack of studies aimed at understanding certain psychological characteristics of intelligence in adult competitive swimmers. In competitive swimming it is important to combine physical performance and psychological. We assume that an individual with a high level of physical capacity could carry out a physical task better than another with low capacity. Sports practice involves several factors: the number of decisions and diversity of intentions, the decision making time, the number of elements to remember, the level of uncertainty about the decision, the order and sequence of decisions and the risk level of the decision, etc. (Sánchez-Bañuelos, 1996). We consider that people who have better cognitive capacities will have an advantage in physical performance. This idea is supported by García & Burgos (2012). Their results show that physical prowess related to cognitive function.

In order to establish a strategy for achieving high performance in swimming and to make decisions about the proper training, it is necessary to know what are the psychological conditions of each swimmer, why certain results occur and what causes them. However, psychological skills training do not always exist within the sport planning (Weinberg, 1996).

This evaluation process should analyze different psychological variables such as intelligence of each swimmer, observing what their strengths and

weaknesses are, and based on that, begin to establish a training program that seeks optimal performance.

Considering that swimming is an individual sport in which self-discipline demands is a critical variable for achieving higher performance in swimming, it seems necessary to determine those specific psychological characteristics in swimmers.

Therefore, recognize and identify a psychological profile in competitive swimmers, can help us decide on those factors inherent sport in the mental aspect.

The aim of this study is to compare the differences in spatial relation, spatial ability and reasoning ability between a group of swimmers (SW) and a group of sedentary people (SE).

Method

Participants

The sample was formed by 58 female participants (24 swimmers and 34 sedentary individuals). The sample was further divided into a swimmers group and sedentary group.

Swimmers group (SW). The swimmers group (SW) was comprised of 24 female swimmers (m = 19.21 years, SD = 2.12). The inclusion criteria for membership in this group included 1) being older than 16 years and registered in any Madrid swim club; 2) training regularly at least two hours a day, 4 days a week; and 3) competing currently at a regional or national level.

Sedentary Group (SE). The sedentary group was comprised of 34 female participants (m = 19.44 years, SD = 1.46). The inclusion criteria for membership in this group included 1) being a college student in Madrid; and 2) not fulfilling the ACSM (2013) recommendations for physical activity during the last two years.

Measures

The instruments applied in this study were the Primary Mental Ability Test (PMA E & R tests) (Thurstone & Thurstone, 1943) and the Differential Aptitude Test (DAT-SR test) (Bennett, Seashore & Wesman, 1959).

PMA R. Reasoning is the capability to solve logical problems, provide, and plan. In this test composed of 30 items, the subject is asked to determine which letter completes a sequence, finding the logical relationship that links them.

PMA E. E, the space factor is the "static display" factor defined as the capability to interpret and recognize a change of position in space, maintaining the internal structure among objects. The test consists of 20 items, each of which presents a model with six similar figures. The subject's task is to determine which of these figures matches the pattern, even if they were drawn on the same plane in a maximum time of 5 minutes.

DAT – SR. This is a spatial orientation test. This test is comprised of eight skills. We used the Spatial Relations (Form L). The purpose of this test is to assess one of the principal intellectual abilities. This test (60 items) requires manipulating objects in three-dimensional space mentally. For each item, there

are four figures of which one was correct.

Procedure

Participants took part in the research voluntarily. Our convenience sample was recruited by asking volunteers from different swimming clubs in Madrid, Spain and at the University of Madrid. Participants completed the tests under the supervision of a researcher. Written informed consent was obtained from all participants following a verbal and written briefing.

Statistical Analysis

Statistical analysis was completed using SPSS version 21.0 (Statistical Package for Social Sciences Inc., Chicago, IL, USA). The level of significance was set at *p value* less than 0.05.Calculation of mean, standard deviation, symmetry and kurtosis was performed. Inferential analyses were calculated using two-way ANOVAs.

Results

Descriptive statistics of the SW and SE group descriptive statistics are shown in Table 1. The SW scores were 7.52 higher than the SE in spatial relation. Similar results occurred in spatial ability (4.61) and reasoning ability (5.89).

Table 1. Descriptive Statistics of SW and SE

		Mean	SD	Min	Max	Asymmetry	Kurtosis	CI
DAT	SW	41.70	10.57	21	58	-0.11	-0.93	39.75 - 48.46
	SE	34.18	9.31	12	49	-0.69	0.12	30.92 - 37.43
PMA E	SW	26.76	11.01	11	54	0.89	0.28	23.65 - 32.46
	SE	22.15	8.87	2	38	-0.12	-0.32	18.85 - 25.44
PMA R	SW	22.95	3.76	16	30	0.01	-0.56	21.32 - 25.42
	SE	17.06	4.82	8	27	0.06	-0.77	15.52 - 18.59

Differences between SW and SE

There were significant differences between groups in the three intelligence variables. SW has higher scores in spatial relation, namely 7.52 points ($p = 0.001$), in spatial ability 4.61 points ($p = 0.036$) and reasoning ability, 5.89 points higher ($p<0.001$) compared to SE.

Table 2. ANOVAs between SW and SE

	F	df	p-value	Partial Eta square	Observed power
DAT	13.45	1	0.001	0.209	0.949
PMA E	4.65	1	0.036	0.084	0.562
PMA R	24.45	1	<0.001	0.324	0.998

Discussion

Recent researchers agree in stating that sport is associated with the development of certain cognitive abilities (Alves et. al, 2013; Miranda & Pytel, 2014). García

& Burgos (2012) analyzed the relationship between physical prowess and cognitive function in elite and amateur sport people, showing that elite gymnastics people presented higher cognitive abilities than amateur sports people. Our results support the idea that the practice of swimming has a positive relationship with cognitive function.

Therefore, it is necessary to know and understand what are the psychological variables related to the practice of swimming. Are these variables modified or accentuated by practicing sports? Or is the practice of swimming influenced by athlete intelligence?

Thus, it was decided to analyze the psychological profile of the swimmers and to observe differences in intelligence between this group (SW) and SE. We have assessed that SW show a different psychological profile than SE, showing higher scores on spatial relation, spatial ability and reasoning ability than SE. We consider that this difference can be due to certain factors: a) training that swimmers have carried out over the years, in which they have learned to fit the movement of the body to external conditions of space and time; b) prior selection occurs in developing swimmers. That means that only those with high abilities can carry out elite swimmers, so it is normal to find such a profile in this kind of people.

These results coincide with previous researches (Faubert, 2013; Mann, Williams, Ward, & Janelle, 2007). Notarnicola, Maccagnano, Pesce, Tafuri, Novielli, & Moretti (2014), suggested that volleyball and tennis players had higher level of spatial ability than non – athletes.

It may be inferred that the SW scores higher than the SE in spatial relation and in spatial ability, because swimming is linked to spatial perception. Before swimming (motor response), the swimmer needs a spatial evaluation. Before and during a competition, the swimmer has a spatial perception, deals with spatial constraints (in this case the dimensions of the lane) as well as with the visual perception of the opponents. In addition, the motor actions required perception, decision-making, and execution. These different perceptions justified how swimming can improve levels of visual-spatial ability (Mann et al., 2007).

Regarding reasoning ability, the results between athletes and non-athletes concur with the finding from García & Burgos (2012). SW is presented as a group of subjects with greater ability to solve problems, draw conclusions and learn intentionally, establishing causal and logical connections.

Several researchers suggest a positive relationship between cognitive abilities and physical practice (Alves et al, 2013; Budde et al., 2008; García & Burgos, 2012; Miranda & Pytel, 2014). In these studies analyzed people performing coordinative physical activities, just like it occurs in swimming. The practice of physical activities used by these authors in their studies is not too different from the one we analyzed, because swimming is a sport which requires a high degree of coordinated movements.

Our results are consistent with those found in recent research (Alvis & Pulzara, 2013) in which it has been observed how athletes have higher scores in certain cognitive abilities such as spatial ability. These results suggest the

196 opportunity to investigate whether the practice of swimming has a positive
197 influence on the development of certain variables intelligence, or if a subject
198 with high scores on spatial relation, spatial ability and reasoning ability will be
199 inclined to practice swimming.

200 Results found in our study allow us to consider that a relationship exists
201 between cognitive abilities and swimming. Our data support the idea that
202 intelligence, a useful variable in sports performance, could be useful in different
203 contexts, like training, education or in the process of selecting the best sports
204 people.

205 **Limitations**

206 Following the approach of Jensen (1998), it would have been relevant apply
207 more than one test to establish measures of intelligence variables. Finally, our
208 study does not determine whether the origin of the changes found is due to
209 aspects of self sample or to evolutionary changes. Despite these limitations, our
210 study has the merit of being the first to examine the differences for spatial
211 relation, spatial spatial and reasoning ability between competitive swimmers
212 and sedentary people.

213 **Conclusions**

214 The psychological profile of competitive swimmers is characterized by having
215 relatively high levels of spatial relation, spatial ability and reasoning ability
216 when compared to a sedentary group. In addition, there are individual
217 differences in certain intelligence variables between the swimmer and the
218 sedentary control group.

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