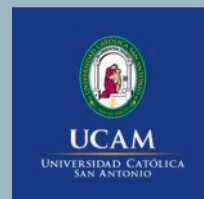


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The pre-participation physical evaluation: fact or fiction?

El reconocimiento médico de aptitud deportiva, ¿realidad o ficción?

Gonzalo Correa González

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A pre-participation physical evaluation can be defined as an evaluation or examination carried out by a doctor on an athlete in order to determine if the latter is eligible for sports activity or if it is contraindicated for them.

It seems obvious that medical examination of the state of health of an athlete should be performed prior to carrying out any regular physical activity to detect conditions that may cause injury or damage, and especially to prevent sudden death, the personal, social and media impact of which is irreparable.

Sudden death in sports is largely due to cardiovascular diseases and anomalies, and a lot of scientific literature has been published to explore the various aspects that characterise such deaths and the measures which should be taken to avoid or reduce their incidence.

There can be little doubt that the most important and effective strategy in the prevention of sudden death in sports consists of specific medical examinations to check the suitability of the subject for sporting activity. Thanks to such examinations, we can learn about the athlete and screen for cardiovascular diseases which could lead to undesirable consequences.

The European and American criteria for such evaluations differ quite considerably, the most notable differences focussing on their cost, the need to apply them to all athletes and, most controversially, the inclusion of a resting electrocardiogram in the process.

Taking into consideration the main European reference document, which embodies the consensus reached by different branches of the European Society of Cardiology, the implementation is encouraged of a common European screening protocol which would include a 12-lead ECG for all individuals who perform intense exercise on a regular basis, after providing them with adequate information regarding its benefits and limitations, and an exercise ECG for those who present moderate, high or very high cardiovascular risk (atheromatous disease), or a biological age of over 35.

In Spain, the Act on the Protection of the Health of Athletes and the Fight against Doping in Sports, amended by Royal Decree-Law 3/2017 of 17 February, states that an effective policy for the protection of the health of athletes and people who perform sports must be established. The specific minimum measures provided for include the obligation to carry out medical examinations prior to the issuance of official federation licenses in those sports where they are considered necessary in order to better prevent risks to the health of the athletes involved. Certain aspects must be taken into account depending on the characteristics of the sport, the exertion and other physical conditions needed to do it, the environmental conditions in which it is carried out and the specific needs of women and men, minors and people with disabilities; all to protect the health of the athlete.

At present, the pre-participation physical evaluation seems to float between reality and fiction...

On the one hand, from a medical-legal point of view, we know what we should do (minimum content of the examination), who should do it (a specifically trained medical professional), when (regularly, periodicity) and to whom (licenced and non-licenced athletes with moderate weekly activity). Such is the reality.

Meanwhile, from a practical point of view, what happens enters the realms of fiction...

In the pre-season and prior to issuing federation licences, medical examinations are needed in many sports disciplines. The bodies/clubs/associations/federations normally need these to be completed quite urgently, but there is almost always one common denominator: to do them at the lowest possible cost.

For many sports federations, passing a pre-participation physical evaluation is not a requirement for a license, and those federations that do require one -and the cost of such evaluations depends on them- do juggling acts to save on money; so much so that they propose a pre-

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participation physical evaluation performed over several appointments, with the consequent impoverishment of the quality and integration of clinical information, the negative repercussions of which, as I see it, ultimately affect the athlete.

First, a medical examiner, usually not a specialist in sports medicine or with specific training in conducting medical evaluations, performs a clinical examination and compiles the subject's case history.

Then a resting 12-lead ECG is recorded by nursing staff.

Thirdly and lastly, a remote interpretation of the results of the ECG is provided by a specialist doctor who does not see the patient/athlete at any time; all to save money.

Such procedures are not recommended by scientific societies in their consensus documents and although they may be legal, they should never be more than fiction.

I invite bodies/clubs/associations/federations to reflect deeply on the importance of the pre-participation physical evaluation and to comply with the recommendations of the consensus documents available for the purpose.

Our primary interest must always be to care for the health of our patients/athletes.

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Performance profile for ILCA class elite sailors. Differences between men and women

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Summary

In sport sailing, there are three fundamental pillars of performance for dinghy sailors (physical condition, cognitive ability and equipment). One of the decisive moments in a single-handed dinghy race is sailing upwind, as it requires a high physical demand from the sailors to keep the boat flat and make the best decisions according to the tactical conditions of the race. The objective of the research is (i) to analyze the performance of elite sailors on the hiking position in a dynamic virtual sailing situation and (ii) to measure the lower body muscle fatigue in the hiking action. The sample consisted of 10 sailors from the Ilca sailing class and belonging to the Olympic teams of the Norwegian, Mexican and Spanish national teams, 6 of them men ($M_{age}=31.67$, $SD_{age}=6.861$) and 4 women, ($M_{age}=30.50$, $SD_{age}=4.655$). The fatigue protocol consisted of a static test and a dynamic test of the sac body position. Both tests measure the sailors' effort up to extreme fatigue or loss of position. The test was performed on the vSail-Trainer® sailing simulator, which allows to reproduce real sailing conditions and displays data on boat control variables. The results obtained show statistically significant differences between the group of women and men on boat speed ($P=0.039$), distance sailed ($P<0.001$) and hiking effort ($P=0.002$). There are statistically significant differences in lower body power pre and post fatigue test. This does not lead to the conclusion that the simulator is a valid tool to assess fatigue specifically in Ilca class sailors.

Key words:

Olympic sailors. Ilca class. Fatigue test. Sailing simulator.

Perfil de rendimiento de regatistas de élite de clase ILCA. Diferencias entre hombres y mujeres

Resumen

En la vela deportiva, tres son los pilares fundamentales del rendimiento de los regatistas de vela ligera (condición física, capacidad cognitiva y material). Uno de los momentos determinantes en una regata de vela ligera individual es la navegación en el rumbo de ceñida, ya que requiere de los regatistas una alta demanda física, para llevar la embarcación plana y tomar las mejores decisiones según las condiciones tácticas de la regata. El objetivo de la investigación es (i) analizar el rendimiento de regatistas de élite sobre la posición de sacar cuerpo en una situación dinámica de navegación virtual. (ii) medir la fatiga muscular del tren inferior en la acción de sacar cuerpo. La muestra fueron 10 regatistas de la clase Ilca de navegación y pertenecientes a los equipos olímpicos de las selecciones nacionales de Noruega, México y España, 6 de ellos hombres ($M_{edad}=31,67$, $SD_{edad}=6,861$) y 4 mujeres, ($M_{edad}=30,50$, $SD_{edad}=4,655$). El protocolo de fatiga estuvo compuesto por un test estático y un test dinámico de la posición de sacar cuerpo. Ambos test miden el esfuerzo de los regatistas hasta la fatiga extrema o hasta perder la posición. El test se realizó en el simulador de vela vSail-Trainer®, el cual permite reproducir condiciones reales de navegación y muestras los datos sobre variables de control de la embarcación. Los resultados obtenidos muestran diferencias estadísticamente significativas entre el grupo de mujeres y hombres sobre la velocidad de la embarcación ($p=0,039$), distancia navegada ($p<0,001$) y *hiking* ($p=0,002$). Existen diferencias estadísticamente significativas en la potencia del tren inferior pre y post test de fatiga. Esto no lleva a concluir que el simulador es una herramienta válida para valorar la fatiga de forma específica en regatistas de clase Ilca.

Palabras clave:

Regatistas olímpicos. Clase Ilca. Test de fatiga. Simulador de vela.

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Introduction

In competitive sailing, there are three fundamental aspects to dinghy sailors' performance. Firstly, the material that is used in competition, such as the vessels and the sails. Secondly, the sailors' cognitive skills, such as the ability to understand and predict weather conditions, the capability for tactics and technique at each moment of the race. Finally, the sailor's physical ability, such as strength, muscle power and aerobic and anaerobic capacity^{1,2}. These three determining performance factors have changed over time, mainly the sailors' physical and cognitive skills, due to the current level of competition.

If we focus on this latter aspect, the sailors' physical capacity is the area of performance most studied to date, with over 50% of research focussed on aerobic, anaerobic, muscle strength, strength, power, Heart Rate (HR) or body composition, among others³⁻⁷. Most of this research looks at dinghy sailors, using single- or double-handed vessels. However, the same physical requirements are not required of sailors in all of them. This is why the types of vessels should be differentiated plus the demands for each of them^{7,8}. Six classes competed at the last Olympic games (Tokyo 2021), in men's, women's and mixed categories. Out of these vessels, it should be mentioned that 1 is windsurf, thereby competing on a board, 3 are double-handed vessels and 2 are single-handed vessels. There are classes where the classifications are different for men and women, as the sail sizes adjust to each gender (male and female), and the sail is smaller for women, as happens in the ILCA and RS-X classes. In other classes such as the 470, classifications are different for men and women, but the vessel is the same, with no difference in the sail surface area. Most research found so far on Olympic class sailors uses single-handed boats as they require sailors to combine cognitive and physical skills. This does not usually happen in double-handed vessels, where one of the crew is usually more physical and the other has better cognitive skills and makes decisions^{9,10}.

One of the determining moments in an individual dinghy race is sailing on a close-hauled course, as it is physically demanding on the sailors to keep the vessel flat and to make the best decisions according to the tactical race conditions¹¹. This race situation produces the most physically demanding action which is the hiking position. For the sailors to make the vessel move as hydrodynamically as possible (flat), they must take their centre of gravity as far as possible from the boat's centre line, merely using the strap in the centre of the vessel which supports the arch of both feet. Many research projects have looked at leaning-out in static situations¹²⁻¹⁴, where the crew must remain in this fully extended position for as long as possible. Over time, it has been demonstrated that, in real sailing situations, this position is dynamic, not static, during sailing, where the crew perform a balancing movement, to synchronise the heel of the boat, with the gusts of wind, the waves and/or the presence of other vessels¹⁵.

Simulators have been used for this reason and due to the difficulties of measuring sailors' performance during this technical action. Simu-

lators used to date have evolved from static benches, which are not the same size as a real vessel¹²⁻¹⁴, up to semi-submersible simulators that simulate various wind conditions, with the dimensions of a real boat^{9,15-17}.

In this regard, this research uses a semi-submersible sail simulator, which represents real sailing conditions in a laboratory-controlled environment, thereby making it easier to measure fatigue indicators in the implicated muscles, directly after performing the action. Consequently, this research aims to provide a reliable tool to measure topflight sailors' performance. The aim of the research is to (i) analyse elite sailors' performance over the hiking or leaning-out position in a dynamic virtual sailing situation. (ii) measure lower body muscle fatigue in the leaning-out action. (iii) Men will have greater sailing performance than women in terms of sailing speed and hiking variables. (iv) After the test, the lower body power will drop in both sexes, and it can be affirmed that the tool is valid to measure fatigue in a specific sailing situation.

Material and method

Sample

The sample for this research was made up of 10 sailors from the former Laser class and the Ilca sailing class. They all belong to national Olympic teams, for Norway, Mexico and Spain, 6 were men, with $M_{age} = 31.67$, $SD_{age} = 6.861$ and 4 women, with $M_{age} = 30.50$, $SD_{age} = 4.655$. Table 1 shows the anthropometric values for both groups. They had all participated in international races in world championships and pre-Olympic races.

The ethics committee from the lead author's university authorised the research (reference number for the institutional review board CE021912). All applicable institutional standards were followed relating to the ethical use of human volunteers (such as the Declaration of Helsinki). Informed consent was obtained in writing from all participants, who were informed exhaustively about the study.

Table 1. Body composition descriptors.

	Men's group			Women's group		
	N	Average	SD	N	Average	SD
Age	6	31.67	6.86	4	30.50	4.65
Weight	6	81.88	2.18	4	61.52	3.39
Height	6	182.17	6.01	4	167.00	3.74
BMI	6	24.82	1.81	4	21.85	0.85
% fat	6	14.03	4.18	4	18.40	1.40
% water	6	63.53	1.56	4	61.08	0.37
Muscle mass	6	68.07	1.81	4	47.95	5.63
Bone mass	6	3.55	0.10	4	2.60	0.18

Procedure

The fatigue protocol comprises two parts: a static test and a dynamic test. Before carrying out the protocol, the yachtsman will run a familiarisation protocol with the simulator, to eliminate the learning component from the performance. This was followed by muscle activation, to prepare the crew for a sub-maximal effort. After a warm-up, and before and after the fatigue test, the sailors performed 2 counter movement jump tests (CMJ).

The sailors chose their preferred side to perform the test, as the dinghy can be sailed either side. All the sailors chose to perform the test on the starboard side (Figure 1). As the literature confirms, the sailors obtain better performance by sailing on the starboard side rather than port¹⁸.

The first test was an isometric test (quasi-isometric) where the simulator was stopped, permanently tilted 5 degrees and fixed as such. The sailors had to grab the sheet and the tiller and hold the hiking position for as long as possible. The test finished when the sailor lost their initial position. This aims to achieve a point of reference for maximum performance.

The second test was performed in a dynamic sailing simulation situation with a wind intensity of 16 knots. The men sailed with the Ilca 7 dinghy sail dimensions and the women used the Ilca 6 dinghy size, as in real situations. They were asked to keep the boat on a close-hauled course for the whole time, with the boat flat or as flat as possible, to maintain maximum performance. To get greater implication from the sailors, the boat's velocity indicator was fitted, asking them to follow this course as fast as possible until reaching maximum fatigue.

Figure 1. Sailors performing the strength test.



Instruments and variables

The muscle power test using the CMJ jump was performed on a contact platform (Chronojump® DNI-A1). This instrument provided the lower body power values and jump height.

The strength test was performed on the sail simulator (vSail-Trainer®), designed by the Virtual Sailing Pty Ltd company, the vSail-Trainer®. The simulator comprises two parts. The first is the hardware, made up of the vessel cockpit and a laptop. The computer controls the second element of the simulator, which is the software for the virtual simulation, the sailing conditions, the projection and the sound of the simulated situation. The cockpit comprises a boat hull, an electronic system and a hydraulic arm. The electric system controls the hull, which is connected to the computer that controls the sailing conditions (wind and intensity). The cockpit was the same as the Ilca vessel, which helps the simulator reproduce the sailor's real situation movements. The simulator works like a real boat, with a tiller to control the course/direction and a sheet to control the main sail. The simulator reproduces the boat's list angle, which means that the sailors have to continually adjust their position in relation to the heeling. The size of the image projected was 2.00 m x 2.50 m for this study, to reproduce real dimensions¹⁹.

The variables evaluated with the simulator were as follows:

- Isometric time: this refers to the number of seconds that the subjects could maintain the hiking position during the static test, where they must maintain the isometric position.
- Dynamic time: this refers to the number of seconds that the subjects could maintain the hiking position during the dynamic test, where they must sail as fast as possible in the close-hauled course, maintaining the hiking position.
- Total distance sailed: number of metres sailed during the test,
- Speed: average speed sailed during the test, measured in knots.
- Hiking: average force exerted during the action of taking the body out during the test, measured in Newtons.
- Point of sail: the average angle of the vessel against the direction of the wind. As this is a sailing test on a close-hauled course (45°), they must stay as close as possible to this point of sail.
- Heeling angle: average value of the vessel hull's lateral angle during the test. This angle is counteracted by the force exerted to lean out or hike.
- Tiller variability: midpoint value of the degrees of variation made by the sailors on the tiller. The larger the angle, the more resistance the tiller gives to the vessel displacement.
- VMG: (Velocity Made Good): understood to be the optimum velocity of the vessel in relation to the course, expressed in knots. The higher the VMG, the greater the performance.

Statistical analysis

The IBM SPSS v.24.0 statistics programme was used to analyse the data. Preliminary tests were run on suppositions to check that the variances were homogeneous, and the variables were normal. The Levene

and Shapiro-Wilks tests were carried out to confirm the suppositions of variance and normality, respectively ($p > 0.05$).

The averages and the standard deviations were calculated for all study variables, for each group (men and women). To compare the differences between the groups, a t-test was performed for independent samples (male group and female group). To compare the differences in lower body power variables pre and post test, the t-test was performed for related samples on both groups, before and after the dynamic sailing test. The level of statistical significance was set as $p < 0.05$ (confidence interval of 95%).

Results

The results for the sailing variables do not demonstrate statistically significant differences between men and women over time or duration of both tests (dynamic and isometric). On the contrary, statistically significant differences are found over the distance sailed ($p < 0.001$), velocity ($p = 0.039$), hiking ($p = 0.002$) variables during the performance of the dynamic test, where the results of these three variables were higher among men than women (Table 2).

Regarding the jump power and jump height results before and after dynamic sailing, we find statistically significant differences between the pre-test and post-test for the jump power variables ($p = 0.02$) and the jump height ($p = 0.005$) in the group of men (Table 3). The results are lower in both variables after carrying out the dynamic sailing test.

Similar results are seen for the group of women, obtaining statistically significant differences between the pre-test and post-test for the jump power variables ($p = 0.006$) and jump height ($p = 0.001$). The results for both variables are lower after the dynamic sailing (Table 4).

Discussion

Taking into account the objectives set out in this research, (i) analyse elite sailors' performance in the hiking position in a dynamic

virtual sailing situation. (ii) measure lower body muscle fatigue in the leaning-out action.

Concerning the first objective and due to adjusting the sail surface area on the ILCA 7 vessel (men) and 6 (women), we consider that there are no differences in the performance of male and female elite sailors. The results show differences in the sailing test between men and women in 3 sailing variables: total distance sailed, sailing velocity and hiking mean, where the results are greater in the group of men over all three variables. The performance in these three variables is interconnected, as greater hiking means that the boat sails flat, generating less resistance with the water (hydrodynamic) and consequently higher velocity²⁰⁻²³. We might think that the heeling could be affected by the effort made during the hiking action and the wind intensity^{24,25}. However, in this case, as we have data on the vessel's heeling angle, we can see that there are no statistically significant differences between the result for men (4.28 ± 2.37) and women (4.17 ± 1.65). Consequently, it is not a matter of hydrodynamics as both groups have the same heeling. We

Table 3. Descriptors for the strength and power test among men.

	Men's group pre		Men's group post		p	Average difference
	Average	SD	Average	SD		
Power	3,879.5	235.78	3,704.2	138.74	0.020	175.33
Height	36.0	4.10	32.3	2.94	0.005	3.67

Table 4. Descriptors for the strength and power test among women.

	Women's group pre		Women's group post		p	Average difference
	Average	SD	Average	SD		
Power	2,656.8	282.10	2,451.0	303.06	0.006	205.75
Height	30.0	2.58	26.5	2.65	0.001	3.50

Table 2. Sailing variables descriptors.

	Men's group			Women's group			p	Average difference
	N	Media	DS	N	Media	DS		
Isometric time (s)	6	207.00	48.175	4	178.50	31.395	0.331	28.500
Time in dynamic (s)	6	363.83	31.410	4	344.25	77.629	0.587	19.583
Total distance sailed (m)	6	1,144.74	37.131	4	896.86	81.448	<0.001	247.876
Velocity (kn)	6	6.24	0.496	4	5.36	0.63	0.039	0.878
Hiking (N)	6	1,590.78	114.74	4	1,173.36	180.94	0,002	417.422
Sailing angle (°)	6	53.89	3.24	4	50.09	1.84	0.069	3.804
Heeling angle (°)	6	4.28	2.37	4	4.17	1.65	0.942	0.104
Tiller variability (°)	6	2.94	1.48	4	4.31	0.34	0.114	-1.370
VMG (kn)	6	3.65	0.25	4	3.33	0.18	0.063	0.325

believe that the hiking difference is due to the greater sail surface area on the men's boat, so the effort to maintain the minimum heel during closehaul must be greater for the men than the women. In this respect, it is worth considering that the men do not present greater strength in relative values than the women. Therefore, the first study hypothesis is partially confirmed, taking into account the latter insight.

Regarding the sailing velocity variable, we can see that the men are capable of sailing faster than the women and so this makes them sail further. This might be due to trimming the sheet. During close-hauled sailing, the crew have the sail's telltales, which indicate their optimum trim. In this respect, during the sailing test, if the group of women did not have optimum closing or as close to the optimum as the men's group, this might be due to fatigue. This fatigue can take place in two different ways. (i) that, due to physical fatigue, if the sail is closed in optimum conditions, the boat will heel by more degrees and the sailor is incapable of continuing to hike to obtain the best performance, so they ease the sail by a few centimetres, losing velocity, but maintaining the minimum heel that they can control with muscular fatigue^{15,26,27}. (ii) that due to physical fatigue, the sailor experiences cognitive fatigue meaning that they cannot focus on the telltales (places with relevant information) and they lose velocity in line with their loss of attention on the location that provides relevant information⁹.

In response to the second objective, to measure muscular fatigue of the hiking action, the CMJ test was used before and after the dynamic sailing test, which takes participants to maximum fatigue. We can see that, in both the men's and women's group, there are statistically significant differences between the pre-test and the post-test for the jumping power and jump height variables. These results demonstrate that this dynamic sailing test takes the sailors to a real fatigue situation in the close-hauled course, when reproducing sailing conditions that require the hiking technique. Until now, simulators have not reproduced realistic sailing conditions that assimilate the test with a real situation^{18,28}. The results demonstrate that in a simulated situation this sailing test is a tool that really produces muscular fatigue in the main musculature implicated in the hiking technique, thereby confirming the second study hypothesis. Consequently, we defend that, henceforth, for sailors, the strength tests in a similar situation to their sailing situation, leaving behind bicycle ergometer tests or treadmills, are unspecific for this type of population.

Conclusions

After review and discussion of the results, we can conclude that the fitness of the male and female sailors in the Ilca class is a determining factor for the dinghy performance. Although the differences between them are not physical when achieving maximum performance, as shown by the boat's control variables, we consider that fatigue affects cognitive capacity, which can determine differences in performance, in other words, fatigue tolerance.

On the other hand, we consider the simulator as a valid tool to assess fatigue specifically among sailors in individual classes, where the hiking position determines sailing performance. The simulator can adjust to the class of vessel and the weather conditions encountered in real situations.

Study limitations

The study is limited by a very small population, despite being Olympic level sailors, the statistical analysis can be affected by the small number of subjects being analysed.

It would be very interesting to run this test at different points in the season, as the sailors' fitness will affect their performance in the sailing test.

Conflicts of interest

The authors declare that there is no conflict of interest.

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A systematic review on the application of Aikido as a psychosomatic tool in therapeutic setting (Part I)

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Summary

It is our contention that Aikido may have sufficient support for its use in complementary therapies in the field of clinical treatment. However, as far as we are aware, no extensive scientific studies highlighting the application of Aikido as a psychosomatic therapy in the field of psychological behavioural disorders has been carried out. Our aim here was to conduct a systematic review of scientific studies associated with the possible psychosomatic benefits of Aikido practice and to examine whether there is any theoretical basis for this psychosomatic health connection. In terms of methodology, a systematic review of published scientific literature on health and Aikido was conducted in adherence with PRISMA guidelines. Three aspects of the application of Aikido were identified, one corresponding to phases more susceptible to psycho-emotional instability such as during the period of adolescence; another aspect related to the treatment of overcoming trauma in subjects with post-traumatic stress disorder and the final aspect related to the improvements as a result of the practical intervention of mindfulness. It is evident from our review, that the treatment of Aikido as a discipline with psychotherapeutic potential requires further expert analysis from a cross-disciplinary and interdisciplinary perspective, which would involve establishing a suitable intervention model in order to attain a deeper understanding of the discipline of Aikido. Moreover, a mastery of the field of psychology and psychiatry is required to understand the internal cognitive processes of the subjects studied.

Key words:

Proprioception. Mindfulness. Martial arts. Complementary therapy. Health. Well-being.

Palabras clave:

Propiocepción. *Mindfulness*. Artes marciales. Terapia complementaria. Salud. Bienestar

Una revisión sistemática sobre la aplicación del Aikido como una herramienta psicósomática en sectores terapéuticos (Parte I)

Resumen

Hasta donde tenemos conocimiento no existe un campo de carácter científico extenso de la aplicación terapéutica de relación psicósomática en el Aikido, en el entorno de los trastornos y afecciones psicológicas del comportamiento. Partimos de la hipótesis de que el Aikido podría tener un respaldo suficiente en su uso en terapias complementarias al ámbito de los tratamientos clínicos. Nuestra finalidad fue realizar una revisión sistemática sobre los estudios de carácter científico asociados a los posibles beneficios psicósomáticos de la práctica del Aikido y comprobar si hay una teoría entre esta conexión de salud psicósomática. Metodológicamente se realizó una revisión sistemática de la literatura científica publicada en materia de salud y Aikido. Para su elaboración se han seguido las directrices de la declaración PRISMA. Se observan tres vertientes de aplicación del Aikido, una correspondiente a fases más susceptibles de inestabilidad psicoemocional como es la adolescencia. Otra vertiente relacionada con el tratamiento de superación de traumas en sujetos con trastorno por estrés postraumático y una última relacionada con la mejora de los aspectos relacionado con la intervención práctica de *mindfulness*. Se evidencia que el tratamiento del Aikido como una disciplina con potencial psicoterapéutico que requiere de un mayor análisis de expertos desde una perspectiva transdisciplinar e interdisciplinar, que permita encontrar un modelo de intervención idóneo para tener un conocimiento más profundo de la disciplina del Aikido. Además, se requiere un dominio del campo de la psicología y de la psiquiatría que permita entender los procesos cognitivos internos de los sujetos estudiados.

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Introduction

It was in the 1960s that the germ of scientific studies exploring the psychological dimension of Martial Artists began. This is the case of Kroll & Carlson in 1967¹ whose aim was to investigate the personality profiles of participants in amateur karate. Three years later Kroll & Crenshaw in 1970² described the personality traits among karatekas, comparing them with gymnasts, football players and wrestlers. In the same year, Pyecha³ defined the personality traits of Judo in relation to other sport disciplines. In 1980, Rothpearl⁴ obtained a considerable sample size of 152 karate practitioners for the study of personality. Fuller⁵ after analysing the psychological traits common to Martial Arts students, reflected on the transfer of training programmes to other population groups and the expectation of their psychological benefit. It was from 1980 onwards that there was a more convincing approach to the psychotherapeutic applications of Martial Arts, with Aikido appearing for the first time in this field of study⁶. And, it was in the 1980s and 1990s that Aikido featured in the academic world as a Martial Art with an acknowledged psychotherapeutic potential, intervention and psychological application.

Benedetti⁷ pointed out that sportsmanship or competition strips Aikido of its essence and that, moreover, Aikido is not just a grouping of oriental fighting techniques, such as is the case of competitive Judo or Karate. Aikido, besides being a Martial Art originating in Japan in the samurai tradition, gives the human being access to another way of being, to a real change⁸. It is thus a highly sophisticated Martial Art which is different from other Martial Arts⁹.

Aikido as a method was created and developed by Morihei Ueshiba (1883 Tanabe-1969 Iwama) in Japan between 1930 and 1960¹⁰. For Morihei Ueshiba, Aikido was the continuation of a syncretic process that began in Japan in the early 17th century, in which the traditional fighting arts (*bushido*) were transformed into disciplines of character development and paths to self-realisation (*budo*)¹¹. This process evolved thanks to the contributions of Chinese and Indian doctrines that shaped the Nipponese spirit, influenced by Zen Buddhism, Taoism and Confucianism⁸. It is, in essence, the consequence of an evolution and adaptation of many Martial Arts systems integrated into a single Eastern philosophical thought process⁶.

Aikido goes beyond the concept of combat, and aims to rediscover a state of psychophysical balance¹² that allows the spontaneous harmonisation of one's existence with the cosmos⁸. Aikido is literally broken down into the following parts: *ai* (union), *ki* (energy), and *do* (way). These three elements have been translated in different ways although they always derive the same meaning: the method or way (*do*) for the harmony or union (*Ai*) of the mental energy or spirit (*ki*)⁶. It is known, for example, that the proprioception factor is one of the most crucial senses for the survival of the human being with a networked system that extends throughout the organism. In this context, survival proprioception plays a fundamental role in the bonding between aikidokas (Aikido practitioners)¹³. Sanati *et al.*¹⁴ locate this essential factor in the joints and specifically through body contact of the wrists as a site of physical conflict and vulnerability in Aikido practitioners. This process of movement control is governed by a trait of 'self-stimulation' or circular action of the nervous system with the environment in which it interacts¹⁵. Proprioception, although most of the time managed unconsciously, is fundamental

to the human experience as it allows us to adapt to our environment. It has been described that the sense of proprioception is constituted by populations of neurons or mechanosensors distributed throughout the body known collectively as proprioceptors¹⁶. These are generators of proprioceptive impulses or afferent neuronal excitatory flow that travels to higher structures such as the cerebellum, sensorimotor cortex and hypothalamus. It is noted that states of abnormal emotional tension are relieved in various relaxation therapies by reducing proprioceptive impulses impinging on the posterior hypothalamus. The hypothalamus is a neuroendocrine integrating organ located in the central region of the brain that regulates emotional balance. Therefore, the management of proprioception in human development is essential for harmonious human behaviour¹⁷.

The model of overcoming the original martial character acquired by Aikido has been a process of transformation unprecedented in the history of Martial Arts. In the practice of Aikido, a vital philosophy is forged based not only on experiencing symbolic defeat without losing one's life, but on symbolic victory unified for both practitioners. As mentioned previously, all the philosophical and religious sources of Aikido such as Zen Buddhism, Taoism and Confucianism⁸ make the discipline of Aikido very different from other Martial Arts. This fact has been due to the capacity of synthesis of the Japanese people throughout history with a tradition of the various currents of thought⁸.

Undoubtedly, Aikido was chosen by Morihei Ueshiba to be the discipline which would transfer the best of traditional arts into a product of ancient wisdom¹⁸. This diverse legacy endows Aikido with certain therapeutic potential value based on how we approach this Art or system of bodily interaction. Lukoff & Strozzi-Heckler¹⁹ approach the character of Aikido by alluding to the psychological healing potential in the incorporation of meditation, concentration and breathing techniques from Zen Buddhism. Lukoff & Strozzi-Heckler¹⁹ further point out that the combination of features such as social contact, physical exertion and, above all, a practice of compassion and self-compassion give Aikido substantial psychosomatic benefits. Morihei Ueshiba distinguishes between body and spirit in terms of a human-being's make-up. For Morihei Ueshiba, the body was that which could blur the light of the spirit and Aikido the means to enlighten the being again⁸. In this sentence of Ueshiba, we can see the therapeutic purpose of Aikido and how, from the beginning, the union between *psyche* and *soma* is a close one.

In this way, the very idiosyncrasy of Aikido means that it creates a very significant symbolic psychosomatic relationship between the pair of practitioners during practice and this is at the origin of its creation. The practice translates into a continuous bodily self-analysis of how to overcome a conflict or struggle in addition to survival and awareness of the other. Morihei Ueshiba implements a modern methodology based on how to manage and resolve an attack in the most relaxed way possible. From the point of view of *tori* (in the role of receiving an attack from *uke*)⁹ points out that the purpose of Aikido is to resolve a physical conflict, managing the attack in the most harmless way and without harming the attacker. Saposnek⁶ describes that the role of *uke*, the attacker, is challenging *tori*, to provoke the confrontation and demonstrate his power over *tori*. The message can literally be translated as: 'you will not be able to change me because I am more powerful than you when I attack you'. This 'conflict', however, becomes an 'opportunity' to learn and

teach the challenger more constructive and harmless ways of asserting their power. The challenger *uke* must accept the mastery of *tori's* role, not to resist and accept the change they teach you if you are open to it. So *uke* must assume that it is useless to act by force based on the principle of non-resistance in order not to experience harm and thus learn 'non-aggressiveness'. Snell²⁰ in this sense, transcribes the shared subjective experience of what he calls 'intersubjective states' of four aikidoka, in the first person, with foundations from Western phenomenology, Zen Buddhism and Shinto, somatic and choreographic practices.

Aikido is a system of interaction of circular forces, undifferentiated cause-effect relationship, mixed for mutual conflict resolution (neutralisation of aggression and redirection of energies) where duality (good-evil, friend-enemy) is eliminated in order to enter into the unity of the relationship⁶. Aikido in its essence is based on overcoming the duality model of 'I win and you lose', to 'you win and I win', a prerequisite for healthy personal relationships from a psychosocial point of view⁹ where the component of proprioceptive and emotional regulation is a key factor of this model of interaction. In this way, 'enemies' are cognitively and deliberately re-educated to be 'partners' and 'attacks' are 'opportunities'. Furthermore, the blurred perceptual boundaries between self and other are reinforced, helping to refocus negatively connoted situations to neutral and non-threatening ones⁵.

In spite of all of this established research regarding the psychosomatic dimension of Aikido, to the best of our knowledge, there is no extensive scientific field of therapeutic application of this psychosomatic relationship in Aikido applied in the fields of psychological disorders. For this reason, and given the particular characteristics of this Martial Art in its origin, we decided to analyse the reviewed academic bibliography of Aikido to check if this analysis would support our hypothesis regarding Aikido and its possible application to therapies related to the fields of psychology and psychiatry. Therefore, we proposed to carry out a systematic review of the scientific studies associated with the possible psychosomatic benefits of the practice of Aikido and to check if there is a theory between this connection of psychosomatic health and proprioception in pairs.

Material and method

In this study a systematic review was conducted of the published scientific literature on proprioception and Aikido in adherence with the PRISMA guidelines for systematic reviews²¹. The process of elaboration involved different phases which are detailed below.

Initial phase / systematic search

The first searches were conducted during the first quarter of 2022 by combining the terms 'aikido', 'proprioception', 'physical sense' and 'health' in the databases Web of Science, Scopus, Ebsco-Host, Dialnet, PubMed, ScienceDirect and Sport Discus. Subsequently, a combination, using the Boolean operators 'and', 'or' or 'near' was used to include both terms, i.e., aikidō (the Japanese term 合気道、合氣道, and its romanised equivalent), proprioception, sensitivity, kinaesthesia as well as their English translations. Martial Arts was a catch-all term used in

the Dialnet or Ebsco-Host databases to find the associations with Aikido as it could itself be part of another semantic or knowledge field. These searches yielded a considerable number of results, some of which were duplicated or of little use to the review. Aikido and Health terms were entered into all the databases, to establish a comparative framework between studies applying Aikido within the field of both Physical and Psychological Therapies.

Inclusion and exclusion criteria / application filters

Once the study of the field of application and the possible combinations of the terms of interest had been carried out, appropriate criteria were applied for each filter to select the results.

For the first filter consisting of reading the 'Title of the manuscript', the search was restricted to scientific journal articles, excluding other publications such as letters, commentaries, editorials, articles for which only abstracts were available, book chapters, final works such as undergraduate, postgraduate or doctoral theses (inclusion criterion 1). No date limitation (inclusion criterion 2) or linguistic restriction was imposed on the search (inclusion criterion 3), given the specificity of the topic, with the exception of articles written in Asian languages whose abstracts were not translated into English (exclusion criterion 1).

According to these criteria, and on the basis of the title alone, 51 articles were considered eligible (after eliminating duplicates between databases), as the subject matter did not correspond to the topic to be addressed. The second filter was applied, the reading of the abstract of the article, and from this reading 32 were discarded, as the subject matter had to be contextualised within the area of knowledge of Aikido and health (inclusion criterion 4) or the field of application of the previously associated terminology (n = 19). Next, we proceeded to the third level or filter, the reading of the 'body of the article'. This stage took into account the existence of Aikido training programmes and the analysis of this intervention on the subjects (inclusion criterion 5). Protocols that were merely descriptive of the technical skills of Aikido learning development were excluded (exclusion criterion 2). In addition, any kind of theoretical essay or dissertation on psycho-cognitive skills that did not focus on the practical application of improvement skills was excluded as well (exclusion criterion 3) (n=11). The remaining articles were included because of their subject-specific therapeutic treatment of these psychocognitive skills (n=8). Finally, 8 articles met the inclusion criteria and were selected for the systematic review. All of them aimed at our objective, i.e. to establish a relationship between Aikido and health aspects related to therapy and psychocognitive functional improvement (Figure 1).

Manual search

Lastly, Google Scholar was used with the combinations seen in previous searches to check whether any articles that had not appeared in the previous searches might have been left out. After applying the corresponding filters, the four articles found were not included as they were duplicates of those found in other databases already consulted. The results obtained in the different databases and the choice of articles in order to elaborate the flow chart are shown below (Table 1).

Figure 1. Adaptation of the filtered phases regarding the inclusion/exclusion criteria of the systematic review to a Flow Diagram.

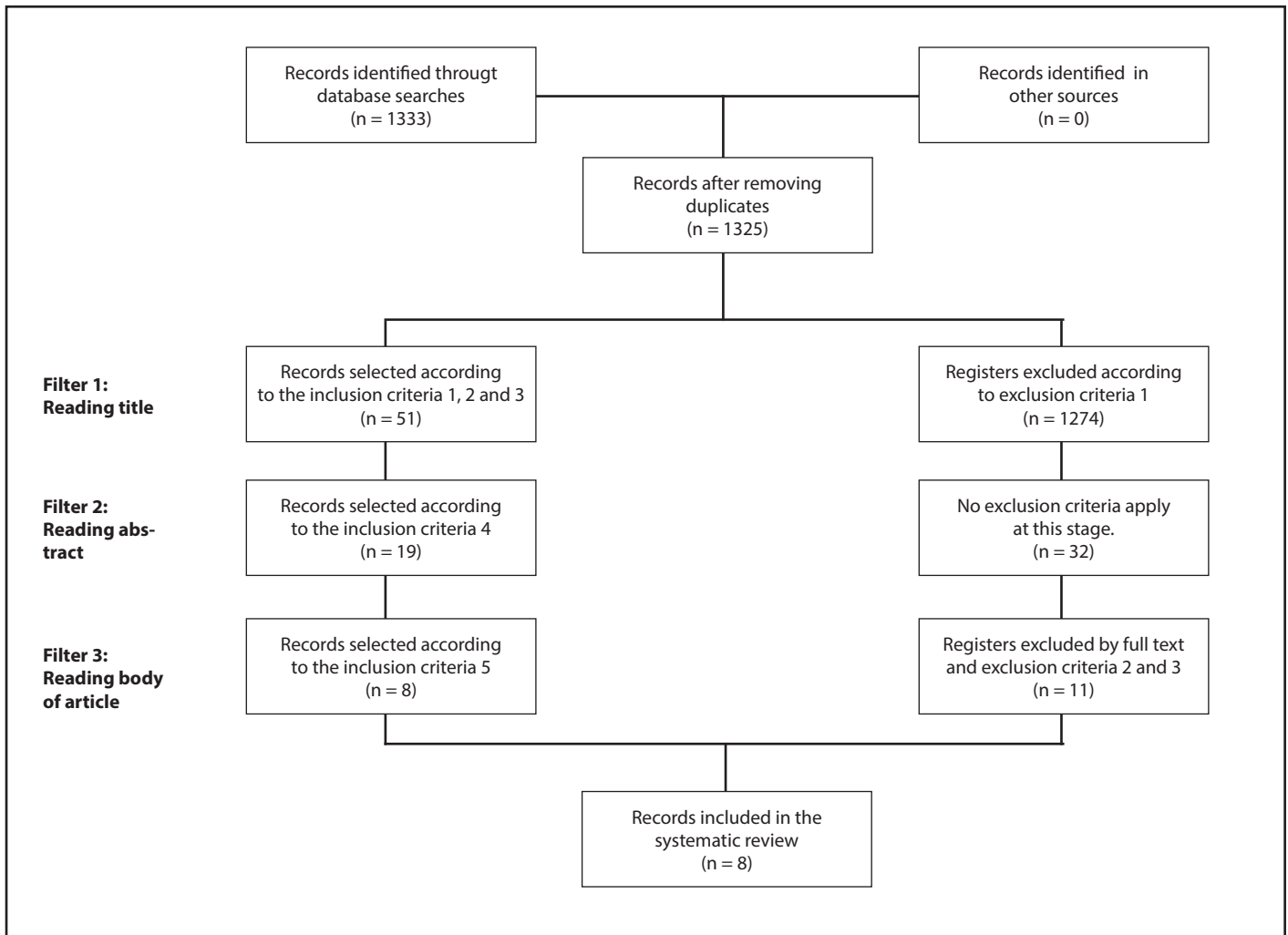


Table 1. Filters used for each database.

Database	Title reading	Abstract reading	Article reading
Web of Science	9	5	2
SCOPUS	7	2	0 (duplicates)
DIALNET	3	0	0
Sport Discus	12	3	2
PUBMED	14	6	4
Science Direct	6	3	0
Total	51	19	8
Google Scholar*	19	4	0 (duplicates)
Total	70	23	8

(*) A supplemental search on Google Scholar was conducted to ensure the systematic review. This last check confirmed that the final total results were definitely eight.

Results

From this search, our findings point to the 1990s as the starting point when the discipline of Aikido began to be incorporated into intervention programmes for the study of the emotional regulation of aggression²², and indeed, whether the practice of Aikido had any affect on self-esteem, anxiety and anger²³. It took more than a decade before studies related to the association of Aikido work with mindfulness²⁴ and its correlation with anxiety disorder²⁵, emerged. For example, Weiss *et al.*²⁶ implemented a programme applying Aikido instructions as a treatment for ex-war veterans suffering from Posttraumatic Stress Disorder (PTSD). Szabolcs, Szabo & Köteles²⁷ study among other oriental forms of physical activity what kind of affect the practice of Aikido and the study of the variable flow experience would have. Ben-Soussan *et al.*²⁸ study variables related to mindful movements. Elsewhere, Szabolcs *et al.*²⁹ evolve to a more complex analysis to analyse the impact of the practice on spirituality, mindfulness, body awareness, and self-compassion (Table 2).

Table 3 shows the methodological characteristics of the studies found. We can classify two large groups, those studies that directly select Aikido practitioners by passing questionnaires to them or by carrying out tests through cohorts of their practice, studying their effects before and after their training^{23,24,27} or in a cross-sectional manner comparing Aikido practitioners directly with other populations^{28,29}. Another group where an intervention programme is applied based on the characteristics of Aikido and designed exclusively for the subjects to practise this Japanese Martial Art for the first time are pre-adolescent initiates, i.e., 22 young university students²⁵ and war veterans with PTSD²⁶.

Table 4 reflects a wide range of variables analysed with each of its scales in which the authors have examined, the extent to which, Aikido

can be inferred in terms of modifying the management of emotions that make up the personal behavioural traits of each individual. Firstly, we find frustration, tolerance, problem behaviours, self-control and aggressive behaviour²²; secondly, self-esteem, state-anxiety and anger²³; and thirdly, self-esteem and anger²⁴; fourth, PTSD and symptoms of depression²⁶; fifth, mindfulness and the psychic and somatic components of anxiety²⁵; sixth, flow experience (in other words, skill-challenge harmony and oneness with the experience) and positive affect and negative affect²⁷; in seventh Mindful Movement (Time-production task and Homolateral interlimb coordination task)²⁸; and finally, spirituality, mindfulness, body awareness, and self-compassion²⁹.

Table 2. Descriptive data.

Authors (Year)	Title	DOI	Journal	Location*
1 Jorge Delva-Tauillili (1995)	Does brief Aikido training reduce aggression of youth?	10.2466/pms.1995.80.1.297	<i>Perceptual and Motor Skills</i> . 80:297-298	Hawaii, Honolulu (USA)
2 Yumi Akuzawa Foster (1997)	Brief Aikido Training versus Karate and Golf Training and University Students' Scores on Self-Esteem, Anxiety, and Expression of Anger	10.2466/pms.1997.84.2.609	<i>Perceptual and Motor Skills</i> . 84:609-610	Wichita, Kansas (USA)
3 John Lothes II, Robert Hakan, Karin Kassab (2013)	Aikido Experience and its Relation to Mindfulness: A Two-Part Study	10.2466/22.23.PMS.116.1.30-39	<i>Perceptual & Motor Skills: Learning & Memory</i> . 116(1):30-39	Wilmington, North Carolina (USA)
4 Tobias C. Weiss, Benjamin D. Dickstein, Joseph E. Hansel, Jeremiah A. Schumm, Kathleen M. Chard (2017)	Aikido as an Augment to Residential Posttraumatic Stress Disorder Treatment	10.1037/mil0000194	<i>Military Psychology</i> . 29(6):615-622	Cincinnati, Ohio (USA)
5 Rodrigo Cuéllar Hidalgo, Aldo Bazán Ramírez, Gerardo Alonso Araya Vargas (2019)	Effects of Aikido practicing on mindfulness and anxiety in Costa Rican university students	10.47197/retos.v0i35.62044	<i>Retos</i> . 35:13-19	San José (Costa Rica)
6 Zsuzsanna Szabolcs, Attila Szabo, Ferenc Köteles (2019)	Acute Psychological Effects of Aikido Training	10.33607/bjshs.v112i1.778	<i>Baltic Journal of Sport & Health Science</i> . 1(112):42-49	Budapest (Hungary)
7 Tal Dotan Ben-Soussan, Joseph Glicksohn, Antonio De Fano, Federica Mauro, Fabio Marson, Manuela Modica, Caterina Pesce (2019)	Embodied time: Time production in advanced Quadrato and Aikido practitioners	10.1002/pchj.266	<i>Psychology Journal</i> . 8:8-16	Roma (Italy)
8 Zsuzsanna Szabolcs, Barbara Csala, Attila Szabo, Ferenc Köteles (2021)	Psychological aspects of three movement forms of Eastern origin: a comparative study of Aikido, Judo and Yoga	10.1080/11745398.2020.1843507	<i>Annals of Leisure Research</i> 1-21	Budapest (Hungary)

(*) Location of the Research Group from which the interest in carrying out a quasi-experimental analysis on the analysis of psychological variables in Aikido has arisen.

Table 3. Objectives and methodologies.

Authors (Year)	Objective	Sample	Design	Intervention*
1 Delva-Tauillili (1995)	To examine whether the practice of Aikido, a non-violent Japanese martial art, effectively reduces aggressive behaviour of preadolescent youth	42 Male Preadolescent Youth, Asian and Pacific Islanders aged 9-12 years (Experimental group: 21 subjects; Control group of 21 subjects on waiting list)	Pre-test and post-test mean scores were performed and compared between the control and experimental groups, before and after 2 weeks of daily training from Monday to Friday	Training on the Basic Principles of Aikido with a methodological structure adapted in the school for pre-adolescents

(continue)

Table 3. Objectives and methodologies (continuation).

Authors (Year)	Objective	Sample	Design	Intervention*
2 Foster (1997)	To investigate if Aikido training is effective in improving selected aspects of personality	69 volunteers were university physical education students from Ohio State University and Stanford University. The 4 initiation groups were divided into three modalities: experimental group of 20 Aikido initiates, 24 karate initiates, 13 golf initiates. There was also a control group of 12 golf initiates	Pre-test and post-test of the means of the variables were carried out over a period of 10 weeks of training	Aikido initiation course in the University context
3 Lothes II, Hakan, & Kassab (2013)	To examine the potential association of training in Aikido may have on mindfulness	179 adult participants over 18 years of age were recruited via email and online. Study I: Experimental group: 159 participants (111 male, 48 female) Aikido students. Control group: 20 participants (4 male, 16 female) psychology students with no martial arts experience. Study II: Experimental group: 12 volunteer Aikido practitioners (3 females, 9 males). Control group: 20 psychology students (13 females, 7 males)	Study I: A cross-sectional data collection for the questionnaires for each subject was carried out online. It took 5 months to collect the 159 surveys and the levels of experience were compared with the ranks acquired and the length of practice experience Study II: Longitudinal design of the experimental group with a control group	Study I: There was no training programme designed <i>ex-profeso</i> within the context of Aikido schools in the USA. Study II: A design was made to insert Mindfulness practices during their Aikido training
4 Weiss <i>et al.</i> (2017)	To examine the effects of augmenting an evidenced-based residential Posttraumatic Stress Disorder (PTSD) treatment program for veterans with group-based instruction in Aikido	193 Former Vietnam War veterans (108 men/85 women) receiving residential treatment for Post-Traumatic Stress Disorder at a Midwest Veterans Affairs Medical Center. Cognitive processing therapy was part of their primary treatment	Quasi-experimental cohort design with a 7-week follow-up for an overall duration of 52 months. Measurement cohorts were applied to both groups of 85 women and 108 men assigned to practise Aikido and non-Aikido in such programmes	Specially designed programme as complementary therapeutic treatment for war veterans
5 Cuéllar, Bazán & Araya (2019)	To examine the effect of practising Aikido on mindfulness and anxiety state in university students with no previous experience in martial arts	24 students from the University of Costa Rica. The experimental group consisted of 12 students from different careers (10 males and 2 females; ages 18-62 years); and the control group consisted of 12 students from the Bachelor in Human Movement Sciences (9 males and 3 females; ages 21-34 years)	Quasi-experimental design, with pre- and post-treatment measurements, with one experimental group and one active control group. Implementation programme based on an 11-week training programme (two weekly sessions of 2 hours each)	Specially designed programme in a context outside of Aikido schools
6 Szabolcs, & Szabo, Kőteles (2019)	To examine for the first time the hypothesis that Aikido training, like many other western forms of organised physical activities, has acute psychological benefits as manifested via favourable changes in affect and the flow experience	53 participants were recruited from Aikido clubs of the Aikido Foundation in the metropolitan area of Budapest aged 18-57 years (85% male-15% female). who practised Aikido as a regular recreational activity	Cohort design at least 3 surveys data collections were conducted for one of the variables and another at least 1 time	The programme included the Aikido sports schools' own training sessions
7 Ben-Soussan <i>et al.</i> (2019)	To examine the effect of Mindful Movements (MMs-specific types of mind-body coordination-demanding physical activity) on Time Perception (TP)	34 healthy adults volunteered, including 11 practitioners of Aikido (4 males and 7 females) and 9 practitioners of advanced Quadrato Motor Training (4 males and 5 females) and 14 physically inactive controls (7 males and 7 females)	A mixed observational study	There was no specific design. They were collected directly from the Aikido Schools
8 Szabolcs <i>et al.</i> (2021)	To examine four characteristics rooted in Eastern philosophy and religious practice, i.e spirituality, mindfulness, body awareness, and self-compassion in healthy individuals	Experimental group of 265 subjects (Aikido with n= 121, 18% female: average age 37+11 years; Yoga with 75, 84% female, average age 44+11 years)- Control group with 76 subjects, 67% female, average age 27 + 9 years old	Cross-sectional study collecting survey data via online questionnaires from subjects belonging to their own sports schools	There was no intervention programme or implementation in the design

*Context of Aikido intervention in this study based on the phases, exercises and fundamentals that are developed in its routines or training protocols.

Table 4. Variables, scales of measurement and results.

Authors (Year)	Psychological, somatic, cognitive and emotional variables	Scales and measures	Relevant results	Conclusions
1 Delva-Tauiiili (1995)	<ul style="list-style-type: none"> - Frustration tolerance - Problem behaviours - Self-control - Aggressive behaviour 	<ul style="list-style-type: none"> - Teacher's Self-control Rating Scale and on aggressive behaviour - Subscales of the Child Behaviour Rating Scale 	No significant differences were found in aggressive behaviour and self-control between the Aikido group and the control group	Methodological limitations such as the lack of randomisation in the groups and the short training time are not sufficient to have a significant effect
2 Foster (1997)	<ul style="list-style-type: none"> - Self-esteem - State-anxiety - Anger 	<ul style="list-style-type: none"> - Self-esteem Scale - State-trait Anxiety Inventory - Anger Expressions Scales from the State-Trait Anger Expression Inventory 	No significant differences were found between the pre-test and post-test in the Aikido group in terms of self-esteem, state anxiety, trait anxiety or anger expression. The Karate group showed significantly lower means on trait anxiety, state anxiety and anger expression	The subjects should be observed for several years of training to evaluate changes in test scores
3 Lothes II, Hakan, & Kassab (2013)	<ul style="list-style-type: none"> - Mindfulness Skills - Mindfulness attention awareness 	<ul style="list-style-type: none"> - Kentucky Inventory of Mindfulness - Skills and Mindfulness Attention Awareness Scale 	The results of both studies show significant increases in mindfulness scores with Aikido training	This kind of field of knowledge requires longitudinal designs and empirical research to progress further
4 Weiss <i>et al.</i> (2017)	<ul style="list-style-type: none"> - Posttraumatic Stress Disorder (PTSD) - Depression symptom 	<ul style="list-style-type: none"> - PTSD Checklist Stressor Specific Version (PCLs) - Clinician Administered PTSD-Scale (CAPS) - Beck Depression Inventory: Second Edition (BDI-II) 	Female veterans who received Aikido experienced a greater decrease in self-reported PTSD and depression symptoms during treatment. No benefits were found in men	The results of this study are affected by certain limitations such as not using a randomised design, which increases the risk of possible therapist and Aikido instructor effects. Furthermore, a better understanding of the mechanism underlying Aikido needs to be developed to help clinicians
5 Cuéllar, Bazán & Araya (2019)	<ul style="list-style-type: none"> - Mindfulness - Psychic Component (PC) of anxiety - Somatic Component (SC) of anxiety 	<ul style="list-style-type: none"> - Mindfulness Attention Awareness Scale (MAAS) - Hamilton Anxiety Scale (HAS) 	Positive effects of Aikido practice on mindfulness and anxiety status were evident. Overall, Aikido practice showed significant effects on mindfulness and anxiety PC and a significant and small effect on SC	The results show that practising Aikido, as might be the case with other martial arts, brings a benefit in mood that exceeds that which can be obtained from regular physical activity as part of an active lifestyle
6 Szabolcs, & Szabo, Köteles (2019)	<ul style="list-style-type: none"> - Flow experience - Skill-challenge harmony - Oneness with the experience. - Positive affect and negative affect 	<ul style="list-style-type: none"> - 10-item psychometrically validate Hungarian version of this instrument (PANAS-HU) based in The Positive Affect Negative Affect Scale (PANAS) - The Hungarian Flow State Questionnaire (FSQ): derived from several versions of the Flow State Scale (FSS) 	The flow experience in aikidokas is similar to aerobic or spinning exercise. More experienced aikidokas reported a higher skill-challenge harmony than less experienced martial artists	These findings reveal relatively clearly for the very first time in the literature that Aikido practice has acute, or immediate, psychological benefits similar to other martial arts and exercises
7 Ben-Soussan, <i>et al.</i> (2019)	<ul style="list-style-type: none"> - Time Production (TP): link bodily perception, human time perception and Mindfulness - Homolateral interlimb coordination - Creativity 	<ul style="list-style-type: none"> - TP/Time-production task - Homolateral interlimb coordination task - Creativity Task (Alternate Uses Task) 	No differences were found between the Aikido and the control group	Future studies should extend the current results, including a larger sample, several training regimes for interventional testing, and additional neuroscientific measures to investigate the hypothesized neural mechanisms
8 Szabolcs <i>et al.</i> (2021)	<ul style="list-style-type: none"> - Spirituality - Mindfulness - Body awareness - Self Compassion 	<ul style="list-style-type: none"> - The Spiritual Connection Questionnaire (SCQ-14) - Mindful Attention Awareness Scale (MAAS). 15-item scale - The Body Awareness Questionnaire (BAQ) - The Self-Compassion Scale (SCS) 	Generally, higher levels of mindfulness, spirituality, body awareness and self-compassion were found in the Eastern movement forms (Yoga, Aikido and Judo) in contrast to the controls. However, in comparison to Aikido and Judo, Yoga emerged to be the most prominent with respect to the examined four characteristics	Intervention studies are needed to explore the causal relationship(s) between these practices and the variables studied, which may lead to safe recommendations for selecting a specific activity for mental health benefits

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A systematic review on the application of Aikido as a psychosomatic tool in therapeutic setting (Part II)

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Summary

It is our contention that Aikido may have sufficient support for its use in complementary therapies in the field of clinical treatment. However, as far as we are aware, no extensive scientific studies highlighting the application of Aikido as a psychosomatic therapy in the field of psychological behavioural disorders has been carried out. Our aim here was to conduct a systematic review of scientific studies associated with the possible psychosomatic benefits of Aikido practice and to examine whether there is any theoretical basis for this psychosomatic health connection. In terms of methodology, a systematic review of published scientific literature on health and Aikido was conducted in adherence with PRISMA guidelines. Three aspects of the application of Aikido were identified, one corresponding to phases more susceptible to psycho-emotional instability such as during the period of adolescence; another aspect related to the treatment of overcoming trauma in subjects with post-traumatic stress disorder and the final aspect related to the improvements as a result of the practical intervention of mindfulness. It is evident from our review, that the treatment of Aikido as a discipline with psychotherapeutic potential requires further expert analysis from a cross-disciplinary and interdisciplinary perspective, which would involve establishing a suitable intervention model in order to attain a deeper understanding of the discipline of Aikido. Moreover, a mastery of the field of psychology and psychiatry is required to understand the internal cognitive processes of the subjects studied.

Key words:

Proprioception. Mindfulness. Martial arts. Complementary therapy. Health. Well-being.

Una revisión sistemática sobre la aplicación del Aikido como una herramienta psicósomática en sectores terapéuticos (Parte II)

Resumen

Hasta donde tenemos conocimiento no existe un campo de carácter científico extenso de la aplicación terapéutica de relación psicósomática en el Aikido, en el entorno de los trastornos y afecciones psicológicas del comportamiento. Partimos de la hipótesis de que el Aikido podría tener un respaldo suficiente en su uso en terapias complementarias al ámbito de los tratamientos clínicos. Nuestra finalidad fue realizar una revisión sistemática sobre los estudios de carácter científico asociados a los posibles beneficios psicósomáticos de la práctica del Aikido y comprobar si hay una teoría entre esta conexión de salud psicósomática. Metodológicamente se realizó una revisión sistemática de la literatura científica publicada en materia de salud y Aikido. Para su elaboración se han seguido las directrices de la declaración PRISMA. Se observan tres vertientes de aplicación del Aikido, una correspondiente a fases más susceptibles de inestabilidad psicoemocional como es la adolescencia. Otra vertiente relacionada con el tratamiento de superación de traumas en sujetos con trastorno por estrés postraumático y una última relacionada con la mejora de los aspectos relacionado con la intervención práctica de mindfulness. Se evidencia que el tratamiento del Aikido como una disciplina con potencial psicoterapéutico que requiere de un mayor análisis de expertos desde una perspectiva transdisciplinar e interdisciplinar, que permita encontrar un modelo de intervención idóneo para tener un conocimiento más profundo de la disciplina del Aikido. Además, se requiere un dominio del campo de la psicología y de la psiquiatría que permita entender los procesos cognitivos internos de los sujetos estudiados.

Palabras clave:

Propiocepción. Mindfulness. Artes marciales. Terapia complementaria. Salud. Bienestar

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Discussion

Aikido as a contemporary Martial Art of the 20th century spread to the West when Morihei Ueshiba decided in 1966 to send his disciples to spread his teachings beyond Japan's borders. This is the case of Mitsumisi Yoshimitsu Yamada (Tokyo, 1938), Mitsunari Kanai (Manchuoko, 1938-Toronto, 2004) in the United States, Masamichi Noro (Aomori, 1935 - Paris, 2013) in France and Nobuyoshi Tamura (Osaka, 1933 - Trets, 2010) in Germany. The first bibliographical reference reflecting on the psychotherapeutic benefits of Aikido was written by Saposnek in 1980⁶. Fuller in 1988⁵. The reference carried a note that clinical and psychotherapeutic applications are in an emerging phase and highlights the psychological characteristics of the Art of Aikido considering the possible uses of the principles of this Martial Art as a systemic or indeed, complementary therapy. This view was previously obscured during the 1960's and 1970's mainly due to the use of Martial Arts in the film industry. The film industry model, spearheaded mainly by Bruce Lee (1940-1973), along with its philosophy and openness to the West on the Zen foundations of the Martial Arts³⁰, contributed to the distortion in interpreting the spiritual and ethical foundations of the Martial Arts⁵.

It was Delva-Tauillili in 1995²² who wrote the first quasi-experimental article on the benefits of Aikido and this was published in the field of psychology. Although, hitherto, Madenlian in 1979³¹, published the first study to analyse a treatment programme involving Aikido on pre-adolescent boys with behavioural problems and self-concept. This article

was excluded from this systematic review as it was published as a chapter in the same year. In any case, the purpose of Delva-Tauillili's²² article was to test whether the practice of Aikido reduced aggressive behaviour in pre-adolescents in a secondary school in Honolulu (Hawaii-USA). More recently, similar research in the field of psychology was carried out by Foster in 1997²³ in Wichita (Kansas-USA), by Lothes II, Hakan, & Kassab in 2013²⁴ in Wilmington (North Carolina-USA), by Weiss *et al.* in 2017²⁶ in Cincinnati (Ohio-USA). It is only very recently that for the first time the interest in Aikido at a scientific level has developed beyond the borders of the USA, and where we find studies, all of which were published in 2019, by Cuellar, Bazán & Araya²⁵ in San José (Costa Rica), by Szabolcs, Szabo & Köteles²⁷ in Budapest (Hungary) and by Ben-Soussan *et al.*²⁸ in Rome (Italy). From this year of publications, we only find continuity in the team of Szabolcs *et al.*²⁹ when in 2021 they published an article with the aim of studying aspects such as spirituality, mindfulness, body awareness, and self-compassion in healthy individuals, through Aikido (Table 3). Possibly the expansion of the influence of Aikido as a Japanese 'product' in North America is due not only to the 'evangelisation' of Aikido by Morihei Ueshiba's disciples, but also to the migration of Japanese citizens to the USA, where the island of Hawaii became an intermediate step to reach the North American continent³².

Still, Aikido as a research practice is also relevant to the somatic domain with a focus on aspects of Mindfulness^{24,25,28,29} or flow experience²⁷ (Table 2). The aspects highlighted in the origin of Buddhism constitute an authentic part of the Zen spirit³³. This trajectory centred on a type

Table 2. Descriptive data.

	Authors (Year)	Title	DOI	Journal	Location*
1	Jorge Delva-Tauillili (1995)	Does brief Aikido training reduce aggression of youth?	10.2466/pms.1995.80.1.29	Perceptual and Motor Skill 80:297-298	Hawaii, Honolulu (USA)
2	Yumi Akuzawa Foster (1997)	Brief Aikido training versus karate and golf training And university students' scores on self-esteem, anxiety, and expression of anger	10.2466/pms.1997.84.2.609	Perceptual and Motor Skills 84:609-610	Wichita, Kansas (USA)
3	John Lothes II, Robert Hakan, Karin Kassab (2013)	Aikido Experience and its Relation to Mindfulness: A Two-Part Study	10.2466/22.23.PMS.116.1.30-39	Perceptual & Motor Skills: Learning & Memory 116(1):30-39	Wilmington, North Carolina (USA)
4	Tobias C. Weiss, Benjamin D. Dickstein, Joseph E. Hansel, Jeremiah A.Schumm, Kathleen M. Chard (2017)	Aikido as an Augment to Residential Posttraumatic Stress Disorder Treatment	10.1037/mil0000194	Military Psychology, 29(6):615-622	Cincinnati, Ohio (USA)
5	Rodrigo Cuéllar Hidalgo, Aldo Bazán Ramírez, Gerardo Alonso Araya Vargas (2019)	Effects of Aikido practicing on mindfulness and anxiety in Costa Rican university students	10.47197/retos.v0i35.62044	Retos 35:13-19	San José (Costa Rica)
6	Zsuzsanna Szabolcs, Attila Szabo, Ferenc Köteles (2019)	Acute psychological effects of Aikido training	10.33607/bjshs.v11i2i1.778	Baltic Journal of Sport & Health Science. 1(112): 42-49	Budapest (Hungaria)
7	Tal Dotan Ben-Soussan, Joseph Glicksohn, Antonio De Fano, Federica Mauro, Fabio Marson,Manuela Modica, Caterina Pesce (2019)	Embodied time: Time production in advanced Quadrato and Aikido practitioners	10.1002/pchj.266	Psychology Journal 8:8-16	Roma (Italy)
8	Zsuzsanna Szabolcs, Barbara Csala, Attila Szabo, Ferenc Köteles (2021)	Psychological aspects of three movement forms of Eastern origin: a comparative study of Aikido, Judo and Yoga	10.1080/11745398.2020.1843507	Annals of Leisure Research 1-21	Budapest (Hungaria)

*Location of the Research Group from which the interest in carrying out a quasi-experimental analysis on the analysis of psychological variables in Aikido has arisen.

of attitude towards life seems to stand out in the results obtained in relation to the contributions of Aikido to psychological health. There are also more specific clinical applications on aspects that influence the emotional state such as self-esteem as well as the level of anger and anxiety²⁴, or its effect on aggressiveness²². According to Fuller in 1988⁵, the strategies used in Aikido for the management of certain problematic states such as anger control, could help to provide alternative or additional ways of working with subjects with temper control difficulties. The findings from the use of Aikido as a continuous therapy applied over a period of two years to individuals diagnosed with PTSD²⁶, provide evidence of significant positive effect. In this case the aim was to support symptoms as a whole, because of stress inoculation as a result of PTSD. Hourani *et al.*¹³ previously applied training programmes using Aikido to US military marines in order to acquire emotional management strategies in stressful situations.

In this type of analysis of the psychosomatic relationship in Aikido and its possible benefits as a therapy to help population groups with or without diagnosis, it is complex to draw conclusions about the influence of Aikido on human behaviour. In this sense, it is worth noting first that the creation of specific programmes in order to apply both strategies, resources and teachings of Aikido as we have found in the review conducted was not validated by external experts. Despite this, three research projects^{22,25,26} were considered as particularly significant. These studies are the only ones found in the scientific literature on intervention programmes through Aikido applied to diverse population groups outside the regulated regime of this Martial Art. Our findings show 21 pre-adolescent island boys between 9 and 12 years old²², 98 war veterans, 52 males with an average age of 52.06 + 10.39 and 46 females with an average age of 46.61 + 8.24 (Weiss *et al.*, 2017). And, in a final instance, 12 adults (10 males, 2 females) of varied age range between 18 and 62 years with a mean age of 28.67 + 12.43 (Table 3)²⁵. In total since the first publication, 83 subjects (males) and 48 (females) outside the field of Aikido have experimented in their first contact with this discipline to test its effects. In the case of Tauilli's study²² where the sample was Pacific Islander pre-adolescents, emotional regulation skills were analysed, that is, giving an appropriate response to the emotions that we experience in each situation; such as, tolerance to frustration, the degree of self-control and in general, the management of aggressive behaviour. Moon³⁴ refers to Aikido as a discipline which is suitable for neutralising and integrating the attacker and as having the potential ability to handle physical violence. In other words, it neutralises and harmlessly redirects the attacker's aggression.

Weiss *et al.*²⁶ examined whether Aikido as part of the treatment of war veterans improved symptoms associated with PTSD, such as flashbacks, nightmares, severe distress and uncontrollable thoughts about a witnessed or experienced traumatic situation. In the study by Weiss *et al.*²⁶ the depression factor, a mental as well as an emotional disorder, was treated as a collateral factor of PTSD. With regard to the study of adults in the university population by Cuellar, Bazán & Araya²⁵, the positive changes that were perceived as a result of the practice of Aikido were on mindfulness (psychic and somatic component) and the state of anxiety (Table 4). It is necessary to point out here that Morihei Ueshiba's philosophy, in its purest form, stems from the psychosomatic relationship of Aikido with the opponent. This philosophy projects a

system of interaction between two human beings in which a maxim of his *budo*, "love reconciliation", seems to be the essential axis of his work³⁵. This maxim in any case speaks of forgiveness, compassion for the other or self-compassion, as characteristics rooted in both Eastern philosophy and spirituality²⁹. Such was Morihei Ueshiba's wish, Aikido as a vehicle of protection for the whole world, with love replacing harm and indeed, death³⁵. Accordingly, there is no doubt that this system of interaction in Aikido would embody, as a starting hypothesis, a therapeutic healing effect.

On the other hand, in the context of Aikido schools, we found a study population of 20 initiates²³, where the rank, gender or age of the participants is not specified. Subsequently, Lothes *et al.*²⁴ collected data in a first study of a sample of 159 aikidokas belonging to the US territory, distinguishing (111 males and 49 females). Lothes *et al.*²⁴ found 86 subjects below black belt or *Kyu ranks*, (60 males & 26 females) and 53 with black belt rank (males & females). In a second study they recruited 12 aikidokas (9 males & 3 females) although in both studies they do not specify the age of these participants. Szabols *et al.*²⁷, meanwhile, recruited 53 adults of mean age 37.2 + 10.56 (45 males & 8 females), of whom 27 subjects were below black belt, and 26 above black belt. Ben-Sousan *et al.*²⁸ collected data from 11 adult Aikido practitioners of mean age 47.8 + 12.04 (4 males & 7 females) without knowing the rank, nor the years of training. Finally Szabolcs *et al.*²⁹ were able to recruit 121 adult aikidokas with a mean age of 37.26 + 10.72 (99 males & 21 females). A total of 247 aikidoka have been questioned since 1997 and 227 since 2013 in the last decade where interest in studying aikidoka personality traits has grown. Most of the studies make a comparison with control groups of the same age not included in the programme²², with healthy people chosen from another field²⁴, or with other practitioners of other sports²³. We can observe control groups that are very unbalanced in number with those analysed on the basis of the practice of Aikido, such as that of Lothes II *et al.*²⁴ in their first study.

Regardless of whether the sample of individuals is drawn from practice schools^{23,24,27-29}, or if the training programme was implemented in a different setting than usual^{22,25,26}, the questionnaire tool seems to have facilitated greater consistency in the sample size studied, whether online²⁴ or on-site²⁷. In any case, there is an interest in studying the influence on interpersonal psychological behaviour through Aikido as an internal conflict resolution tool. First of all, it can be seen in terms of a phase or stage considered as being particularly conflictive in human beings, such as in adolescence. During adolescence, conflict is considered adaptive, as conflictual interactions have a relational developmental purpose between children and parents³⁶. In the study of Pacific Islander pre-adolescents, the aim is to analyse certain variables of emotional regulation by these children in order to see if they are able to improve them²³. Secondly, in a separate study, Aikido is used as part of a treatment for those diagnosed with PTSD, and the association with depression as the most characteristic trait of ex-war veterans²⁶ (Table 3).

Internal conflict is the origin of behavioural traits such as low frustration tolerance, high irritability, high irascibility, poor control of aggression or anxiety and poor management of these states^{22,25,26}. These traits are related to a lack of self-esteem and self-confidence^{23,24} (Table 4). Because Aikido harnesses the natural abilities of being human, it offers an immediate sense of empowerment to beginners, which can enhance

Table 3. Objectives and methodologies.

Authors (Year)	Objective	Sample	Design	Intervention*
1 Delva-Tauiilili (1995)	To examine whether the practice of Aikido, a non-violent Japanese martial art, effectively reduces aggressive behaviour of preadolescent youth	42 Male Preadolescent Youth, Asian and Pacific Islanders aged 9-12 years (Experimental group: 21 subjects; Control group of 21 subjects on waiting list)	Pre-test and post-test mean scores were performed and compared between the control and experimental groups, before and after 2 weeks of daily training from Monday to Friday	Training on the Basic Principles of Aikido with a methodological structure adapted in the school for pre-adolescents
2 Foster (1997)	To investigate if Aikido training is effective in improving selected aspects of personality	69 volunteers were university physical education students from Ohio State University and Stanford University. The 4 initiation groups were divided into three modalities: experimental group of 20 Aikido initiates, 24 karate initiates, 13 golf initiates. There was also a control group of 12 golf initiates	Pre-test and post-test of the means of the variables were carried out over a period of 10 weeks of training	Aikido initiation course in the University context
3 Lothes II, Hakan, & Kassab (2013)	To examine the potential association of training in Aikido may have on mindfulness	179 adult participants over 18 years of age were recruited via email and online. Study I: Experimental group: 159 participants (111 male, 48 female) Aikido students. Control group: 20 participants (4 male, 16 female) psychology students with no martial arts experience. Study II: Experimental group: 12 volunteer Aikido practitioners (3 females, 9 males). Control group: 20 psychology students (13 females, 7 males)	Study I: A cross-sectional data collection for the questionnaires for each subject was carried out online. It took 5 months to collect the 159 surveys and the levels of experience were compared with the ranks acquired and the length of practice experience Study II: Longitudinal design of the experimental group with a control group	Study I: There was no training programme designed ex-profeso within the context of Aikido schools in the USA. Study II: A design was made to insert Mindfulness practices during their Aikido training
4 Weiss <i>et al.</i> (2017)	To examine the effects of augmenting an evidenced-based residential Posttraumatic Stress Disorder (PTSD) treatment program for veterans with group-based instruction in Aikido	193 Former Vietnam War veterans (108 men/85 women) receiving residential treatment for Post-Traumatic Stress Disorder at a Midwest Veterans Affairs Medical Center. Cognitive processing therapy was part of their primary treatment	Quasi-experimental cohort design with a 7-week follow-up for an overall duration of 52 months. Measurement cohorts were applied to both groups of 85 women and 108 men assigned to practise Aikido and non-Aikido in such programmes	Specially designed programme as complementary therapeutic treatment for war veterans
5 Cuéllar, Bazán & Araya (2019)	To examine the effect of practising Aikido on mindfulness and anxiety state in university students with no previous experience in martial arts	24 students from the University of Costa Rica. The experimental group consisted of 12 students from different careers (10 males and 2 females; ages 18-62 years); and the control group consisted of 12 students from the Bachelor in Human Movement Sciences (9 males and 3 females; ages 21-34 years)	Quasi-experimental design, with pre- and post-treatment measurements, with one experimental group and one active control group. Implementation programme based on an 11-week training programme (two weekly sessions of 2 hours each).	Specially designed programme in a context outside of Aikido schools
6 Szabolcs, & Szabo, Köteles (2019)	To examine for the first time the hypothesis that Aikido training, like many other western forms of organised physical activities, has acute psychological benefits as manifested via favourable changes in affect and the flow experience	53 participants were recruited from Aikido clubs of the Aikido Foundation in the metropolitan area of Budapest aged 18-57 years (85% male-15% female). who practised Aikido as a regular recreational activity	Cohort design at least 3 surveys data collections were conducted for one of the variables and another at least 1 time	The programme included the Aikido sports schools' own training sessions
7 Ben-Soussan <i>et al.</i> (2019)	To examine the effect of Mindful Movements (MMs-specific types of mind-body coordination-demanding physical activity) on Time Perception (TP)	34 healthy adults volunteered, including 11 practitioners of Aikido (4 males and 7 females) and 9 practitioners of advanced <i>Quadrato</i> Motor Training (4 males and 5 females) and 14 physically inactive controls (7 males and 7 females)	A mixed observational study	There was no specific design. They were collected directly from the Aikido Schools

(continue)

Table 3. Objectives and methodologies (continuation).

8	Szabolcs <i>et al.</i> (2021)	To examine four characteristics rooted in Eastern philosophy and religious practice, i.e spirituality, mindfulness, body awareness, and self-compassion in healthy individuals	Experimental group of 265 subjects (Aikido with n= 121, 18% female: average age 37+11 years; Yoga with 75, 84% female, average age 44+11 years)- Control group with 76 subjects, 67% female, average age 27 + 9 years old	Cross-sectional study collecting survey data via online questionnaires from subjects belonging to their own sports schools	There was no intervention programme or implementation in the design
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*Context of Aikido intervention in this study based on the phases, exercises and fundamentals that are developed in its routines or training protocols.

self-esteem⁵. The interaction systems that incorporate the conflict itself during the confrontation, designs coping strategies according to some authors as a psychotherapeutic model with great healing potential³⁵. Aikido has built-in resources and procedures for dealing with adaptive conflict in interpersonal combat with the other. We can describe as an example two types: the techniques called *Tai Sabaki*, a type of dodging based on moving away from the path of the attack just before impact in order to proceed to use this energy to redirect the conflict. Others, those of psychophysical preparation to face the conflict known as *Aiki Taiso*, based on breathing techniques and meditation. In this last group, the studies proceed to analyse the effects of Aikido training on psychological or mental variables such as mindfulness²⁵, flow experience, skill-challenge harmony, oneness with the experience²⁷. Time Perception Production²⁸, assesses the importance, experience and beliefs of spiritual connection to an inner power, interpersonal energy, ultimate force, so it measures an aspect of spirituality²⁹ (Table 4).

Aikido, fundamentally based on this system of psychosomatic relationship with the other, as described earlier, is not only hypothesised to reduce and help aggressiveness, improve self-confidence or improve anxiety control and management, but seems to also establish a sensitive connection from the earthly to the spiritual and vice-versa. Moon³⁴ alludes to the words of O'Sensei or Morihei Ueshiba where he explains that victory at the expense of others is not true victory; the benefit lies in when your actions help to overcome the mental conflict in yourself. Moon³⁴ also points out to the meaning of *Aiki* not as a technique to fight or defeat the enemy, but as a way of reconciliation with oneself.

However, Delva-Tauiilili²² found no significant differences between practitioners enrolled in an Aikido programme and the control group in terms of aggression and self-control variables. Foster²³ also found no significant differences between the pre-test and post-test in the Aikido group in terms of self-esteem, state anxiety, trait anxiety or anger expression. In this study the Karate group showed significantly lower means than the Aikido group on trait and state anxiety, and anger expression. In the same vein Lothes *et al.*²⁴ found no significant differences from the pre-test and post-test in the Aikido group, in relation to self-esteem, anxiety state, trait anxiety and anger expression. Even compared to the Karate group, the latter showed significantly lower means in trait anxiety. Anxiety is a predisposing factor for aggression. Aggression is channelled through releasing aggression or, on the contrary, other strategies have to be applied. Rohtpearl (1980)⁴ based on an analysis of karatekas of different ranks, confirmed the cathartic and circular theories of aggression, so that the results where karatekas show lower levels of anxiety may be

due to this theory. Aggression is regarded as something to be treated in martial arts, especially in the use of Taekwondo³⁷. Regardless of the age of the subjects, or whether or not they continuously practise Aikido in their lives, these findings²²⁻²⁴ suggest that the anxiety-aggressiveness binomial requires other alternative or complementary therapeutic treatments to psychiatry, beyond the practice of Aikido (Table 4).

Contrastingly, we observed a lack of homogenisation of the protocols analysed in relation to the analysis of the independent variable, Aikido. The analysis of this Art requires approaching the developed senses of corporeality, embodiment and aesthetic pleasures in a somatic teaching felt by individuals¹². It is necessary to observe the qualitative aspects of this evidence, in that in many occasions, teaching processes are not taken into account and integrated in understanding of the phenomenon at the individual level in order to experience real transformation³⁸. It may be this lack of somatisation as integrated in the foundations established by Morihei Ueshiba that certain factors of emotional regulation have not reflected improvements in the studies of Delva-Tauiilili, Foster, and Lothes *et al.*²²⁻²⁴.

We must not forget that Morihei Ueshiba was a mystic with enlightening experiences like St. John of the Cross in the Christian tradition. Master Ueshiba focused on transmitting generationally using a key concept in Aikido: *kimusubi* which means "uniting oneself with one's partner". uniting your own ki with that of the other without fissures. *Aiki*, "gathering ki", is similar to *ki-musubi* but with more emphasis on the momentum and harmonisation of a conflicting force¹⁸. The essence of Morihei Ueshiba's work on the transcendence of the human being from the physical interaction of conflict and overcoming it through the Art of Aikido is the basis of healing. The expression 'loving reconciliation' is common in his terminology³⁵. The influence of Shintoism or Buddhism and even *Mikkyo* seems to be present in the figure of Morihei Ueshiba. *Mikkyo*, considered to be the most mystical branch of Buddhism in addition to instruction in the teachings and practices of the tradition, involves and requires "*kanjo* empowerments" (initiatory power transmissions)³⁹. Morihei Ueshiba uses 'transcendence' as the tool to aid healing. Transcendence was sought by Morihei Ueshiba on the basis that human beings naturally have a creative expansive potential to be developed, where they are capable of states beyond the physical⁴⁰. This is based on subjective perceptual experiences that transcend certain states (*hypereo*). This concept in the world of arts and dance was interpreted by the choreographer Erick Hawkins, as the need to expand a core concept in movement work: "kinesthetic awareness". This is defined as the sensation of movement in a somatic connection of muscles, fascia

Table 4. Variables, scales of measurement and results.

Authors (Year)	Psychological, somatic, cognitive and emotional variables	Scales and measures	Relevant results	Conclusions
1 Delva-Tauiiili (1995)	<ul style="list-style-type: none"> – Frustration tolerance – Problem behaviours – Self-control – Aggressive behaviour 	<ul style="list-style-type: none"> – Teacher's Self-control Rating Scale and on aggressive behaviour – Subscales of the Child Behaviour Rating Scale 	No significant differences were found in aggressive behaviour and self-control between the Aikido group and the control group	Methodological limitations such as the lack of randomisation in the groups and the short training time are not sufficient to have a significant effect
2 Foster (1997)	<ul style="list-style-type: none"> – Self-esteem – State-anxiety – Anger 	<ul style="list-style-type: none"> – Self-esteem Scale – State-trait Anxiety Inventory – Anger Expressions Scales from the State-Trait Anger Expression Inventory 	No significant differences were found between the pre-test and post-test in the Aikido group in terms of self-esteem, state anxiety, trait anxiety or anger expression. The Karate group showed significantly lower means on trait anxiety, state anxiety and anger expression	The subjects should be observed for several years of training to evaluate changes in test scores
3 Lothes II, Hakan, & Kassab (2013)	<ul style="list-style-type: none"> – Mindfulness Skills – Mindfulness attention awareness 	<ul style="list-style-type: none"> – Kentucky Inventory of Mindfulness – Skills and Mindfulness Attention Awareness Scale 	The results of both studies show significant increases in mindfulness scores with Aikido training	This kind of field of knowledge requires longitudinal designs and empirical research to progress further
4 Weiss <i>et al.</i> (2017)	<ul style="list-style-type: none"> – Posttraumatic Stress Disorder (PTSD) – Depression symptom 	<ul style="list-style-type: none"> – PTSD Checklist Stressor Specific Version (PCLS) – Clinician Administered PTSD-Scale (CAPS) – Beck Depression Inventory: Second Edition (BDI-II) 	Female veterans who received Aikido experienced a greater decrease in self-reported PTSD and depression symptoms during treatment. No benefits were found in men	The results of this study are affected by certain limitations such as not using a randomised design, which increases the risk of possible therapist and Aikido instructor effects. Furthermore, a better understanding of the mechanism underlying Aikido needs to be developed to help clinicians
5 Cuéllar, Bazán & Araya (2019)	<ul style="list-style-type: none"> – Mindfulness – Psychic Component (PC) of anxiety – Somatic Component (SC) of anxiety 	<ul style="list-style-type: none"> – Mindfulness Attention Awareness Scale (MAAS) – Hamilton Anxiety Scale (HAS) 	Positive effects of Aikido practice on mindfulness and anxiety status were evident. Overall, Aikido practice showed significant effects on mindfulness and anxiety PC and a significant and small effect on SC	The results show that practising Aikido, as might be the case with other martial arts, brings a benefit in mood that exceeds that which can be obtained from regular physical activity as part of an active lifestyle
6 Szabolcs, & Szabo, Köteles (2019)	<ul style="list-style-type: none"> – Flow experience – Skill-challenge harmony – Oneness with the experience. – Positive affect and negative affect 	<ul style="list-style-type: none"> – 10-item psychometrically validate Hungarian version of this instrument (PANAS-HU) based in The Positive Affect Negative Affect Scale (PANAS) – The Hungarian Flow State Questionnaire (FSQ): derived from several versions of the Flow State Scale (FSS) 	The flow experience in aikidokas is similar to aerobic or spinning exercise. More experienced aikidokas reported a higher skill-challenge harmony than less experienced martial artists	These findings reveal relatively clearly for the very first time in the literature that Aikido practice has acute, or immediate, psychological benefits similar to other martial arts and exercises
7 Ben-Soussan <i>et al.</i> (2019)	<ul style="list-style-type: none"> – Time Production (TP): link bodily perception, human time perception and Mindfulness – Homolateral interlimb coordination – Creativity 	<ul style="list-style-type: none"> – TP/Time-production task – Homolateral interlimb coordination task – Creativity Task (Alternate Uses Task) 	No differences were found between the Aikido and the control group	Future studies should extend the current results, including a larger sample, several training regimes for interventional testing, and additional neuroscientific measures to investigate the hypothesized neural mechanisms
8 Szabolcs <i>et al.</i> (2021)	<ul style="list-style-type: none"> – Spirituality – Mindfulness – Body awareness – Self Compassion 	<ul style="list-style-type: none"> – The Spiritual Connection Questionnaire (SCQ-14) – Mindful Attention Awareness Scale (MAAS) - 15-item scale – The Body Awareness Questionnaire (BAQ) – The Self-Compassion Scale (SCS) 	Generally, higher levels of mindfulness, spirituality, body awareness and self-compassion were found in the Eastern movement forms (Yoga, Aikido and Judo) in contrast to the controls. However, in comparison to Aikido and Judo, Yoga emerged to be the most prominent with respect to the examined four characteristics	Intervention studies are needed to explore the causal relationship(s) between these practices and the variables studied, which may lead to safe recommendations for selecting a specific activity for mental health benefits

and tendons with the union of thought ("think-feel") to reach a state of "intellectual knowing with sensory experiencing" among other aspects he incorporated in his somatic trainings the 'Imagery'⁴¹ and the influence also of Zen Buddhism. In this way he developed a method of combining techniques from this Eastern philosophy with Western science⁴².

The psychosomatic benefits that Mindfulness practices bring through mindfulness of the present moment draw from a part of Buddhist philosophy which is deeply rooted in Aikido. In other words, the quality of Mindfulness improves when this modality of Martial Art is practiced²⁵. However, Szabolcs *et al.*²⁹ find that the discipline of Yoga is more beneficial in relation to mindfulness than Aikido or Judo when analysing the global factor of well-being in the human being (Table 4). Therapeutic treatments have been carried out combining the practice of mindfulness and the theoretical-cognitive application of the field of psychoneuroimmunoendocrinology, on topics such as stress, well-being, perception, the importance of emotions in health and empathy⁴³. Psychoneuroimmunology studies those states of abnormal tension produced by an excess of this afferent neuronal excitation flow. Although it has been described that there is an individual variability that seems to be related to specific personality traits as well as to defence and adaptation mechanisms⁴⁴. The psychoneuroimmunoendocrine axis directly reflects the interactions that exist between the psyche, neural functions, endocrine and immune responses⁴⁵. Alterations of stress mediators such as cortisol, as well as local and systemic immune disorders have been described⁴⁶. For example, continuous stressful situations affect the balance of this psychoneuroimmunoendocrine axis, as in the case of post-traumatic stress syndrome in former combatants who have survived a war¹⁹. Aikido seems to have the necessary tools to align this psychoneuroimmunoendocrine axis although other disciplines where there is no confrontational work such as Yoga may embody a better adaptive response. We must not forget that the martial origin can generate a certain tension that unless it is released may not have all the therapeutic potential in its favour.

Fuller in 1988⁵ points out that unlike other arts in which certain skills can be acquired through practice against an imaginary opponent or an inanimate target, Aikido training is almost exclusively interactive. The interaction contains a natural set of checks and balances that continually confront each student with a mirror image of their own behaviour and its effect on others. Aikido's principles of fusion and non-deterrence require students to learn, both literally and metaphorically, to put themselves in the place of their aggressor in order to see how to resolve the conflict. Fuller⁵ notes that Aikido training requires cooperative rather than competitive practice, offering the experience of both personal strength over others and vulnerability at the hands of those same individuals. Its techniques, which provide a constructive means of resolving disputes in a harmless manner, inherently demand an empathetic appreciation of the other person's position.

This review provides us with a vision of Aikido as a Martial Art that could be applied as a complementary or alternative treatment to facilitate the resolution of psychological conflicts or to aid individuals who find themselves in conflictive moments in critical stages of their lives. Since the first experimental studies, there have been attempts to improve the management of emotional skills such as frustration tolerance, self-control, anger management, anxiety, aggressive behaviour

and to achieve true self-confidence. The results so far do not support significant improvements in the application of Aikido programmes as seen in the studies of Delva-Tauiilili²² and Foster²³. Possibly these results are due to the age of the participants in the pre- and post-adolescent stage, the small sample sizes of 21 and 69, or perhaps the duration of the programmes applied, 2.5 and 10 weeks. It is surprising that after Foster's study in 1997²³, Aikido has not been applied again to improve the management of emotional skills.

In this framework of action, we reflect on Morihei Ueshiba's Theory of 'Loving reconciliation'³⁵. This theory is a statement of intent in conflict resolution. It could be a fundamental justification for applying Aikido in the framework of intervention to improve emotional skills in early life stages both pre-adolescence and post-adolescence. But this does not seem to be the case. It is likely that in the case of Aikido something more is needed. We posit possibly a Theory of conflict release, reflected in the Principle of Sphericity where the play of two orbital forces make the attacker or uke role project out of tori's orbit¹⁰. That is to say, 'I' welcome the conflict, a union takes place in the void, without an aggressive, harmful or direct contact but by spiral orbital flow into the surrounding space where finally both orbits are released without any trauma between adversaries.

The findings from the study of Aikido in Weiss *et al.*²⁶, in which Aikido was used as a combined therapeutic treatment with Cognitive Processing Therapy (CPT) in ex-military patients from the Vietnam War (1 November 1955 - 30 April 1975) were exceptional. These individuals suffered from Post-traumatic Stress Disorder with symptoms of depression. In this case, even applying 52 weeks of Aikido-based intervention programme only the symptoms were improved in Females compared to their control group. Both in the studies of Delva-Tauiilili²², Foster²³ or Weiss *et al.*²⁶ alluding to the latter, we understand that a better understanding of the mechanisms underlying Aikido is needed, which would help to complement actions in patients who are in the process of clinical treatment or in need of vital well-being.

For this reason, other studies found subsequently: Lothes II, Hakan, & Kassab, 2013; Szabolcs, Szabo & Köteles, 2019; Cuéllar, Bazán & Araya, 2019; Ben-Soussan *et al.* 2019; y Szabolcs *et al.* 2021^{24,25,27-29} have mostly focused directly on aspects of mindfulness, spirituality, self compassion or flow experience.

Conclusion

As a result of this review we have been able to clarify certain psychotherapeutic and clinical aspects of Aikido. In the experimental studies analysed, there is a common denominator based on the sensitive pair work in the interaction between subjects that enhances the overall proprioceptive work of the individual, which we believe to be decisive in the psychosomatic relationship created in Aikido and which heretofore has remained unacknowledged in bibliographical references.

It is our contention that Aikido has the potential to become a discipline suitable for application in all facets of mindfulness work. Furthermore, as a key to the whole systematic review, we highlight the process of interaction with the opponent and the transformation that can come to exist if the management of the confrontation is resolved according to the canons of Aikido and its creator Morihei Ueshiba.

Regardless of the psychological profile of the aikidoka and its field of application, what is essential is to reflect on whether Aikido, as a very sophisticated system in terms of its construction of psychosomatic training techniques, can become useful as a Complementary Therapeutic Treatment in both psychological and psychiatric clinical processes.

If we really know how to control the identical somatic mechanisms originally proposed by Master Morihei Ueshiba in the application of his teaching, we will be able to achieve therapeutic healing. Otherwise, we can consider Aikido as a sports activity or martial work in pairs at the same level as the other modalities, sometimes even below.

Furthermore, a dilemma arises in this analysis based on whether the psychological profile of the practitioner is shaped by the practice of Aikido itself or, on the contrary, whether there is a type of person with certain psychological and personality characteristics who is attracted to this type of discipline.

It is clear that there are limitations to the experimental research found, although it is recognisable that at least some progress has been made since the 1990s.

It is evident that the treatment of Aikido as a discipline with psychotherapeutic potential requires further expert analysis from a transdisciplinary and interdisciplinary perspective to propose an intervention model integrating a profound knowledge of the discipline of Aikido. Additionally, a mastery of the field of psychology and psychiatry is required in order to understand the internal cognitive processes of the subjects studied. For example, it is clear from our review that cross-sectional cohort analyses are not useful in the study of certain emotional variables, but they are useful in the facets and scope of mindfulness.

In the future, longitudinal and qualitatively consistent studies are required in terms of control of the variables that allow the exhaustive follow-up of the subjects in order to fully understand the somato-cognitive processes of the participants themselves in the process of assimilation of the Art of Aikido. The purpose of these processes will be firstly to provide the subjects with practical resources to prevent stressful situations or to face conflicts. And secondly, to help deal with already acquired conflicts in a process of de-traumatisation, de-sensitisation or self-resolution of these conflicts. Proprioception is a multidimensional factor that has not yet been scientifically studied as described above among aikidoka. The psychosomatic relationship with the multidirectional analysis of proprioception would facilitate the understanding of Morihei Ueshiba's precepts regarding the sensory-perceptual and motor state of actions among these Aikido practitioners. Future research should further investigate the relationship with aspects of proprioception in interaction with perception, somato-cognitive, emotions and verbalisation of processes in pairs.

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Conflict of interest

The authors do not declare a conflict of interest.

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Evaluation of maximal oxygen uptake pre- and post-COVID-19 in elite footballers in Argentina

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Summary

Introduction and objectives: The SARS-CoV-2 infection appears to cause functional impairment of cardiopulmonary performance in many athletes. We studied the post-COVID-19 impact on the cardiopulmonary system, through the maximal ergospirometry test, in elite professional soccer players.

Material and method: The sample consisted of 10 AFA (Argentine Football Association) first division soccer players, who underwent pre and post COVID-19 infection maximal oxygen uptake (VO_{2max}) tests. The variables analyzed were absolute and relative VO_{2max} , maximal aerobic speed (MAS), first ventilatory threshold (VT1), second ventilatory threshold (VT2), maximal heart rate (HRmax) and respiratory exercise ratio (RER).

Results: The mean age was 22.4 ± 6.9 years, body mass 71.5 ± 7.1 kg and height 176.2 ± 6.9 cm. Post COVID-19 subjects significantly decreased VO_2VT2 by 18% ($P = 0.028$) and RER significantly decreased by 5% ($P = 0.02$). HRmax was the only variable that significantly increased post COVID-19 by 1.8% ($P = 0.04$). No significant changes was observed in body mass 71.5 ± 7.1 vs 73.9 ± 7.4 ($P < 0.118$), VO_{2max} 61.7 ± 5.2 vs 59.0 ± 5.1 ml·kg⁻¹·min⁻¹ ($P < 0.213$), MAS 18.7 ± 0.9 vs 18.6 ± 0.5 km·h⁻¹ ($P < 0.739$), VO_2VT1 39.2 ± 4.0 vs 37.8 ± 4.3 ml·kg⁻¹·min⁻¹ ($P < 0.460$), speed at VT1 11.6 ± 0.5 vs 11.8 ± 0.6 ($P < 0.480$) and other variables.

Conclusion: It seems reasonable and safe to evaluate athletes after SARS-CoV-2 infection with ergospirometry to ensure health conditions and trainability. In this type of athletes (elite soccer players), the use of the second ventilatory threshold (VT2) can be used as a strategy to observe post-COVID-19 changes. The decrease found may be related more to the cessation of training than to cardiopulmonary damage.

Key words:

COVID-19. Athletic performance.
Exercise. Sport medicine.
Ventilatory threshold.

Evaluación del consumo máximo de oxígeno pre y post COVID-19 en futbolista de élite en Argentina

Resumen

Introducción y objetivos: La infección por SARS-CoV-2 parece provocar en muchos atletas un deterioro funcional del rendimiento cardiopulmonar. Se estudió el impacto post COVID-19 en el sistema cardiopulmonar, a través del test de ergospirometría máxima, en futbolistas profesionales elite.

Material y método: La muestra estuvo compuesta por 10 futbolistas de la primera división AFA (Asociación de Fútbol Argentino), a quienes se realizaron test de consumo de oxígeno máximo (VO_{2max}) pre y post infección por COVID-19. Las variables analizadas fueron VO_{2max} absoluto y relativo, velocidad aeróbica máxima (VAM), primer umbral ventilatorio (VT1), segundo umbral ventilatorio (VT2), frecuencia cardiaca máxima (FC_{max}) y cociente respiratorio (RER).

Resultados: El promedio de la edad fue $22,4 \pm 6,9$ años, masa corporal $71,5 \pm 7,1$ kg y estatura $176,2 \pm 6,9$ cm. Los sujetos post COVID-19 disminuyeron significativamente un 18% el VO_2VT2 ($p = 0,028$) y el RER disminuyó significativamente 5% ($p = 0,02$). La FC_{max} fue la única variable que post COVID-19 se incrementó significativamente 1,8% ($p = 0,04$). No se observaron cambios significativos en la masa corporal; $71,5 \pm 7,1$ vs $73,9 \pm 7,4$ ($p < 0,118$), VO_{2max} $61,7 \pm 5,2$ vs $59,0 \pm 5,1$ ml·kg⁻¹·min⁻¹ ($p < 0,213$), VAM $18,7 \pm 0,9$ vs $18,6 \pm 0,5$ km·h⁻¹ ($p < 0,739$), VO_2VT1 $39,2 \pm 4,0$ vs $37,8 \pm 4,3$ ml·kg⁻¹·min⁻¹ ($p < 0,460$), Velocidad al VT1 $11,6 \pm 0,5$ vs $11,8 \pm 0,6$ ($p < 0,480$) y demás variables.

Conclusión: Parece razonable y seguro evaluar a los atletas después de la infección por SARS-CoV-2 con ergospirometría para asegurar las condiciones de salud y entrenabilidad. En este tipo de atletas (futbolistas elite), la utilización del segundo umbral ventilatorio (VT2) puede ser utilizado como estrategia para observar cambios pos COVID-19. La disminución hallada, puede estar relacionada más al cese del entrenamiento que al daño cardiopulmonar.

Palabras clave:

COVID-19. Rendimiento deportivo.
Ejercicio. Medicina del deporte.
Umbral ventilatorio.

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Introduction

Coronavirus disease 2019 (COVID-19) has affected more than 150 million people worldwide¹. Major sporting events (Olympic Games, world and national championships, etc.) had to be temporarily suspended, meaning that all professional sport had to adapt to the situation². This was mainly because the disease caused by the SARS-CoV-2 virus is, beyond lung involvement, potentially a multi-organ disease. That is to say, it acts by affecting different organs and systems, including the lungs, heart, blood vessels, brain, liver, kidney and intestine³. As a result, there has been an increase in people with such sequelae as pulmonary fibrosis, myocarditis, chronic heart failure or chronic kidney disease⁴.

In professional athletes affected by COVID-19, there is always doubt about the impact that the virus may have on the body and whether they will return in peak physical condition. Post-COVID-19 assessments are important in general and a comprehensive evaluation of the cardiopulmonary system is especially important⁵. The cardiopulmonary exercise test (CPET) or ergospirometry allows dynamic evaluation of cardiac, respiratory, metabolic and neuromuscular function by analysing the gases breathed during a standardised stress test. It measures oxygen uptake and peak uptake during exercise ($\text{VO}_{2\text{peak}}$ or $\text{VO}_{2\text{max}}$), as well as many other physiological variables and ergospirometric parameters⁶.

In the current health context, CPET is included in the list of tests for monitoring patients who have suffered from COVID-19 infection, as reflected in the guidelines published by the European Respiratory Society (ERS)/American Thoracic Society (ATS) task force⁷ and the American College of Cardiology⁸.

While much remains to be discovered about the long-term impact of COVID-19, cardiopulmonary disturbances and symptoms, such as dyspnoea or fatigue, may persist for months and are possibly related to infection-related pulmonary or interstitial muscle and vascular deconditioning^{9,10}. In elite male handball players with a recent history of COVID-19 infection, a significant reduction in $\text{VO}_{2\text{max}}$, oxygen pulse and pulmonary ventilation (PV) was evidenced through ergospirometry, opening the way to interpretation that COVID-19 infection leads to a deterioration of cardiopulmonary performance during physical exertion¹⁰. There are few studies which analyse the impact of COVID-19 on cardiopulmonary variables in elite athletes.

This study aimed to analyse the post-COVID-19 impact on the cardiopulmonary system by means of a maximal ergospirometry test on elite professional footballers. Such an analysis should allow us to better understand how this disease affects highly trained athletes.

Materials and methods

Population and design

The sample consisted of 10 football players from the AFA's (Argentine Football Association) Primera División with the following charac-

teristics; age 22.4 ± 6.9 years old, body mass 71.5 ± 7.1 kg and standing height 176.2 ± 6.9 cm.

The study has an observational design and its level of analysis is relational. The sample was selected intentionally and for convenience. The players had been measured with ergospirometry prior to the COVID-19 disease at the beginning of the 2021 pre-season period as part of a systematic performance evaluation protocol carried out by their club. The players who tested positive for COVID-19 during this period were tested again with ergospirometry on their return to professional sporting activity post-COVID, 10 days after medical discharge. This meant it was possible to compare maximal oxygen uptake before and after infection.

In order to be included, all the players had to test positive for SARS-CoV-2 by a specific RT-PCR using nasopharyngeal swabs. The most frequent symptoms were anosmia, fever, asthenia and adynamia, although 5 subjects were asymptomatic.

The study was carried out in accordance with the Declaration of Helsinki, and respecting Resolution 1480/11 of the Argentine Ministry of Public Health, Guide for Research with Human Beings. The data from the evaluations that football players usually undergo in their sports career were used. Participation in this study was voluntary and the players were explained beforehand what the measurements consisted of and that their data would always be kept anonymous. Informed consent was obtained from all the players taking part.

Cardiopulmonary exercise test (CPET)

In the lab test, the players did a 3-minute warm-up. The test was incremental, starting at $8 \text{ km}\cdot\text{h}^{-1}$ and increasing the speed by $1 \text{ km}\cdot\text{h}^{-1}$ every 1 minute until exhaustion, with a fixed slope at 1% ¹². The mean temperature during the test ranged from 22 to 24°C . The players' body mass and height were also measured. The COSMED® model K5 gas analyser was used on the treadmill (Figure 1). It has linear and fast-response sensors¹². The flow meter is a digital turbine with a flow range of 0.08 - 16 l/s , an accuracy of $\pm 2\%$ or 50 ml/s and a resistance of $<0.6 \text{ cmH}_2\text{O}$ s/l up to 14 l/s . The O_2 sensor is a gas flow controller (GFC) with a range of 0 - 100% , an accuracy of $\pm 0.02\%$ and a response time of $\sim 120 \text{ ms}$. The CO_2 sensor is a non-dispersive infrared (NDIR) sensor with a range of 0 - -10% , an accuracy of $\pm 0.02\%$ and a response time of $\sim 100 \text{ ms}$. This type of evaluation has been described in the literature to measure professional footballers¹³.

Gas exchange was measured with dynamic micro mixing chamber. The data processing software was OMNIA® PC. Oxygen uptake (VO_2), carbon dioxide production (VCO_2) and heart rate (HR) were measured. Gas exchange was quantified with the dynamic micro mixing (DMM) chamber mode in which proportional fractions of exhaled gas are sampled from several breaths within a small chamber of approximately 2 ml ¹⁵. Maximal aerobic speed (MAS) was measured. Relative VO_2 and CO_2 were calculated in $\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$ and as % predicted, the first (VT1) and second ventilatory thresholds (VT2) were calculated in $\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$,

Figure 1. Portable gas analyser used in the study.

HR was calculated at VT2 and as a % of VO_{2max} , and the speeds at which the thresholds were reached and the respiratory exchange ratio (RER) were also determined. Prior to the CPET, a resting electrocardiogram and colour doppler echocardiogram were performed on all the players, with no abnormalities found in any of them. No arrhythmias were observed during the stress test.

Statistical analysis

The data were analysed using the IBM SPSS Statistics V22.0 package. The sample was described, indicating mean and standard deviation. Prior to analysis, the Shapiro-Wilk normality test with a significance level ($\alpha=0.05$) was performed, indicating that the variables behaving normally are all except ($p < 0.05$): post- VO_2VT_2 , post-MAS, pre-SpeedVT1, post-SpeedVT1, pre-SpeedVT2 and post-SpeedVT2. Accordingly, testing for related samples (before-after design) was carried out using the t-test and the non-parametric Wilcoxon test. Differences were interpreted with

the size effect using Cohen's method; <0.5 (small), 0.5 to 0.8 (medium), >0.8 (large)¹⁶.

Results

The ranges obtained for the variables measured pre-COVID-19 were as follows: absolute VO_{2max} between 3,768 and 4,917 $ml \cdot min^{-1}$; relative VO_{2max} between 54.6 and 68.3 $ml \cdot kg^{-1} \cdot min^{-1}$; MAS between 17 and 20 $km \cdot h^{-1}$; RER between 1.12 and 1.29; METs between 15.6 and 19.5 $kcal/min$; VT1 between 32.6 and 44.5 $ml \cdot kg^{-1} \cdot min^{-1}$; VT2 between 44.2 and 57.8 $ml \cdot kg^{-1} \cdot min^{-1}$; HR_{max} between 179 and 189 $beats \cdot min^{-1}$; SpeedVT1 between 11 and 12 $km \cdot h^{-1}$; SpeedVT2 between 14 and 16 $km \cdot h^{-1}$ and $\%VO_2VT_2$ between 76% and 88%.

The ranges obtained for the variables measured post-COVID-19 were as follows: absolute VO_{2max} between 3,533 and 5,094 $ml \cdot min^{-1}$; relative VO_{2max} between 52.3 and 68.2 $ml \cdot kg^{-1} \cdot min^{-1}$; MAS between 18 and 19 $km \cdot h^{-1}$; RER between 1.10 and 1.22; METs between 15.0 and 19.5 $kcal/$

Table 1. Description of the variables measured pre- and post-COVID-19.

Variables (n=10)	Pre-COVID-19 (Mean \pm SD)	Post-COVID-19 (Mean \pm SD)	Diff (post-pre)	p<	Cohen's d
Body mass (kg)	71.5 \pm 7.1	73.9 \pm 7.4	2.41	0.118	0.55 (medium)
VO_{2max} ($ml \cdot min^{-1}$)	4,402.5 \pm 387.4	4,362.4 \pm 528.4	40.10	0.686	0.13 (small)
VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	61.7 \pm 5.2	59.0 \pm 5.1	2.75	0.213	0.42 (small)
MAS ($km \cdot h^{-1}$)	18.7 \pm 0.9	18.6 \pm 0.5	0.10	0.739	0.10 (small)
HR_{max} ($beats \cdot min^{-1}$)	185.4 \pm 6.1	188.8 \pm 5.4	3.40	0.040	0.76 (medium)
METs ($kcal/min$)	17.6 \pm 1.5	16.8 \pm 1.5	0.78	0.222	0.42 (small)
RER (VCO_2/VO_2)	1.2 \pm 0.1	1.1 \pm 0.1	0.06	0.024	0.86 (large)
VO_2VT_1 ($ml \cdot kg^{-1} \cdot min^{-1}$)	39.2 \pm 4.0	37.8 \pm 4.3	1.38	0.460	0.24 (small)
VO_2VT_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	50.7 \pm 4.4	45.6 \pm 4.1	5.10	0.028	0.83 (large)
SpeedVT1 ($km \cdot h^{-1}$)	11.6 \pm 0.5	11.8 \pm 0.6	0.20	0.480	0.22 (small)
SpeedVT2 ($km \cdot h^{-1}$)	14.8 \pm 0.6	14.6 \pm 0.5	0.20	0.419	0.25 (small)
VO_2VT_2 ($\%VO_{2max}$)	82.3 \pm 3.4	77.5 \pm 5.1	4.80	0.670	0.66 (medium)

VO_{2max} : maximal oxygen uptake; METs: metabolic equivalent of task; RER: respiratory exchange ratio; VO_2 : oxygen uptake; MAS: maximal aerobic speed; HR_{max} : maximal heart rate; VO_2VT_1 : oxygen uptake at first ventilatory threshold; VT2: second ventilatory threshold; HR: heart rate.

min; VT1 between 32.3 and 44.9 ml·kg⁻¹·min⁻¹; VT2 between 41.3 and 53.1 ml·kg⁻¹·min⁻¹; HR_{max} between 179 and 195 beats·min⁻¹, SpeedVT1 between 11 and 13 km·h⁻¹; SpeedVT2 between 14 and 15 km·h⁻¹ and %VO₂VT2 between 67% and 83%.

The variables measured pre- and post-COVID are presented in Table 1.

A significant decrease in VO₂VT2 by 18% (p=0.028) was observed in the post-COVID-19 subjects. RER also fell significantly by 5% (p = 0.02). HR_{max} was the only variable that increased significantly after COVID-19, by 1.8% (p = 0.04). As shown in Table 1, no significant changes were observed in the other variables measured.

Discussion

The main result of this study was that in elite professional footballers who were measured before and after COVID-19 with a maximal ergospirometry test, differences were observed in the variables VO₂VT2 (p =0.028), HR_{max} (p =0.04) and RER (p =0.02).

The post-COVID-19 respiratory quotient was lower (Table 1), but although this difference can be interpreted as significant, its importance is low because in both cases the values exceeded 1.1, revealing that significant work intensities were achieved. The heart rate increased (Table 1), which should be interpreted with caution, because while this might indicate greater exertion, the differences were small. Oxygen uptake at the first ventilatory threshold (VO₂VT2) was lower in the post-COVID-19 evaluation (Table 1). The decrease of VO₂ at VT2 in the post-COVID-19 evaluations demonstrates the impact of detraining during the weeks of isolation and the convalescent stage even though they were all mild cases.

These results coincide with two recently published studies, although it should be clarified that these were carried out in other sporting populations^{11,17}. Fikenzer *et al.*¹¹ tried to characterise the early effects of SARS-CoV-2 infections on myocardial morphology and cardiopulmonary function in 8 elite male handball players (27 ± 3.5 years old) compared to 4 uninfected teammates (22 ± 2.6 years old). The infected athletes were examined 19 ± 7 days after first testing positive by PCR. Ergospirometry analysis showed a significant reduction in VO_{2max} (-292 ml/min, -7.0%, p =0.03), oxygen pulse (-2.4 ml/beat, p = 0.015, -10.4%) and minute ventilation (VE) (-18.9 l/min, -13.8%) in those athletes with a history of infection (p <0.05, respectively). The maximal heart rate was seven beats/min higher (+3.7%, p =0.038). The authors suggest that a possible explanation for the changes observed could be the prevalence of pulmonary thrombosis and microembolism, contributing to reduced oxygen uptake, decreased O₂ pulse, and increased heart rate, albeit without clinical evidence of pulmonary thrombosis or embolism. The lung changes only occurred at peak load, indicating a more pronounced functional effect of SARS-CoV-2 infection on the heart. Similarly, Sliz *et al.* observed pre- and post-COVID-19 changes in 45 recreational and professional endurance athletes of both sexes. The

evaluations were carried out with direct measurement and the device used was a treadmill or cycle ergometer depending on the competitive discipline¹⁷. Unlike our study, the authors reported a significant 6% decrease in VO_{2max}. They did, however, observe a 7% decrease in VO₂ at the anaerobic threshold and reported no differences in HRmax or maximal aerobic speed, coinciding with our study¹⁷.

To date, we have not found scientific evidence from tests carried out on elite footballers. For this reason, this study provides important evidence which should be taken into consideration in post-COVID-19 sports training planning. We were obliged to compare our results with studies focusing on different sports disciplines^{11,17}. Although this can be interpreted as a limitation, it is extremely difficult to evaluate athletes of this kind due to the complexity of the sports calendar and the availability of VO_{2max} measured with a gas analyser before and after COVID-19 for later comparison. The results point to the importance of carrying out evaluations of this kind on elite athletes for monitoring.

Conclusions

SARS-CoV2 infection causes functional impairment of cardiopulmonary performance in many athletes. It seems reasonable and safe to test athletes after SARS-CoV2 infection with ergospirometry to ensure health and trainability conditions. Detecting the decrease of the second ventilatory threshold (VT2) post-COVID-19 allows us to interpret the relevance of detraining in elite footballers. It is very important to demonstrate in this group of professional elite athletes without pre-existing diseases that the greatest impact of this disease is generated in a variable related more to halting training than to cardiopulmonary damage. Knowledge of their limitations can help the adaptation processes for recovery to pre-COVID-19 performance levels, stressing these physiological variables.

Conflict of interest

The authors declare that they are not subject to any type of conflict of interest.

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Hemodynamic and motion demands of soccer referees: a comparison between series A and B of the State Championship of Rio de Janeiro, Brazil

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Summary

Introduction: Soccer referees need excellent conditioning to withstand the physical and psychological demands of games. **Objective:** To compare the hemodynamic variables, speed, cadence, and distance coursed of referees during soccer games of series A and B in Rio de Janeiro, Brazil.

Material and method: The total number of decisions made during the 10 soccer matches evaluated was 1,224 observable decisions of 10 professional Soccer referees (one per soccer match: 5 in series A and 5 in series B). We used a frequency meter (Polar, model V800, PolarFlow software) and video footage of the games (Sony, model PXW-Z150, 4K). The moments considered were: the decision, 15 seconds that preceded it, and the period from the beginning of each stage to each decision. Were studied the hemodynamic [average heart rate (mean HR), maximum heart rate (HR_{max}), and minimum heart rate (HR_{min})] and motion variables [average speed (V_{med}), maximum speed (V_{max}), average cadence (cadence_{med}), maximum cadence (cadence_{max}), minimum cadence (cadence_{min}), and distance covered]. Descriptive measures were used to present the results of the variables studied and the Student's T-Test for independent samples to test the study hypotheses. The significance level was set at 95% ($P < 0.05$).

Results: The matches of series A had a greater number of interventions and greater hemodynamic load at the exact moment of the decision than those of series B, significantly ($P < 0.05$): mean HR, HR_{max}, HR_{min}, V_{max}, Cadence_{med}, and Cadence_{max} in series A were higher compared to series B. In the 15 seconds before the decisions: mean HR, HR_{max}, and HR_{min} in series A were higher than in series B, and V_{med} in series B was higher in relation to series A. At the exact moment of the decisions: mean HR in series A was higher in relation to series B.

Conclusion: Referees' interventions are generally carried out under high hemodynamic pressure. The matches played in the A series require a higher number of interventions and hemodynamic intensity than the matches in the series B under high hemodynamic pressure, other psychological factors may play a role; however, this needs to be studied in greater depth.

Key words:

Heart rate. Intensity. Decision. Referee. Soccer.

Las demandas hemodinámicas y de movimiento de los árbitros de fútbol: una comparación entre las series A y B del Campeonato Estatal de Río de Janeiro, Brasil

Resumen

Introducción: Los árbitros de fútbol necesitan un excelente acondicionamiento para soportar las exigencias físicas y psicológicas de los partidos.

Objetivo: Comparar las variables hemodinámicas [frecuencia cardíaca media (mean HR), frecuencia cardíaca máxima (HR_{max}) y frecuencia cardíaca mínima (HR_{min})] y desplazamiento [velocidad media (V_{med}), velocidad máxima (V_{max}), cadencia media (cadence_{med}), cadencia máxima (cadence_{max}), cadencia mínima (cadence_{min}) y distancia recorrida] durante intervenciones arbitrales en partidos entre las series A y B en Río de Janeiro, Brasil.

Material y método: Se analizaron 1.224 decisiones observables de 10 árbitros profesionales de fútbol cada uno en 1 partido (10 partidos del Campeonato Carioca: 5 en la serie A y 5 en la B). Se utilizaron frecuencímetros (Polar, modelo V800, software PolarFlow) y secuencias de video de los juegos (Sony, modelo PXW-Z150, 4K). Los momentos considerados fueron: la decisión, los 15 segundos que la precedieron y el tiempo desde el inicio de cada etapa hasta cada decisión.

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Resultados: Los partidos de la serie A tuvieron mayor número de intervenciones y mayor carga hemodinámica en el momento exacto de la decisión que los de la serie B. significativamente ($p < 0,05$): mean HR, HR_{max}, HR_{min}, V_{max}, cadence_{med} y cadence_{max} en la serie A fueron mayores que en la serie B. En los 15 segundos previos a las decisiones: mean HR, HR_{max} y HR_{min} en la serie A fueron mayores con relación a la serie B, la V_{med} en la serie B fue mayor en relación a la serie A.

Conclusión: Las intervenciones de los árbitros generalmente se realizan bajo presión hemodinámica elevada. Los partidos disputados en la serie A requieren un número de intervenciones e intensidad hemodinámica superior a los partidos de la serie B. En el momento exacto de las decisiones, la FC de los árbitros aumentó en relación a los 15 s que la precedieron, demostrando que, además de las intervenciones que se realizan bajo una presión hemodinámica elevada, pueden influir otros factores psicológicos; sin embargo, esto necesita ser estudiado con mayor profundidad.

Palabras clave:

Frecuencia cardíaca. Intensidad.
Decisión. Árbitro. Fútbol.

Introduction

Soccer referees play an important role in the practice of the sport, as they analyze the game and apply the rules. Among the demands of the match, it is necessary to be well-positioned to make decisions with greater tranquility¹, follow the bids as closely as possible, with a well-angled optic, which allows it to be as correct as possible, mitigating the influence of psychological or physical pressures^{2,3}. Therefore, referees need good physical conditioning to perform intermittent and prolonged exercises^{4,5}.

A systematic review⁶ analyzed 2936 matches and described that Soccer referees move in a very peculiar way, covering an average distance of 10.36 ± 1.11 km per match. Additionally, it revealed that these displacements have types of movements that have been described as: standing, walking, running, running fast, and running moving backward. Thus, it was found that the referees sprinted for less than 1% of the game time and moved most of the time intermittently and with a low average speed of 5.9 ± 0.26 km/h, with high-speed peaks of 3 ± 1.41 seconds. At these times, the average maximum speed (V_{max}) was 19.84 ± 1.56 km/h. It was also found that the maximum heart rate (HR_{max}) of the referees was, on average, 185.02 ± 6.99 beats per minute (bpm). However, the authors emphasize that there is still considerable progress to be made in the cognitive aspect.

For the referees to be able to act in matches, the Brazilian Soccer Confederation (CBF) periodically performs physical tests, which are recommended by the legislation of the *Fédération Internationale de Soccer Association* (FIFA)⁷. This test is divided into two phases, both of which are extremely exhaustive⁸.

Helsen and Bultynck⁹ point out that referees make, on average, 137 observable decisions during the game. This was measured through the referees' body language in the video replay of the matches and ranged from 104 to 162 observable decisions per game. This study⁹ states that training and visual assessments are still very limited because they are generally performed in static environments.

Therefore, it is clear that it is necessary to plan and execute effective training, based on the heart rate (HR) zone that will be used in matches, the distances covered in the games, and the average and maximum speeds required to prepare the referee to meet game displacement and positioning needs^{10,11}, as well as the FIFA physical test.

However, there is a gap in knowledge regarding the physiological and environmental circumstances in which referees make their decisions in the bids of Soccer matches. In this context, the present study aimed to compare the hemodynamic variables, speed, cadence, and distance coursed of referees during soccer games of series A and B in Rio de Janeiro, Brazil.

Material and method

Study design

This study was characterized as an analysis of results collected in field research, of a quantitative, transversal, and observational nature¹².

Participants

The total number of decisions made during the 10 soccer matches evaluated was 1,224 observable decisions of 10 professional Soccer referees (one per soccer match: 5 in series A and 5 in series B). The inclusion criteria were: being a Soccer referee registered with the Soccer Federation of the State of Rio de Janeiro (FERJ) and playing in official professional games of the series A and B of state championships. The exclusion criteria were: the referee not having correctly performed the protocol standardized by the study for the start of the match, starting the stopwatch with his arm outstretched, which would make it impossible to synchronize the time of the filming of the game with that of the frequency meter; or the match footage suffers interruptions.

Research ethics

This study is part of a project approved by the Research Ethics Committee CAAE Nº 06805512.9.0000.5291, with protocol Nº 223412. All study procedures followed the current legislation of the Brazilian National Health Council for research with human beings¹³. All participants voluntarily signed an informed consent form before entering the study.

Procedures

Before the start of the warm-up for the matches and in an appropriate place, the referees underwent a test offered by the HR monitor

model V800, made by Polar, to verify the maximum oxygen volume (VO_{2max}). They were instructed not to speak and to remain relaxed in the supine position for about 1 to 3 minutes when the frequency meter measurement was started. For anthropometric assessment, we used an anthropometric body control scale with portable digital bioimpedance OMRON (USA), model HBF-514C, a hand-held sensor for portable digital bioimpedance OMRON, and a Sanny tape measure (Brazil).

For the quantitative analysis of the data, all the referees were instructed that they could use the Polar brand V800 GPS frequency meter, the same used to perform the VO_{2max} test. The equipment was adjusted to the physical and physiological characteristics of the participant before the games and was activated at the beginning of each half and turned off shortly after the end of each stage by the referee. Silva *et al.*¹⁴ validated the reliability and reproducibility of the data obtained by the frequency meter used in this study.

To identify decisions during the matches, the games were filmed with a professional Sony camera, model PXW-Z150, with 4K resolution quality. To synchronize the time of the frequency meter with the time of decisions in the games, the referees were instructed to start recording the frequency meter so that it was visible in the replay of the match, extending the arm in front of the body. It was necessary to segment the replay of the match so that the initial time of the filming was the exact moment in which the frequency meter was triggered by the referee and, thus, the time of the filming and the frequency meter were synchronized.

To identify the referees' decisions during the game, the exact moment when the referee gestured or whistled, whichever happened first, was considered, to demonstrate the decision during the match.

The decisions taken during the games were: direct free kick in favor of the attack; direct free kick in favor of the defense; direct free kick in favor of the attack, with application of a yellow card; direct free kick in favor of the defense, with application of a yellow card; direct free kick in favor of the attack, with application of the second yellow card and, consequently, the red card; direct free kick in favor of the defense, with application of the second yellow card and, consequently, the red card; direct free kick in favor of the attack, with application of the direct red card; direct free kick in favor of the defense, with application of the direct red card; throw-in in favor of the attack; throw-in for the defense; application of the yellow card; application of the red card; goal kick; corner kick; technical time; end of the game period; ball to the ground; goal; off-side; penalty; penalty with application of a yellow card; goal with the application of a yellow card.

For the analysis of hemodynamic variables (mean HR, HR_{max} , HR_{min} , and HR amplitude) and variables related to displacement (V_{med} , V_{max} , and V_{min} , in km/h; $cadence_{med}$, $cadence_{max}$, and $cadence_{min}$, in steps/min; distance covered, in km), the Polar Flow program was used. In addition to the exact moment of decision making in each observed decision, the period of 15 seconds that preceded it, as well as the period from the beginning of the match to the decision, were considered.

The most used movement pattern was verified in the periods: a) between the beginning of the match and each decision taken; b) the 15 seconds preceding the decision; c) the moment of the decision. The patterns considered were based on the V_{med} of the period and, to compare this data, the amplitude between the V_{max} and V_{min} of this

Table 1. Categorization of referee displacements regarding the speed.

Movement pattern	Speed (km/h)
Walking	0 – 7.2
Jogging	7.3 – 14.4
Running	14.5 – 19.8
High intensity running	19.9 – 25.2
Sprint (running at maximum intensity)	>25.2

interval was analyzed. The standards used followed those described by Di Salvo *et al.*¹⁵ and are described in Table 1.

Matches are divided into two 45-minute stages, plus extras that the referee deems relevant to make up for a lost time, according to the rules of the sport¹. All games had a technical time-out, which is a two-minute stoppage that takes place in Rio de Janeiro games, at the first opportunity in which the game is interrupted by a game marking, from the twentieth minute played of each stage.

In the games played by the series A, the central referees had the help of two additional referees (positioned on the goal line close to the goal), in addition to the conventional ones, two assistant referees, and a fourth referee, unlike in the series B, where there is no figure of the additional referee, positioned at the goal line.

Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS), version 25. Descriptive measures were used to present the results of the variables studied and the Student's T-Test for independent samples to test the study hypotheses. We opted for parametric statistics, based on the central limit theorem¹⁶, which refers to the convergence of sums of random variables for a normal distribution in large samples (>30) since a dataset with 1,224 events was analyzed. The level of significance was set at 95% ($P < 0.05$).

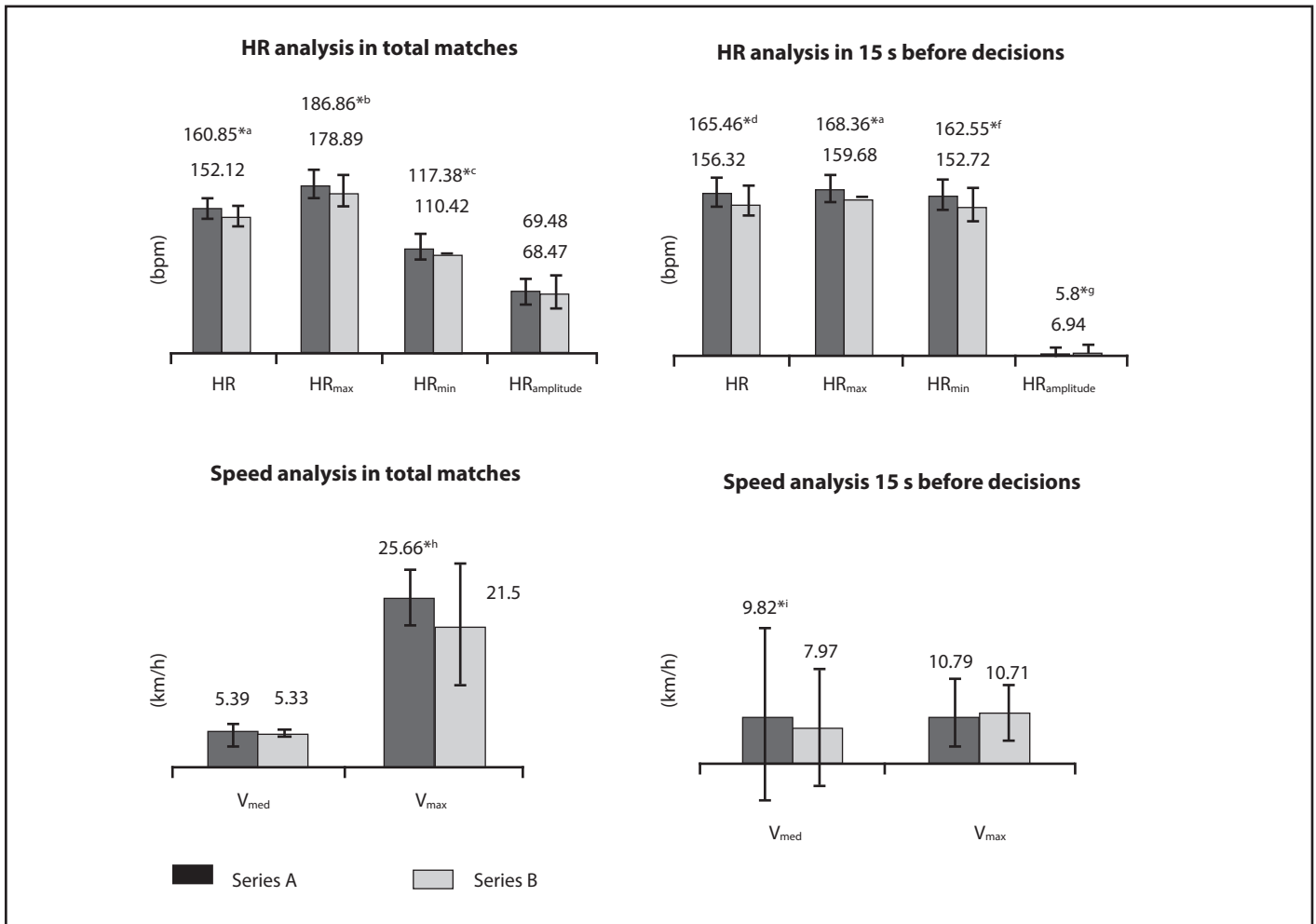
Results

The mean age of the referees involved in the study was 37.20 ± 5.05 years; mean height was 1.84 ± 0.06 m; mean body mass of 84.53 ± 7.14 kg; the mean fat percentage measured was $14.83 \pm 3.4\%$, and they had a mean VO_2 of 48.90 ± 3.66 mL/kg/min. It was collect to characterize the simple.

The 1,224 decisions analyzed, in the total of matches, generated an average of 124 ± 11.24 decisions per game, where the game in which the referees showed the highest number of decisions totaled 142 and the lowest number of decisions observed in a game was 108. In series A games, the average of decisions was 131.8 ± 8.37 (124 -142) per game, in series B, this average was 116 ± 7.88 (108 -125).

All decisions in which the referee whistled and/or gestured demonstrating his interference in the game were analyzed, which generated a total of 1224 analyses, 650 in games played by series A and 574 in games played by series B.

Figure 1. Analysis of HR and speed in total matches and 15 seconds before decisions.



HR: heart rate; bpm: beats per minute; s: seconds; HR_{max}: maximum heart rate; HR_{min}: minimum heart rate; V_{med}: average speed; V_{max}: maximum speed; $P < 0.05$ in Student's t-test for independent samples (*: $P < 0.001$; ^b: $P < 0.001$; ^c: $P < 0.001$; ^d: $P < 0.001$; ^e: $P < 0.001$; ^f: $P < 0.001$; ^g: $P = 0.001$; ^h: $P < 0.001$; ⁱ: $P = 0.025$).

The hemodynamic variables, as well as those related to displacement, were verified during the referees' observable decision-making, in the matches, and were compared considering the possibility of being influenced by the level of competition. Figure 1 and Table 2 demonstrate which variables have significantly changed depending on the level of competition.

Figure 1 presents the variables mean HR, HR_{max}, HR_{min}, HR amplitude, V_{med}, and V_{max}, descriptively, in the time between the beginning of each match time until the moment of each decision and in the period of 15 s that precedes the referees' decisions.

Table 2 presents, in a descriptive way, the study variables related to displacement, in two periods: between the beginning of each match time until the moment of each decision and in the period between the decision and the 15 seconds that precede it. Based on the period between the making of each decision and the 15 seconds that precede it, the *N* remains the same because they are the same decisions.

Table 3 presents the study variables at the exact moment of each decision.

Based on the exact moment of decision making, only four variables are described, because, as it is not a time interval, but a single moment for each decision, only the variables mean HR, V_{med}, cadence, and movement pattern are possible to measure. The mean HR in the decisions taken in the series A games surpassed the result of the series B ($P < 0.001$). We observed that, at the moment of the decision, the referees stop to gesture and/or whistle. Both actions influenced the values of the variables V_{med}, cadence, and movement pattern, which presented low values in all the analyzed games.

Discussion

This study aimed to analyze the hemodynamic variables and those related to the displacement of Soccer referees from series A and B

Table 2. Variables related to displacement in the periods: between the beginning of each stage of the match until each decision and 15 s before the decisions.

Variable	N	Mean	SD	P-value
(Period: from the beginning of each stage to each decision)				
Covered distance A (km)	650	1.99	1.32	0.211
Covered distance B (km)	574	1.89	1.34	
Cadence A (steps/min)	650	72.84	3.46	<0.001*
Cadence B (steps/min)	574	71.06	4.05	
Cadence _{max} A (steps/min)	650	109.39	6.8	<0.001*
Cadence _{max} B (steps/min)	574	103.67	8.77	
Cadence _{min} A (steps/min)	650	24.92	7.04	0.001*
Cadence _{min} B (steps/min)	574	23.73	5.93	
Movement pattern A (km/h)	650	1.01 (walking)	0.1	0.008*
Movement pattern B (km/h)	574	1.00 (walking)	0	
(Period: 15 s before decisions)				
Covered distance A (km)	650	0.02	0.01	0.317
Covered distance B (km)	574	0.02	0.01	
Cadence A (steps/min)	650	71.49	14.74	0.125
Cadence B (steps/min)	574	70.24	13.58	
Cadence _{max} A (steps/min)	650	81.24	17.24	0.023
Cadence _{max} B (steps/min)	574	79.06	16.16	
Cadence _{min} A (steps/min)	650	60.76	15.69	0.744
Cadence _{min} B (steps/min)	574	60.46	15.9	
Movement pattern A (km/h)	650	1.59 (walking)	0.96	0.013*
Movement pattern B (km/h)	574	1.46 (walking)	0.83	

SD: standard deviation; A: related to series A games; B: related to series B games; Covered distance: covered distance until the decisions in the period; Cadence: average cadence of the referees in each period; Cadence_{max}: maximum cadence of the referees in the period; Cadence_{min}: minimum cadence of the referees in each period; Movement pattern: predominant movement pattern in each period; *: P<0.05 in Student's t-test for independent samples.

Table 3. Hemodynamic variables and movement pattern at the exact moment of decision making.

Variable	Serie	N	Mean	SD	P-value
Mean HR (bpm)	A	650	166.03	14.14	<0.001*
	B	574	157.04	14.70	
V _{med} (km/h)	A	650	8.24	7.77	0.177
	B	574	7.73	5.70	
Cadence (steps/min)	A	650	70.59	19.83	0.414
	B	574	69.65	20.28	
Movement pattern (km/h)	A	650	1.54 (walking)	0.93	0.444
	B	574	1.51 (walking)	0.85	

SD: standard deviation; mean HR: average heart rate of the referee at the exact moment of each decision making; V_{med}: average speed at the exact moment of each decision making; Cadence: average cadence of the referee at the exact moment of each decision making; Movement pattern: movement pattern at the exact moment of each decision making.

of the State Championship in Rio de Janeiro, Brazil, based on the moments in which the referees intervene in the games. The number of interventions comprised 1,224 observable decisions in 10 matches. In terms of cognitive demand, games in the main category (series A) outperformed those in series B, with an average of 132 decisions per

game. This average is close to the study by Helsen and Bultynck⁹, who observed an average of 137 decisions per game, in an analysis of 31 games, during the second phase of Euro 2000. These findings suggest that, in terms of the number of interventions, the referees in this study are similar to Europeans.

These data also suggest that the game has a lot of interruptions and that the ball time in dispute seems to be greatly reduced in Soccer since a match lasts 90 minutes, plus stoppage time. This suggests a value greater than one game interruption per minute. In the present study, the number of game interruptions in series A exceeded that of series B, even considering that in series B the stadiums are usually more modest and with smaller fields, which would favor a greater number of interruptions. This may have happened because, in series A, the games were played with greater intensity as the results were presented, which will be discussed below.

Mean HR seems to be a good indicator of the physical effort imposed on the referee in matches. The HR increases to supply oxygen to the muscles required during the effort. However, this rate can also be affected by other reasons, including stress¹⁷. In our study, it seemed that the decisions made in the games of the series A demanded more from the referees than the games of the series B since the averages of mean HR, HR_{max}, and HR_{min} in the games of the series A significantly surpassed the values presented in the games of the series B. These factors indicate that the games played in the superior category are more intense, since, corroborating these findings, in our study, the averages of V_{max}, cadence, and cadence_{max} were also higher in the A series games.

Concerning mean HR, the series A games were more intense and/or more stressful, showing an average value of 160 bpm. D'Ottavio and Castagna¹⁸ carried out a study with referees from the Italian Soccer Federation in the main series, who had an average age of 37.5 years, very close to the referees in our study. The authors found a mean HR of 163 bpm in the matches. Still dealing with the main series, the study of Krusturp and Bangsbo¹⁹ found results that corroborate these findings, as the sample had an average age of 38 years and presented a mean HR in games of 162 bpm.

The study by Oliveira *et al.*²⁰, although it had a sample with a mean age of 36.36 and the referees had a mean HR of 160.51 bpm, differed from the others because they analyzed the under-20 category of the Paulista Championship, Brazil. This suggests that, apparently in this pre-professional category, the game has the same intensity as the A series of our study and exceeds the intensity of the series B games of our study, which presented a mean HR of 152.12 ± 9 bpm. In general, referees exercise arbitration with a very high mean HR, when compared to referees from other modalities who also exercise their function in movement, for example in basketball, in the study by Vaquera *et al.*²¹, in which basketball referees, during the main European tournament, presented a mean HR of 140.3 bpm.

In terms of HR_{max}, the results showed that the referees, during the matches, make decisions, several times, with a very altered hemodynamic state and, in our study, the games played in the superior category were more intense for the referees. The intensity of matches in series A was higher than in series B since, in our study, there was a significant overcoming in relation to V_{max}, which in series A was 26.66 km/h against 21.50 km/h in series B games.

The cadence_{med} and cadence_{max} were also significantly higher in series A, reaching 109.39 steps/min. This high intensity in games is compatible with the study of Mallo *et al.*²². The authors, although not comparing different categories, found an average mean HR of 187 bpm, showing that the referees' heart in matches is quite demanded. Additionally, the referee needs to be conditioned to ratiocinate in some moments of the game with very high HR. Furthermore, this study²² found that time spent performing high-intensity activities correlated with the distance traveled by the ball during games.

These results demonstrate that there is a high hemodynamic load imposed on the referees during games, including a high level of the aerobic system, as well as anaerobic capacities to meet the demands of the game. Therefore, the referee must be prepared in a very specific way. The results of this study support the adoption of intensive and intermittent training, which should, in the first place, prioritize high-intensity aerobic exercise, aiming to support and maintain high HR during the game. Also, it develops the anaerobic system because, although involved to a lesser extent, it plays an important role, with short and several periods of high-intensity activities during decisions in the game.

Cognitive factors, related to referees' interventions during matches, must be involved in the training of these professionals. Weston *et al.*²³ found a relationship between the intensity of the referees and that of the players and emphasize that the most important thing for arbitration is the decision-making process. Similarly, the games in the A series of the present study are more intense than those in the B series and the level of competition interferes with the hemodynamic response presented by the referees.

In the total period that precedes the decisions cumulatively in this study, the "walk" movement pattern prevailed, which confirms that the most used system in the game is the aerobic one, corroborating with the study of Johnston and McNaughton²⁴. However, the V_{max} reached by the referees in the present study was quite high, 25.66 ± 4.27 km/h, in series A, and 21.50 ± 8.88 km/h, in series B. Although this value is a little lower than that measured by Silva²⁵, who verified 25.96 km/h demonstrated by a referee in a match of the Campeonato Goiano, in 2016. The value found in the present study is very high and this leads us to state that these professionals need to severely change their pace of travel during matches. Still about V_{max} , the A series of the present study surpassed the results of the study by Santos *et al.*²⁶, carried out with 30 referees from Bahia, where the highest speed reached in the game was 24 km/h, and although, according to D'Ottavio and Castagna¹⁸, sprints last from 2 to 4 seconds only, they can be crucial when making decisions in the game and can completely change the referee's optics at decision time, making him manage to be close or not to the throw, in a long throw for example, or a crucial move in the game.

It was found that the cadence behaved in the same way as the variable V_{max} , as there was a considerable difference between the cadence_{med} and the cadence_{max}, which corroborates the previous paragraph, with the great intermittence and sudden change in intensity during decisions, throughout the game, but in the search for greater depth. Regarding the variables of this study, in the moments closest to when the referees showed to have taken the decisions, the analysis of the moment of the decision and the 15 s that precede it, revealed interesting data.

Although a comparison was not made between the 15 s that precede the decisions with the exact moment in which they are taken, the data revealed a tendency that in the 15 seconds before the decision, the mean HR is greater than in the total period of the stage, from the start of the match to the referee's intervention in the game. Apparently, in this short period of 15 s before the referee's intervention in the game, the mean HR increases with the other moments of the match and, perhaps, for this reason, FIFA has reduced the stimulus time in the physical assessment test from 30 s to 15 s, because, currently, the referees cover 75 m in this short time interval, for 40 times²⁷. This fact cannot be confirmed because the literature has not presented any justification for this change in the test distance. The results of the present study show that the average distance in this period was 20 m. According to Krustup and Bangsbo¹⁹ and Castagna *et al.*²⁸, who stated that the longest distance traveled in a straight line (without changing direction) is around 35–40 m. This information alone already demonstrates that there is a lack of specificity (running without change of direction) in the aptitude test carried out by the referees.

Still concerning the period of 15 s before each intervention in the game, the HR_{max} was also significantly higher in series A (165.46 ± 14.44 bpm) and series B (156.32 ± 14.86 bpm). A factor that ratifies and justifies this superiority, in relation to FC in the total period of the match, is that the FC_{min} was significantly higher in the A series matches. Therefore, in the superior category, as the game is more intense, the referees already start from a higher HR than in the series B games and, perhaps, for this reason, the hemodynamic variables mean HR and HR_{max} reached higher averages in the A series of this study, both in this short period of 15 s and in the period from the beginning of each stage of the game until the intervention of the referees in the games.

The HR amplitude in this period was 5.80 ± 5.91 bpm, in the A series against 6.94 ± 6.10 bpm in the B series. These low values suggest that the HR does not change abruptly in relation to the average of the match, in the eminence of decision making. Perhaps for this reason, in the study of Silva²⁹, the more experienced referees were more correct in decisions, as she states that the more experienced referees controlled the intensity better during the match, obtaining less variation than the less experienced referees. However, psychological factors and the current mental state can interfere with decisions. This same study claims that watching videos before matches minimizes the mistakes of these professionals. Thus, in the present study, the analyzes regarding the exact moment of the referees' interventions revealed that the mean HR was also higher in the series A, which seems to be a consequence of the superiority of the HR-related variables in the 15-second periods preceding the interventions of the arbitrators, a fact already discussed in the previous paragraph.

It has been observed that referees often demonstrate decisions by standing still or slowing down. This made the analysis shown in Figure 1 present low average values in relation to the standards of each variable, except for the referee's mean HR, at the exact moment of each decision making (Table 3); because the deceleration or stop time is very short and the heart rate gradually drops.

According to Oliveira *et al.*³⁰, if, at the time of the decision, there is some psychological pressure, it can raise the referee's HR. However, none of the results of the present study can corroborate this assertion, as it did

not analyze the psychological factor. The aforementioned authors³⁰ state that referees tend to increase their attention span during the match and that the increase in the level of anxiety reduces the focus of attention. In this way, he justified in his study the improvement in the speed of concentration of the referees at the end of the games, since, at this moment, the level of tension decreases. These authors also state that activation is a multisensory phenomenon, consisting of physiological arousal and the interpretation of a referee, for example, the elevation of HR in the heart, and confidence and anxiety in the brain. This need for activation may have contributed to a trend towards an increase in mean HR at the exact moment of the interventions in relation to the 15 s that precede them, both in the results of series A and B. However, as discussed earlier, this can also be a consequence of the change in intensity in this short period.

This study has a limitation regarding the variables related to cadence since the instrument used does not present validation in relation to this item, where the step is considered by an estimate related to the data entered by the user (height, body mass, and age).

Conclusion

The results show that soccer referees intervene in soccer matches, about 137 times, and under strong hemodynamic and psychological stress. The matches played in the highest category (series A) require a greater demand from the referees for interventions, surpassing in hemodynamic intensity the interventions carried out in the games of the lower category (series B).

Due to the particularities verified about the hemodynamic factors to which the referees are exposed in the games, they need to be trained in an environment as close as possible to the reality of the matches, where they can make decisions based on a high HR, value around 160 bpm, and need to increase the intensity for 15 s, culminating with a moment of intervention in the game of a cognitive nature.

At the exact moment the decision is made, the HR of the referees tended to increase in relation to the 15 seconds that preceded it, demonstrating that interventions are usually carried out under high hemodynamic pressure, in addition to suggesting that other psychological factors can have a big influence at this time. However, this needs to be studied in greater depth. Studies are suggested with the moments of decision-making intervention of the referees with a greater focus on psychological factors, which take into account the level of the opposing teams in the confrontations, as well as analyze the result of the matches and the team that is acting in their stadium.

Conflict of interest

The authors do not declare a conflict of interest.

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Adductor functionality and strength in high-level rink hockey players

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Summary

Objective: To evaluate adductor strength and groin function in high level rink hockey players and its relationship with groin pain in the previous season.

Material and method: A cross-sectional study was performed where hip/groin strength and function was assessed via 5 seconds Squeeze Test and Hip and Groin Outcome Score in 11 high level rink hockey players.

Results: Overall prevalence for groin pain was 81.8% (54% of the participants suffered groin pain during the previous season), and 18.2% suffered time-loss groin pain. Mean strength in the 5SST was 254.68N (3.25Nm/Kg) and HAGOS questionnaire reached 90/100 points in the whole sample. Similar adductor strength values were observed between healthy athletes and previously injured who suffered time-loss groin pain ($P=0.261-0.948$; $g: 0.04-0.85$). Statistically significant differences were found for the following HAGOS subscales: Pain, function, sports and recreational activities, and quality of life between groups ($P=0.005-0.042$; $g: 0.34-2.65$; $r: 0.3-0.61$).

Conclusion: More than a half of the participants suffered groin pain, of which one third suffered time-loss groin pain. Function assessed via HAGOS seems to be the main proxy that discriminates between groups. Medical staff should implement this questionnaire to detect and avoid the progression of this injury.

Key words:

Groin pain. Squeeze test. Rink hockey. Adolescent. Level of evidence: IV.

Funcionalidad y fuerza de aductores en jugadores de hockey sobre patines de alto nivel

Resumen

Objetivo: Evaluar la fuerza de los músculos aductores y la funcionalidad en jugadores de hockey sobre patines de alto nivel y su relación con sufrir dolor inguinal (DI) en la temporada anterior.

Material y método: Se realizó un estudio transversal donde se registraron los valores de fuerza mediante el *Squeeze Test* de 5 segundos (5SST), y la funcionalidad de la cadera e ingle mediante el cuestionario *Hip and Groin Outcome Score* (HAGOS) en una población de 11 jugadores de hockey sobre patines de alto nivel.

Resultados: La prevalencia total de DI fue de 81,8% (en la anterior temporada el 54% sufrió DI), de los cuales un 18,2% llegó a detener la práctica deportiva. La fuerza media para el 5SST es de 254,68N (3,25Nm/kg) y la funcionalidad alcanzó los 90/100 puntos en el cuestionario HAGOS para toda la muestra. La fuerza muscular fue similar entre jugadores que habían sufrido DI con pérdida de tiempo durante la última temporada y jugadores sanos en ($p=0,261-0,948$; $g: 0,04-0,85$). Se encontraron diferencias significativas en las siguientes subescalas del cuestionario HAGOS: Dolor, actividades deportivas y recreacionales, y calidad de vida entre ambos grupos ($p=0,005-0,042$; $g: 0,34-2,65$; $r: 0,3-0,61$).

Conclusión: Más de la mitad de los jugadores sufrieron DI, de los cuales un tercio llegó a detener su actividad. La funcionalidad medida a través del HAGOS se erige como el principal indicador que mostró diferencias entre grupos. Los servicios médicos de jugadores jóvenes de hockey sobre patines deberían usar este cuestionario para poder detectar precozmente la aparición y evitar la progresión de esta lesión.

Palabras clave:

Dolor inguinal. *Squeeze test*. Hockey sobre patines. Adolescente. Nivel de evidencia: IV.

Accesit to the best communication of the Conference of Badajoz

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Introduction

Groin pain (GP) is a common complaint in sports involving changes of direction and pace, such as soccer, rink or ice hockey. Moreover, the literature on this subject has increased substantially since the publication of the Doha consensus establishing a standard terminology for the classification of this pathology¹. Given the complexity of this injury, there is a need to quantify those cases in which the injured athlete continues activity but with reduced performance (non-time-loss injury) as well as those cases in which the athlete is forced to completely stop physical activity (time-loss injury [TL])². In a season, the prevalence of time-loss groin pain (TLGP) varies between 13.6% and 32.5% depending on the sport in question, with soccer being the sport with the highest number of cases³. An analysis of the complete spectrum shows higher rates, even reporting a cumulative prevalence of GP of 45% up to 59% in some cohorts^{4,5}. However, if only the TLGP is reported then this underestimates the extent of the issue. This is because, out of all the cases of GP, those with a time loss account for just 10-34% ((cases with time loss/total cases) × 100)^{5,6}.

The physiological characteristics of rink hockey could facilitate the occurrence of GP in this population. Thus, a player can skate up to 5,568 metres (SD = 0.750) in a game, of which 739 (SD = 0.209) are made at high speed (>5 m*s). Furthermore, the player performs more than 300 changes of pace during the game (160 ± 27 accelerations and 143 ± 26 decelerations), requiring great muscle strength in the lower extremities in order to cope with the demands of the sport⁷. The practice of sport involves a risk of sustaining an injury, and this is also the case for hockey. Recently, a number of studies have focussed on the epidemiology of this sport. Thus, there is a reported general incidence of 3.23 to 9.7 injuries per 1,000 hours of exposure^{8,9}. On the other hand, a high incidence of tendinopathies has been observed in this population, accounting for 11% of the total injuries affecting the adductor muscles¹⁰. Quintana-Cepedal et al. observed that 16% of time-loss injuries affected the hip/groin and that the incidence of GP injuries was 0.71/1,000 h⁹. The hip/groin is the area presenting the most problems in this sport, just like other multi-directional sports^{5,11}. The main risk factors are: having sustained a previous episode of GP; having less strength in the adductor muscles; not following a specific exercise protocol for these muscles; getting poor results in the HAGOS questionnaire; or being a male athlete¹²⁻¹⁶.

However, to date, no risk factor has been studied in rink hockey players and, in general, little analysis has been made of GP in youth populations. Therefore, the key objective of this investigation was to determine the strength values at 5SST and functionality (measurements through the HAGOS questionnaire) in high-level youth rink hockey players.

Material and method

Design

This cross-sectional analytical study was conducted in December 2021 (end of the first round of the competition league) on the occasion

of the Spanish Regional Championship of Under-16 male rink hockey teams (Langreo, Asturias). The study followed the principles of the Declaration of Helsinki and the STROBE criteria (Strengthening the Reporting of Observational Studies in Epidemiology)¹⁷. The study was recorded in clinicaltrials.gov (ID: NCT05273008) prior to the inclusion of the first participant and has the approval of the Ethics Investigation Committee of the Principality of Asturias (Code: 2021.543).

Participants

The participants were selected by convenience sampling. A total of 12 athletes from the regional teams were eligible to participate in the study, with 11 of these players agreeing to take part in the investigation, obtaining data from 91.66% of the sample. The inclusion criteria were as follows: to be selected to participate in the championship and to agree to take part in the investigation, having signed the appropriate consent form. The exclusion criteria were: to have sustained a CPT injury in the 3 months prior to the championship or not to have played in any team match over the last season. Table 1 shows the demographic details of the participating athletes.

Procedures

Prior to the start of the study, the participants and their legal guardians were informed about how the study would be conducted and were given an information sheet and asked to sign a consent form to agree to participate. All the data were collected on the same day. Firstly, the participants completed the HAGOS questionnaire, and then the strength measurements were made. The HAGOS questionnaire measures functionality through 6 subscales (symptoms, pain, daily activity, sport and recreational activities, participation in physical activities, and quality of life) which are scored from 0-100¹⁸. This questionnaire was completed online using a Google form (<https://forms.gle/LDZkavy7it85UMPT7>) which also contained questions on demographic characteristics (age, height, weight) and prior history of GP (GP since starting to practice the sport and in the last season) differentiating between non-time-loss (the athlete can still participate but with a lower performance) and TL (the athlete stops activity for at least a day as a result of the injury). The

Table 1 Demographic information on participants.

Variable	Result
Age (IQR)	15 (15-15)
Height, cm	175.63 (6.56)
Weight, kg	68.54 (9.76)
BMI	22.20 (2.76)
Position P, Player	9 (81.8%)

The results are reported as Mean ± Standard Deviation (SD), Median and Interquartile Range (IQR), as appropriate. Position P: Position on the rink, BMI: Body Mass Index.

Figure 1. 5-second squeeze test (5SST).



strength of the adductor muscles was obtained through a 5SST using a handheld dynamometer (ActivForce 2, ActivForce, San Diego, CA, USA)¹⁹. Prior to the first measurement, two submaximal repetitions were made in order to familiarise the athlete with the test. The 5SST was made with the patient in a supine position and, with the examiner placing their forearm just above the medial malleoli, the participant was asked to continually and isometrically press one leg against the other while exerting the maximum possible force (Figure 1). Athletes were given verbal encouragement during each repetition in order to ensure that they exerted their maximum possible force. After each measurement, we recorded the peak force value (N) and the pain reported in the groin area on a visual analogue scale (0-10)²⁰. The dominant leg, defined as the athlete’s preferred kicking leg, was measured first²¹. A record was also made of the length of the extremity (from the anterior superior iliac spine to the medial malleolus) in order to calculate the torque generated based on the following formula: $T = Nm/Kg$, where T is the torque, Nm is the force measured in Newtons and multiplied by the length of the extremity (in metres), and Kg is the athlete’s weight²².

Statistical analysis

The statistical analysis was performed with SPSS version 21 (IBM, Chicago, IL, USA), the significance level was set to $p < 0.05$. The Shapiro-Wilk test was used to check the normality of the quantitative variables. The values were reported as either mean and standard deviation (SD) or median and interquartile range, as appropriate. The Student-t test was used for the hypothesis testing, comparing the TLGP in the last season with adductor strength and functionality (HAGOS). The Mann-Whitney U-test was used in those cases in which the distribution of the dependent variable was not normal. The effect size (ES) was calculated using Hedges’ g in order to determine the practical relevance of the results. The effect sizes were classified as: Small ($g = 0.2$), medium ($g = 0.5$) and large

($g = 0.8$)²³. For the non-parametric subscales of the HAGOS questionnaire the r statistic was used ($r = Z/\sqrt{n}$) which takes the following values: Small ($r < 0.3$), medium ($r > 0.3$ and < 0.5) and large ($r > 0.5$).

Results

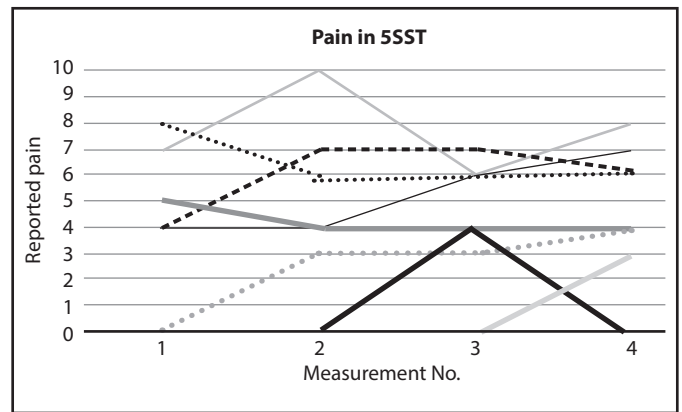
A total of 9 (81.8%) players had experienced GP throughout their respective sports careers and 6 (54%) during the past season. A total of 6 players had suffered TLGP while only 2 had to stop playing for this reason during the past season (18.2%). Figure 2 shows the pain scores reported by each player during the 5SST. For each 5SST, the mean pain reported was 3.1/10 (SD =3).

Groin pain and strength in the 5SST

For the entire population, the mean absolute strength for the dominant and non-dominant leg was 263.81 N (SD =43.5) and 245.54 N (SD =52.9), respectively. And 3.36 Nm/Kg (SD = (0.58) and 3.14 Nm/Kg (SD =0.79) reported in relative values.

Table 2 shows a comparison of the absolute and relative strength values for each group. No significant differences were found between healthy players and players with TLGP in the previous season for either absolute strength or relative strength ($p = 0.26-0.95$).

Figure 2. Pain reported by the players in each 5SST.



Pain reported by the player on 0-10 VAS after each 5SST. Measurements 1 and 3 are for the dominant leg.

Table 2 Comparison between TLGP and healthy players for the strength variables.

	Healthy	GP CPT	Difference of means	ES (g)
Strength D, N	256.5 (43.7)	296.5 (32.5)	40	0.85
Strength ND, N	237.3 (55)	282.5 (19.7)	45	0.8
Torque D, Nm/Kg	3.36 (0.63)	3.33 (0.4)	0.03	0.04
Torque ND, Nm/Kg	3.12 (0.82)	3.24 (0.96)	0.12	0.13

N: Newtons, m: metres, Kg: Kilograms. The data are presented as a Mean (Standard Deviation). * $p < 0.05$

Table 3 Comparison of the functionality measured with the HAGOS form, between healthy players and those who experienced TLGP last season.

Subscales	Healthy	GP CPT	ES
Symptoms	82.88 (12.4)	78.5 (4.9)	0.34 ^a
Pain**	94.77 (3.9)	84 (1.4)	2.65 ^a
ADL	100 (5)	90 (20)	0.31 ^b
PISA	91 (19)	67 (28)	0.61 ^b
PIPA	100 (25)	81.5 (13)	0.30 ^b
QOL*	92.77 (6.6)	80 (7)	1.75 ^a
Total*	92.1 (5.2)	80 (5.6)	2.10 ^a

ADL: activities of daily living; PISA: participation in sports activities; PIPA: participation in physical activity; QOL: quality of life; ES: effect size. *p <0.05; **p <0.01; aHedges' g; br=Z/√n.

Groin pain and HAGOS

The average values for each subscale for the entire sample were 92.8 (SD = 5.61), 82.1 (SD = 11.4), 100 (Range = 20), 91 (Range = 47), 88 (Range = 25), 90.4 (SD = 8.2) and 90 (SD = 7) for symptoms, pain, daily activity, sport and recreational activities, participation in physical activity, and quality of life and the total (mean of the subscales), respectively. Significant differences were found for the subscales of pain, sport and recreational activities, quality of life and the total (p = 0.04-0.005) (Table 3).

Discussion

This is the first study to report values for strength, functionality and previous history of groin pain in youth rink hockey players. We found a prevalence of 54% groin pain, and one-third of the cases were associated with time loss in the last season. The strength values were similar in both groups. However, the values recorded in the subscales of pain, sport and recreational activities, quality of life and the mean of all the subscales were lower for injured players compared to healthy players.

The results show that practically half the players taking part in the study (54%) experienced GP during the last season. However, only 18.2% stopped their activity for at least one day due to this injury. The actual prevalence of this injury is underestimated when only the TLGP is reported. Mercurio *et al.* compared the prevalence of TLGP over a season in various sports, whereby soccer showed the greatest incidence (32.5%), followed by five-a-side soccer (25.5%) and basketball (25.2%). Given that sports disciplines such as water polo (17.6%) and volleyball (13.6%)³ recorded similar values to our athletes, we could consider rink hockey to be a sport with a moderate risk of injury (18.2%) with regard to this pathology. Notwithstanding this, it should be clarified that our athletes are teenagers, unlike the aforementioned study in which the participants had an average age of 25 years. As hip/groin injuries account for 10-14% of total injuries in youth soccer players (under-16)^{24,25}, both

sports share a similar prevalence. It is concerning to find these rates in athletes who are still physically developing, especially considering that the key risk factor for groin injury in the future is to have sustained such an injury in the past^{12,13}.

This pathology is complex and there is a need to study it in its entire spectrum. Our results reveal that 33% of GP cases are TL. Likewise, studies on soccer players report that 10-34% of GP cases are TL^{5,6}. This same pattern can be seen in ice hockey where, over one season, the measurement of TLGP only accounts for 42.2% of all the cases. The evidence confirms the relevance of taking all episodes of GP into account, given that less than half are TL.

With regard to strength, this study is in line with others conducted on similar populations. We obtained an absolute and relative strength of 254.6 N and 3.25 Nm/kg, respectively. Two recent studies reported adductor strength values in soccer players from lower categories: for the under-17 category, the mean strength was 239.7 N; 3.1 Nm/kg and 289.9 N; 3.5 Nm/kg, in absolute and relative terms respectively^{26,27}. Curiously, Esteve *et al.*²⁸ recorded the lowest strength values (2.81Nm/kg) in soccer players in the senior category (Age: 23 years, SD = 4), although this results could be explained by the fact that the measurements were taken during the pre-season. In view of our results, the practice of roller hockey leads to similar strength adaptations as to those found in soccer.

With regard to strength in the 5SST, no significant differences were found between the groups (p = 0.26-0.95). Although prior evidence affirms that a lack of strength is a risk factor for sustaining this injury^{12,13}, an analysis of the latest studies reveals contradictory results. Wörner *et al.*²² reported a difference of 0.35Nm/kg (p <0.001) between the players exhibiting a pain of less than 3/10 during the 5SST, although in a later study, this same author found no differences (p ≥0.15)²⁹. A possible explanation for the divergences described could be the lack of control over the length of time in which the players had been injured. If we take this factor into consideration, athletes experiencing GP for a duration of more than 6 weeks had 15.3% less strength than their healthy counterparts²⁸.

We recorded a total functionality of 90/100 measured through the HAGOS questionnaire. Healthy players scored 92.1/100 while players injured in the last season scored 80/100, giving a 12.1-point difference between the means. Furthermore, significant differences were found for 3 subscales (p = 0.05). Since it first started to be used, a number of studies have confirmed that the HAGOS tool is valid to differentiate between injured and healthy players. The first study published in 2013 obtained a total significant difference of 5.3 points, also finding differences in all the subscales³⁰. More recent studies have reported total significant differences of between 8.2 to 20.6 points³¹⁻³³. However, when comparing the results by subscales, only Carolan *et al.*³³ and Thorborg *et al.*³¹ reported differences in all the subscales, while in the study by DeLang *et al.*³² no differences were found in the subscales for activities of daily living, and sport and recreational activities. The differences between the studies may be due to the heterogeneous nature of the samples used in each one, despite the fact that they were conducted in different sports (soccer vs. hockey); our results are in keeping with those obtained by other groups of investigators³⁰⁻³³.

This is the first study to report values for strength, functionality and history of GP in under-16 high-performance rink hockey players. However, it is not without limitations. Firstly, the study sample is small and

therefore has insufficient statistical power. A further limitation is that it did not record the length of time in which the players were experiencing GP. It is possible that some players may have had GP symptoms for a longer period of time. Despite this, the study does consider the entire spectrum of the injury and, therefore, there is no underestimation of cases. It is also made on a population for which little literature is available. In the future, other lines of investigation could focus on the epidemiology of the injury in female hockey, the functional shortcomings as a result of GP and which could condition performance, and prevention. For these subjects, studies are already available in other areas, with some promising results.

Conclusion

There is a high prevalence of groin pain in its entire spectrum in high-level youth players. Functionality, measured through the HAGOS questionnaire, was able to differentiate between healthy players and those with previous injuries, while strength was similar between groups. Within the detection and treatment of groin pain, HAGOS appears to be a good tool and, therefore, its use is recommended in this population.

Conflict of interest

The authors have no conflict of interest whatsoever.

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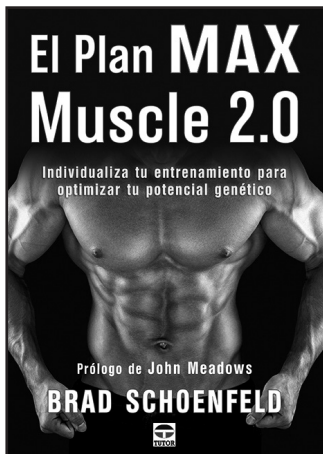
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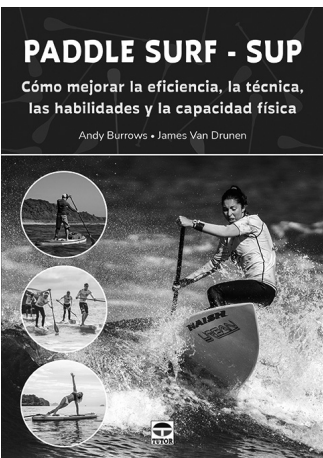
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Campaña de aptitud física, deporte y salud



La **Sociedad Española de Medicina del Deporte**, en su incesante labor de expansión y consolidación de la Medicina del Deporte y, consciente de su vocación médica de preservar la salud de todas las personas, viene realizando diversas actuaciones en este ámbito desde los últimos años.

Se ha considerado el momento oportuno de lanzar la campaña de gran alcance, denominada **CAMPAÑA DE APTITUD FÍSICA, DEPORTE Y SALUD** relacionada con la promoción de la actividad física y deportiva para toda la población y que tendrá como lema **SALUD – DEPORTE – DISFRÚTALOS**, que aúna de la forma más clara y directa los tres pilares que se promueven desde la Medicina del Deporte que son el practicar deporte, con objetivos de salud y para la mejora de la aptitud física y de tal forma que se incorpore como un hábito permanente, y disfrutando, es la mejor manera de conseguirlo.

BIOALTITUDE® V100



Válido para realizar
Ejercicio en Hipoxia



60 Litros



120 Litros



15 Litros

EJERCICIO EN HIPOXIA PARA LA MEJORA DEL RENDIMIENTO

Datos Técnicos - Bioaltitude® V100

HIPOXIA: Flujo: 40 - 100 L/min - Concentración de O₂: 8,5% - 20%

Flujo promedio máximo: 100 L/min.

Flujo pico máximo: 140 l/min

HIPEROXIA: Flujo: 0 - 15 L/min

Concentración de O₂: 70% - 93%

TIPO DE HIPOXIA: Dormir / Reposo / Ejercicio /
Sprints repetidos (RSH)

MÉTODO: Separación del aire por método físico

AIRE HIPERÓXICO: Sí, hasta 15 L/min

MEDIDAS / PESO: 34,4 x 30,6 x 56,5 cm / 20 Kg

NIVEL SONORO: <50 dB

BOLSA DE EXPANSIÓN: Incluida. 60 litros de capacidad.

Opcional hasta 240 litros.

TUBOS: 2 x 3 m

GARANTÍA: 3 años o 5000 horas, en nuestras instalaciones

MANTENIMIENTO: Mínimo (limpieza de filtros y reemplazo filtro

Hepa cada 6 meses)

PESO: 20 kilos

OTROS GENERADORES



400 x 365 x 650 mm
31 Kilos



318 x 191 x 520 mm
11 Kilos



760 x 540 x 1390 mm - 120 Kilos