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A MULTIDIMENSIONAL APPROACH TO THE STUDY OF WATER POLO PERFORMANCE

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A multidimensional approach to the study of water polo performance

Abstract

Nowadays, the ability to change swimming styles and body positions, involving continuous shifting from horizontal to vertical posture and performing jumps, as well as technical skills and tactical behaviour of players, play a fundamental role in water polo performance. To face with these demands, the coaching staff of elite and sub-elite water polo clubs might adopt a variety of training methods, also based on their specific coaching philosophies. A multidimensional approach based on the understanding of the coaches' national coaching philosophy integrated by the individuals and collective tactical assessment, monitoring of players' workload and recovery status, could positively affect the coaching staff's analysis and interpretation of water polo performance. The aim of this PhD dissertation was to investigate on water polo performance by establishing an ecological and multidimensional approach to the physical monitoring and technical-tactical evaluation of water polo players. This research included cross-sectional and longitudinal observational designs with the application of questionnaires and match analysis tools. Data collection took place in three steps, making four different studies and testing five different hypotheses. The first part of this dissertation investigated on national water polo coaching schools, the second part on the use of Team Sport Assessment Procedure (TSAP) instrument to analyse the technical and tactical performance, while the third part focused on the monitoring of players match loads. Analytical and basic descriptive, univariable, and multivariable statistical methods have been used as the main tools for cognitive reasoning and qualitative defining of the investigated phenomena.

In the study 1 the purpose was to survey 40 head coaches of three important national water polo schools (Italy, Greece, and Serbia) to identify and compare their coaching philosophies and training methodologies. The survey was based on five sections (Technical staff composition, Team roster, Weekly periodization, Testing and monitoring, Tactics and strategies). By means of detailed descriptive statistic, the study gave interesting information on how 40 high-ranking elite and sub-elite teams of different national championships organize their training during a typical week of the competitive season.

The aim of the study 2 was to provide an analysis of offensive actions, by means of the Team Sport Assessment Procedure (TSAP) of the first four youth national teams during the 20th FINA Junior Water Polo World Championships. Twenty-nine elite youth (U20) water polo matches, involving the national teams of Greece (n= 7), Serbia (n= 7), Italy (n= 7) and Croatia (n= 8) were selected for the analysis. The TSAP included: i) two indicators of gaining possession of the ball; ii) four indicators of disposing the ball. Using these indicators, the following indexes of technical performance were computed: Volume of Play (VP), Efficiency Index (EI) and Performance Score (PS). The field was divided in twelve zones. The one-way ANOVA showed no significant differences between teams for all parameters ($p>0.05$), except that for Offensive Balls (OB) and Successful Shots (SS) occurred in specific zones of the field: for OB significant differences were found in zone 1 ($p= .019$), in zone 2 ($p= .014$) and in zone 5 ($p= .007$); for SS significant differences were found in zone 1 ($p= .026$) and in zone 2 ($p= .008$).

The aim of the study 3 was to use the same instrument (TSAP) to give a technical and tactical analysis of offensive phases in an Italian elite senior water polo team, playing in the Italian First League championship during the season 2021-22 (19 matches). Using the same indicators of the study 2, Volume of Play (VP), Efficiency Index (EI) and Performance Score (PS) indexes were computed for each player of the roster (n= 15). The multiple linear regression showed a significant association for playing position and VP and PS. Perimetral players showed the highest VP (65%) and PS (66%) values, center defenders the highest values of CB (30%), while center forwards gained the highest amount of exclusion handling the ball (48%).

The study 4 aimed to investigate the effects of playing positions and contextual factors (match outcome, final score difference, match location, travel duration, number of scored and conceded goals) on the internal match load, players' perceived recovery and players' well-being. The session-RPE (s-RPE), Perceived Recovery Scale (PRS) and Hooper Index (HI) of 17 male elite water polo players were monitored during all matches (regular season and play-out) of the 2021-22 Italian Serie A1 championship.

Three separate, mixed linear models for repeated measures showed significant main effects: drawn compared to won matches led to higher s-RPE values (mean ± SE= 277 ± 17.6 vs. 237.3 ± 20.6), while longer travel duration (estimate= −0.148) and goals scored (estimate= −3.598) led to lower s-RPE values; balanced compared to unbalanced matches led to higher PRS values (mean ± SE= 6.8 ± 0.3 vs. 5.1 ± 0.4), while playing time (estimate= −0.041) and goals scored (estimate= −0.180) led to lower PRS values; higher scores of the HI were registered for regular season compared to the play-out (mean ± SE= 15.6 ± 0.9 vs. 13.5 ± 0.8).
This dissertation study could be characterized as a fundamental and applied research since it provides a novel and multidimensional approach within the general knowledge that already exist in water polo performance, providing useful and applicable information to water polo coaches. The TSAP instrument offer productive feedback to coaches to perceive the different requirements of playing and to evaluate how players understand the game, showing that several contextual factors could affect the tactical behaviours of the team and players. Furthermore, our study marks the importance of ecological and non-invasive monitoring tools to assess internal match load, recovery, and the well-being of elite water polo players.

Keywords: team sport; coaching philosophy; match analysis; TSAP; workload monitoring
Scientific field: Physical education and sport
Scientific subfield: Science of Physical education, Sports and Recreation
UDK number: 797.253.015

Višedimenzionalni pristup u izučavanju igranja vaterpola

Rezime

Sposobnost promene načina plivanja i položaja tela, uključujući kontinuirano prebacivanje iz horizontalnog u vertikalni položaj i izvođenje skokova, kao i tehničke veštine i taktičko ponašanje igrača, imaju fundamentalnu ulogu u odnosu na realizaciju vaterpolo performanse. Da bi se suočili sa ovim zahtevima, treneri vaterpolo klubova moraju usvojiti znanja u odnosu na različite metode treninga, koja su u odredjenom stepenu zasnovana na njihovoj specifičnoj trenerskoj filozofiji. Višedimenzionalni pristup trenažnog rada zasnovan na razumevanju nacionalne trenerske filozofije koju integrišu pojedinci ali i kolektiv, baziraju se na taktičkoj proceni, praćenju opterećenja i statusa oporavka igrača, mogu pozitivno uticati na analizu i tumačenje vaterpolo učinka trenerskog osoblja. Cilj ove studije je bio ispitivanje vaterpolo performanse uspostavljanjem ekološkog i višedimenzionalnog pristupa u odnosu na fizičko praćenje i tehničko-taktičkom ocenjivanju vaterpolista. Ovo istraživanje je obuhvatilo poprečne i longitudinalne opservacione dizajne uz primenu upitnika i alata za analizu podudaranja elemenata prostora vaterpolo igre. Prikupljanje podataka odvijalo se u tri faze, elaborirajuči iste u odnosu na četiri različite studije i a za potrebe testiranja pet različitih hipoteza. Prvi deo je bio da se istraži nacionalne vaterpolo trenerske škole, drugi deo je bio da se postigne TSAP instrument, a treći da se prati opterećenje igrača. Kao glavni statistički alati korišćeni su analitičke i osnovne deskriptivne, univarijabilne i multivarijabilne statističke metode.

U studiji 1 anketirano je 40 glavnih trenera tri vrhunske nacionalne vaterpolo škole (Italija, Grčka i Srbija) kako bi se identifikovale i uporedile njihove trenerske filozofije i metodologije treninga. Anketa se zasnivala na pet sekcija (Sastav tehničkog osoblja, Spisak tima, Nedeljna periodizacija, Testiranje i praćenje, Taktike i strategije). Uz pomoć detaljne deskriptivne statistike, studija je dala značajne informacije o tome kako 40 visokorangiranih vaterpolo timova različitih nacionalnih šampionata organizuje svoje treninge tokom tipične nedelje takmičarske sezone.

Cilj studije 2 bio je da pruži analiza ofanzivnih akcija, pomoću promene metode Procedure za procenu timskog sporta (TSAP) a kod prve četiri plasirane reprezentacije juniorskog uzrasta tokom 20. FINA juniorskog (U20) svetskog prvenstva u vaterpolu. Za analizu je odabrano 29 vaterpolo utakmica u kojima su učestvovale reprezentacije Grčke (n= 7), Srbije (n= 7), Italije (n= 7) i Hrvatske (n= 8). TSAP je uključivao: i) dva indikatora sticanja lopte u posedu; ii) četiri indikatora bacanja (dodavanja i šutiranja) lopte. Koristeći ove indikatore, izračunati su sledeći indeksi tehničkih performansi: Indeks obima performanse (VP), Indeks efikasnosti (EI) i Skor učinka (PS). Teren je bio podeljen na dvanaest zona. Jednosmerna ANOVA nije pokazala statistički značajne razlike između timova za sve parametre ($p>0,05$), osim što su se za ofanzivne lopte (OB) i uspešne šuteve (SS) desile u određenim zonama terena: za OB značajne razlike su nađene u zoni 1 ($p= .019$), u zoni 2 ($p= .014$) i u zoni 5 ($p= .007$); za SS značajne razlike nađene su u zoni 1 ($p= .026$) i u zoni 2 ($p= .008$).

Cilj studije 3 je bio da se pomoću istog instrumenta (TSAP) definiše tehnička i taktička analiza ofanzivnih faza u italijanskoj elitnoj seniorskoj vaterpolo ekipi, koja je igrala u šampionatu italijanske Prve lige tokom sezone 2021-22 (19 mečeva). Koristeći iste indikatore studije 2, indeksi obima igre (VP), indeksa efikasnosti (EI) i skor učinka (PS) izračunati su za svakog igrača posebno (n= 15). Analiza višestruke linearne regresije pokazala je značajnu povezanost za igračku poziciju i indekse VP i PS. Konkretno, spoljni (krilni) igrači su pokazali najveći procenat VP (65%) i PS (66%) respektivno. Odbrambeni igrači – centralni bekovi su imali najveći nivo osvojenih lopti (30%), dok su igrači na poziciji centra ostvarili najveći broj isključenja držeći loptu (48%).

Studija 4 imala je za cilj da istraži efekte igračke pozicije i kontekstualnih faktora (ishod utakmice, konačna razlika u rezultatu, lokacija meča, trajanje putovanja, broj postignutih i primljenih golova) na unutrašnje opterećenje utakmice, percipirani oporavak igrača i osećaj opšteg zadovoljstva igrača. Session-RPE (s-RPE), percipirana skala oporavka (PRS) i Hooper indeks (HI) 17 muških elitnih vaterpolista praćeni su tokom svih mečeva (regularne sezone i plej-auta) italijanske Serije A1 prvenstva 2021-22 godine. Tri odvojena, mešovita linearna modela za ponovljena merenja pokazala su značajne glavne efekte: izvučeni u poređenju sa dobijenim mečevima doveli su do viših vrednosti s-RPE (srednja vrednost ± SE= 277 ± 17.6 naspram 237.3 ± 20.6), dok je duže trajanje putovanja (procena = -0,148) i postignuti golovi (procena = −3.598) doveli su do nižih vrednosti s-RPE; izbalansirani u poređenju sa neuravnoteženim mečevima doveli su do viših PRS vrednosti (srednja vrednost ± SE = 6.8 ± 0.3 naspram 5.1 ± 0.4), dok su vreme igre (procena = −0.041) i postignuti golovi (procena = −0.180) doveli do nižih vrednosti PRS; viši rezultati HI su registrovani za regularnu sezonu u poređenju sa play-outom (srednja vrednost ± SE = 15.6 ± 0.9 naspram 13.5 ± 0.8).

Ova studija se može okarakterisati kao fundamentalno i primenjeno istraživanje jer pruža novi i višedimenzionalni pristup u okviru opštih znanja koja već postoje u vaterpolo sportu, pružajući korisne i primenljive informacije vaterpolo trenerima. TSAP instrument nudi produktivnu povratnu informaciju trenerima da sagledaju različite zahteve igre i da procene kako igrači razumeju igru, pokazujući da nekoliko kontekstualnih faktora može uticati na taktičko ponašanje tima i svakog igrača. Štaviše, naša studija označava važnost ekoloških i neinvazivnih alata za praćenje za procenu unutrašnjeg opterećenja utakmice, oporavka i dobrobiti kod elitnih vaterpolista.

Ključne reči: timski sport; trenerska filozofija; analiza utakmice; TSAP; praćenje opterećenja
Naučna oblast: Fizičko vaspitanje i sport
Uža naučna oblast: Nauke fizičkog vaspitanja, sporta i rekreacije
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ABBREVIATIONS

ANOVA: Analysis of variance
a.u.: arbitrary unit
BM: Body mass
BMI: body mass index
CB: Conquered balls
CD: Center defender
CF: Center forward
CROSS: Consensus-based checklist for reporting of survey studies
CSCS: Certified strength and conditioning specialists
CV (%): Coefficient of variance
DOMS: Delayed muscle onset soreness
EI: Efficiency Index
G: Goalkeeper
H_G: General hypothesis
H_1: Hypothesis number 1
H_2: Hypothesis number 2
H_3: Hypothesis number 3
H_4: Hypothesis number 4
H_5: Hypothesis number 5
HI: Hooper index
HR: Heart rate
ITL: Internal training load
LB: Lost balls
M: Men
M + W: Men + Women
NA: Notational Analysis
NB: Neutral balls
OB: Offensive balls
P: Perimetral player
PRS: Perceived recovery scale
PS: Performance Score
RB: Received balls
RPE: Rating of Perceived Exertion
SPSS: Statistical package for the social sciences
SS: Successful shots
TL: Training load
TMA: Time Motion Analysis
TSAP: Team Sport Assessment Procedure
TQR: Total Quality of Recovery
U14: Under 14 age category
U16: Under 16 age category
U18: Under 18 age category
U20: Under 20 age category
VAR: Video Assistant Referee
VP: Volume of Play
W: Women
WP: Wing player

1. INTRODUCTION

1.1 Actual basic water polo statistics facts

Through its history, water polo is now experiencing a period of rapid growth and it is practiced almost all over the world by female and male athletes of different age. The last maxi-research conducted by FINA (in 2019) among its 209 affiliated national federations, to which responded 198 federations states that the number of athletes who practice water sports is more than 34 million, of which 478791 are water polo players. The number of water polo players is lower compared to swimmers (n= 30’882984) and long-distance swimmers (n= 2’582675), but higher compared to artistic swimming athletes (n= 134789), divers (n= 77101) and divers from great heights (n= 30415). Moreover, there are 35000 water polo players of elite level, which participate in senior competitions of the highest rank.

In the world scenario, Europe remains the beating heart of water polo with 267513 players (55.9%), followed by America (n= 114438, 23.9%), Oceania (n= 44381, 9.2%), Africa (n= 30764, 6.4 %) and Asia (n= 20985, 4.3%) (Fina, 2019). The figure 1 shows the distribution of the total amount of all European athletes (elite, junior, youth) involved in official water sport activities considering the 2019-20 season.

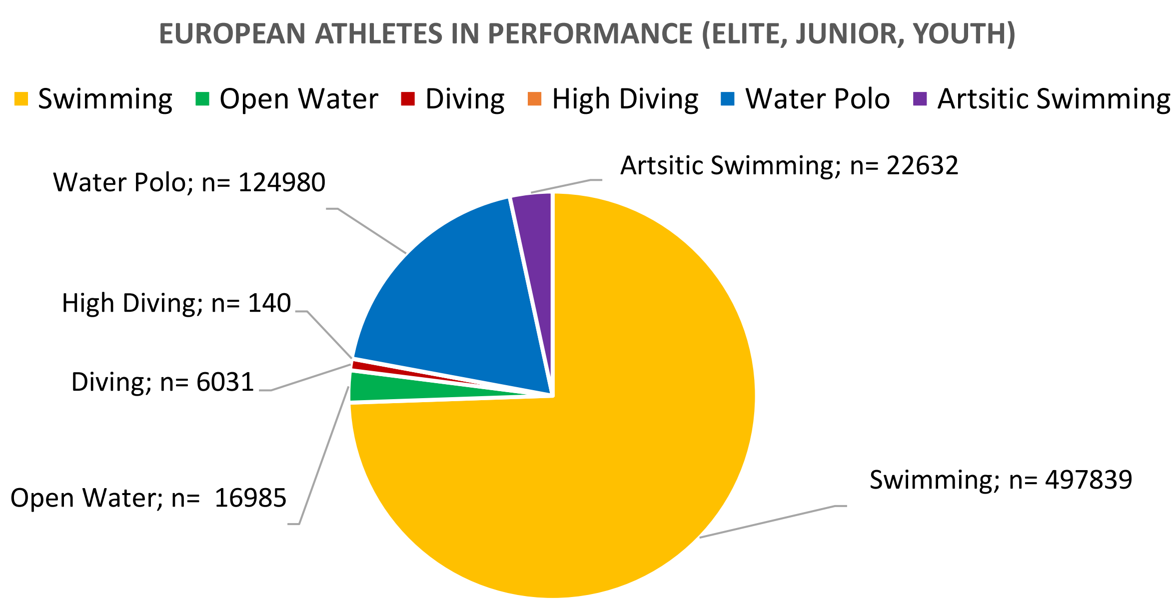


Figure 1. Distribution of the total amount of European athletes (elite, junior, youth) involved in official water sports (Fina, 2019)

In addition to the national championships, in Europe are hosted important tournaments that involve the best clubs belonging to different parts of the continent: the LEN Champions League (men and women), The LEN Euro Cup (men and women) and the LEN Challenger Cup (men).

The LEN Champions League is considered the most important competition for club, organized by the European Swimming Federation (LEN, Ligue Européenne de Natation) since the 1963-64 season for men and 1987-88 for women. Until the season 2022-23, the Italian club of Pro Recco (men) and Orizzonte Catania (women) are the most successful clubs in the history of this ambitious tournament, with 11 and 8 victories, respectively.

Regarding the competitions for national teams, the results achieved by the national teams of the European countries confirm the importance of this aquatic sport for our continent, especially for men competitions. As well as other disciplines, also in water polo the Olympic games represent the most important international event for national team. Indeed, among the team sports played with a ball, water polo has been one of the first to be included in the summer Olympic Games program, since the 1900 edition in

Paris. From 1900 to the 2020 edition in Tokyo (hosted in 2021 due to the COVID-19 pandemic), 17 different countries have won a total of 82 Olympic medals in men's water polo. In particular, 11 nations made the history of this sport in the Olympic Games winning the gold medal, 13 nations the silver and 12 nations the bronze ones. Considering the countries, Hungary has won the highest number of Olympic medals (winning also the more gold and bronze medals), followed by Belgium and Yugoslavia (with the highest number of silver medals). Table 1 resumes the Roll of Honour of the men Olympic Games history in water polo. The women's water polo tournament was introduced only from the 2000 edition of the Olympic Games (hosted in Sydney). However, the United States have been the most successful country in the history of women tournament, being the only national team to win more than one edition of the Olympic Games. Table 2 resumes the Roll of Honour of the women Olympic Games. As shown by the table, only 8 national teams got Olympic medals in the female editions, of which 6 teams are European water polo national teams. Finally, Italy has been the first and for now only country to win both the men and women water polo Olympic Games tournament.

Table 1. Men Olympic games Roll of Honour (1900-2021)*

	Gold	Silver	Bronze	**Total**
Hungary	9	3	4	**16**
Yugoslavia	3	4	1	**8**
Italy	3	2	3	**8**
Sovietic Union	2	2	3	**7**
USA		3	3	**6**
Belgium		4	2	**6**
Great Britain	4			**4**
Serbia	2		2	**4**
Germany	1	2	1	**4**
France	1		3	**4**
Croatia	1	2		**3**
Svezia		1	2	**3**
Spain	1	1		**2**
Russia		1	1	**2**
Netherlands			2	**2**
Serbia and Montenegro		1		**1**
Greece		1		**1**

*only the edition of the III Olympic games (1904) were not considered in the current table, since only 3 clubs (all from the USA) participated to this competition

Table 2. Women Olympic games Roll of Honour (2000-2021)

	Gold	Silver	Bronze	**Total**
USA	3	2	1	**6**
Italy	1	1		**2**
Australia	1		2	**3**
Netherlands	1			**1**
Spain		2		**2**
Greece		1		**1**
Russia			2	**2**
Hungary			1	**1**

1.2 History and development of water polo

Like other team sports, water polo has evolved over the time through rules changes, advancements in training methods, equipment, and facilities. This aquatic team sport has been played since the mid-19th century. It was first played in England and later recognized and developed by the Scottish mariners in the Atlantic Ocean, before becoming popular throughout Europe at the beginning of the 20th century (Donev and Aleksandrović, 2008). Nowadays, water polo characteristics are considerably dissimilar from those of the game's early development, which took place in England in the late 1800s. Over its hundred-year history almost every aspect of the game has changed, favouring an evolution of several factors: the length and number of periods of play, the number of players in the team, time of ball possession, exclusions and many other aspects which have overall changed the dynamic of water polo game. In general, by implementing several aspects in the history of this sport, the evolution of water polo has been a long process constantly bringing significant improvements in technical, tactical, and physical performance (Hraste et al., 2013).

Modern water polo is played by 2 teams made up of 6 outfield players (usually, 1 center forward, 1 center defender, 4 perimetral players) and one goalkeeper, on a 30m x 20m field for men and 25m x 20m for women. The match is divided into 4 periods of 8 minutes each, with a time limit for ball possession of 30 seconds and 20 seconds in a possible phase of re-possession or numerical superiority (Li and Graham, 2021).

Analysing the history of water polo, six stages of development can be classified, each one characterized by the various changes in the rules, which still influence the structure of the game, the conditional skills required, and the training philosophies implemented by the technical staff (Hraste, 2021). To comprehend the growth of this sport, it is essential to analyse each stage of its development.

The many stages of water polo's evolution are distinguished based on the period, the nature of the conditions at that time and the important modifications periodically made to improve the game's structure.

According to the chronological classification conducted by the study of Donev and Aleksandrović (2008), the first phase of water polo development can be comprised between 1869 and 1907 and identified as a period of search for identity and standardization of the game rules. During this period the matches were characterized by a rough and uncontrolled game, with many dives and sinks, without correct techniques and rules.

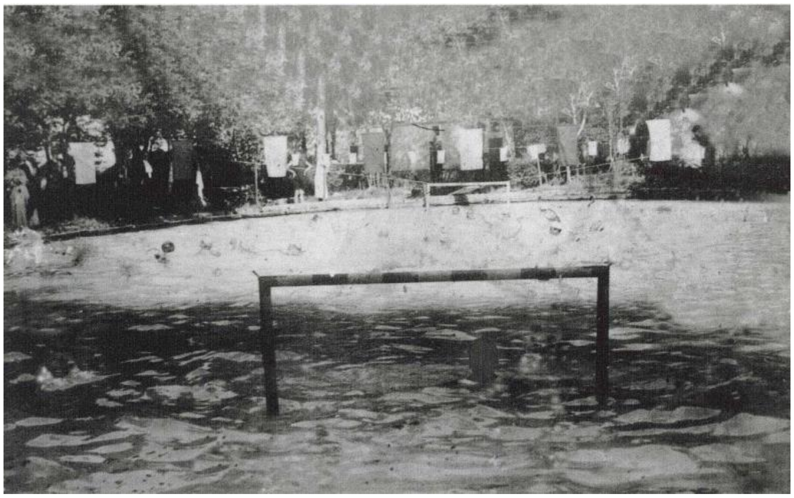


Figure 2. The team of S.S. Lazio Nuoto, year 1905, playing at the water polo field ‘Acque Albule’ in Tivoli, Italy (http://www.sslazionuoto.it/)

Being a new sport, water polo was initially called ‘water soccer or rugby’ and like these two sports already developed in that period, it incorporated rules and a game system in which the defence phase prevailed over the offensive one. The first water polo match was played without a goal, with three players in the water from each team. It was also possible to score with two hands, by throwing the ball into a goal made by a platform or a boat on the playing field. In this period the game was not successful, it was exclusively played in conjunction with swimming or rowing competitions, resulting decidedly unattractive.

The second phase of water polo development covered the period between 1908 and 1949. This phase can be marked as a period of revision and internationalization of the game. In 1908, the International Swimming Federation FINA (‘Federation Internationale de Natation’) was established. The name ‘water soccer’ was officially declared invalid, while ‘water polo’ was declared as the new official name. The initial rules, with modifications that referred exclusively to the penalty shot and the exclusion of players that committed a foul, have been in force until 1949. In those years, various technical skills have been modified and improved, becoming fundamental for the improvement of the game in the following years. For example, in 1928, the Hungarian water polo coach Bela Komjadi invented the ‘air pass’ or ‘dry pass’, a technique in which one player passes the ball directly in the air to another player who receives it directly hand without the ball hitting in the water (Hraste et al., 2013). This new passing technique made the game more offensive and dynamic, contributing to the growth of the individual technique of each single player, in fact, previously, the players first dropped the ball into the water and only then handled it. According to Pierotti (2016), during the matches of this historical period the duel between center defender and center forward has been introduced by adopting a game system known as the 2-2-2 system, or a ‘zig-zag’ line with two players in the defensive half, two players in midfield and two players in the offensive half. The new game system favoured the development of slightly faster and more technically skilled players in ball control. However, during this period the range within the competition field was limited and the opportunity to develop a more dynamic style of play was limited since for most athletes water polo was only a secondary sport played during the summer season, with very poor conditional trainings in terms of swimming, strength, and game skills. The matches of this period were characterized by a very small number of exclusion fouls and the first signs of ‘zone’ defence, developed to force opposing players to move close to play in the opposition's half and then immediately make a counterattack after recovering the ball.

Figure 3. The team of S.S. Lazio Nuoto, winner of the 1945 Italian Championship. It has been the first post-World War II Championship. Standing L-R: Ivo Bitetti, Marcello Mainetti, Catalani, Tamagnini, Aldo Ghira, Franco Baccini. Squatting L-R: Camillo De Giovanni, Caselli, Gemignio Ognio (http://www.sslazionuoto.it/)

The study of Donev and Aleksandrović (2008) identifies as the third stage the years from 1950 to 1969. In this period there were significant changes in the rules of the game which brought a sort of revolution in the development and improvement of water polo. Among the main changes, the most important is certainly considered the one that allows the game to continue without interruption even after the referee has whistled a normal game foul. With this changes, the game became faster, the players were forced to become physically stronger and highly swimming evolved. Until 1956 water polo was usually played with very heavy and asymmetrical ball, which further slowed down the game. In this phase the yellow and rubber ball was officially introduced, which allowed players to have better visibility and handling, consequently favouring faster and more spectacular matches. The new rules also eliminated slow players from the game and favoured a game system based on both offensive and defensive phases. Indeed, during this period, all the players on the field participated in both the offensive and defensive actions, favouring the development of more transitions and transfers phases. The role of the center forward changed significantly and was no longer linked only to maintaining the position in attack but became the organizer of the offensive phase with an additional role of assist-man for teammates. In the defensive phase, the concept of man-to-man pressing was implemented, increasing contrasts, fights, and duels between opponents. According to the rules of that period, the match was played with 2 halves lasting 10 minutes without any substitution, while an expelled player had the obligation to remain out of the game until the next scored or conceded goal. Starting in 1961, each of the 2 halves has been divided in other 2 halves, and the game assumed the configuration of four 5 minutes quarters (Juba et al., 2008).

During this stage, the semi-final of the 1956 Olympic Games in Melbourne, played between the USSR and Hungary has become the most famous match in the water polo history. At that time, the tensions between the two national water polo teams were already high because the USSR had used their political control over Hungary to mimic the training methods and strategies of the Hungarian Olympic champions (Burnton, 2011). The match took place on 6 December 1956 during the background of the 1956 Hungarian Revolution, which was repressed by the USSR. In that match Hungary defeated the USSR 4 – 0 and the match was renamed 'blood in the water' after that the Hungarian player Ervin Zádor emerged during the last two minutes with blood pouring from above his eye after being punched by Soviet player Valentin Prokopov (Burnton, 2011). The film ‘Children of Glory’ commemorates this match and the Hungarian Revolution of 1956 (https://youtu.be/WN6o7h8na98).

Figure 4. The team of S.S. Lazio Nuoto, winner of the 1956 Italian National Championship. Standing from left: Sergio Catalani (Manager), Felice Virno, Franco Berenga, Franco Baccini, Lucio Ceccarini, Nino Antonelli. Sitting from left: Salvatore Gionta, Paolo Pucci, Carlo Peretti, Camillo De Giovanni (head coach), and Raffaele Gambino (http://www.sslazionuoto.it/)

The fourth stage has been identified from 1970 to 1986 (Donev and Aleksandrović, 2008). Towards the end of the third stage, spectator interest in water polo decreased and many countries warned that this team sport was in danger condition after the 1968 Olympic Games in Mexico City. Therefore, in 1970 FINA made a new change of the water polo rules, which introduced the penalty foul after the third consecutive serious foul (Pierotti, 2016).

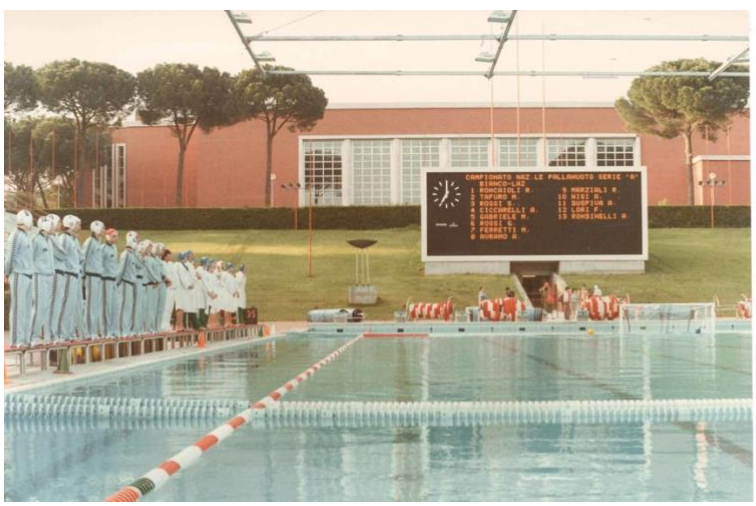


Figure 5. Season 1983-84, match between S.S. Lazio Nuoto and C.N. Posillipo played at the 'Stadio del Nuoto', in the complex of Foro Italico (Rome, Italy) (http://www.sslazionuoto.it/)

Then, in this phase, the game system changed because the new rules limited a team's ball possession to 45 seconds. The game became faster and more interesting, achieving a perfect balance between offensive and defensive phases. Contacts and duels between players diminished due to more strict referee decisions, which favoured the attackers and the development of the game, punishing the defenders for holding, sinking, or throwing against the opponent. During most of the 1970s water polo was a good historical moment for players and spectators.

Hraste et al. (2013) identified the fifth stage as the period from 1987 to 2012. The same authors extend the stage until 2019 (Hraste, 2021). Anyway, in this more recent phase water polo is identified as a high intensity game. The specific demands of the sport during this period have significantly increased the volume and intensity of trainings and competitions. This aspect has led to a significant increase in the intensity and volume of swimming within matches and training sessions, consequently increasing the general conditional abilities of the athletes. In this phase, training with overloads and new equipment for gym and water work acquired greater significance, contributing to the remarkable development of all forms of strength in water polo (Melchiorri et al., 2016). At this stage, the exclusion time of a player was reduced to 20 seconds while the ball possession was limited to 30 seconds. The length of the game was extended to four quarters of 8 minutes each. The seven-metre line was introduced, later moved to 5 metres, which allowed for a direct shot on goal after a common foul. A new rule has also been introduced to substitute players during the match and allowing to call a 'time-out' per team (Juba et al., 2008). Furthermore, since 2005 the ball deflected off the field of play by a defender after a shot by the attacker is considered a change of ball possession. Each of these changes has had a positive effect on the development and acceleration of the game, making water polo a more attractive sport. The pace of the game has become high, but at the same time in some phases of the match water polo was still characterized by numerous static situations, fights and physical contacts which often lead to unpleasant 'accidents' between players.
During this stage, after 100 years of the presence of men water polo in Olympic Games, a women's tournament was first introduced to 2000 Olympic Games in Sydney.

Figure 6. Season 2007-08, the S.S. Lazio Nuoto team leaded by the legendary coach Pierluigi Formiconi and the captain Claudio Sebastianutti (at the head coach's left, Claudio is the current head coach) (http://www.sslazionuoto.it/)

Nowadays, water polo is in its sixth phase of history, where multiple physical parameters have become indispensable, making water polo training decidedly more complex and consequently making physical preparation assume a decisive role also for the technical-tactical development of players (Melchiorri et al., 2016). The table 3 resumes the 6 stages of water polo evolution.
Therefore, analysing the historical development of water polo, it can be observed that the presence of continuous changes also derived from other team sports, from their styles and methodologies. To face with the new game demands, in addition to the traditional figure of coach, such continuous evolution also required the contribution of other professional figures within the coaching-staff, as strength and conditioning coaches, goalkeeper coaches, technical collaborators, and match analysts.

Table 3. Summary of the water polo evolution

Evolution of the game in 6 phases	
I phase 1869-1907	Game identity and rules standardization
II phase 1908-1949	Internationalization of the game
III phase 1950-1969	Radical change of the rules and game improvement
IV phase 1970-1986	Increased game speed and player performance
V phase 1987-2019	High intensity matches and training sessions
VI phase 2019-Today	Dynamism of the game

1.3 The latest rules of water polo

Despite the continuous changes and the considerable improvements, after 2012 water polo remained full of contacts, holds, dives, and pulls, not always penalized by the referees, despite the rules providing that they are judged as serious fouls (Hraste et al., 2013). Therefore, the physical strength seemed to dominate the course of the matches and water polo was risking of losing its prestigious Olympic Games status unless new rule changes make it more attractive to spectators. According to FINA, water polo needed further modifications which contributed to reduce players's rough behaviours in the game that could be perceived violent from spectators, and which could have a direct impact in the reduction of fouls from physical contacts, with a consequent acceleration of the game and determine a higher number of expressions of technical skills. The rule's change was also expected to contribute to the reduction of physical strenght in the game, increasing the need to implement innovative technical knowledge and tactics. Hypothetically, it was thought that by changing the rules, sheer strength would have less effect on the result of water polo matches and that speed, accuracy and coordination would become more important aspects (Li and Graham, 2021).

It is precisely for this reason that today we are probably in the most important moment of the sixth phase of the development of water polo. In fact, after few small changes made since 2013, the new rules have been officially implemented for the 2019-20 season, in prevision of the 2020 Olympic Games in Tokyo (WWPCA, 2019). The new rules have had a relevant impact especially in the youth categories, while for the adult non-professional levels players showed more difficulty to follow the new directions. The duration for ball possession has been limited to 20 seconds after a situation of numerical superiority or (re)possession of the ball after taking a shot on goal. The number of time-outs has decreased from 4 to 2 and the central interval between the second and third quarters of the game has been reduced to 3 minutes. After the foul, the game can restart immediately from the position of the ball and after the foul has been hit players can directly go to the conclusion even after feinting or swimming and without necessarily having to pass the ball to another teammate. Quick substitutions have been allowed between players up to their own half of the pitch (at the lateral side of the pool). Moreover, a 6-meter field line has been introduced to regulate the new rules of the penalty foul, where an attacker who is impeded from behind by the defender during the execution of a shot on goal, earns a penalty shot even 'with the ball in hand'. All these changes made the game more intense, enjoyable, and televised, still modifying performance models and game systems. The figure 7 shows some technical differences between two editions of water polo men World Cup played with different rules.

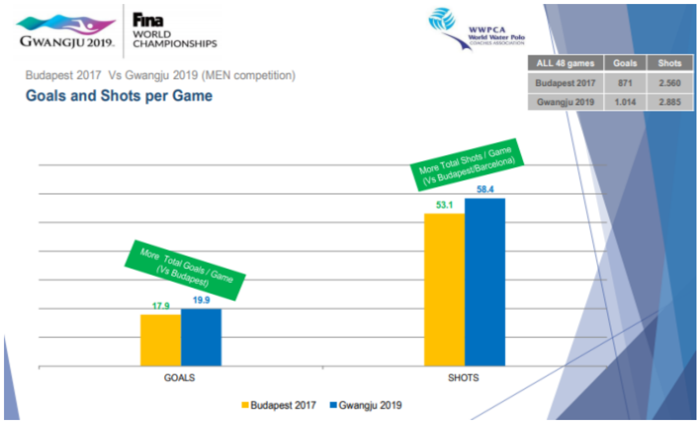


Figure 7. Difference between Goals and Shots per game of World Cup played in Budapest (2017, old rules) and Gwangju (2019, new rules) (WWPCA, 2019)

Furthermore, due to the new rules the number of ordinary fouls has been significantly reduced and the technical-tactical innovations have been created in the attack phase thanks to a more fluid and less fragmented game. The interpretation of these new rules seems to support and stimulate the creativity of players and coaches, making water polo a more attractive and dynamic sport.
Since the 2020 Olympic Games in Tokyo, the first-ever use of Video Assistant Referee (VAR) in water polo matches has been introduced. The official protocol defines six situations in which VAR can be used (Total Waterpolo, 2023):

- Goal/No goal;
- Goal scored at shot clock expiration or at the end of a period;
- When there is a shot taken at the end of a period and there is an excluded player,
- Jury table errors and/or failures of the electronic system, including time-out buttons;
- Review of a violent action situation (formerly named brutality);
- Interference with the taking of a penalty throw.

In line with his history and development, in 2022 water polo keeps changing its regulation. In fact, the FINA Technical Waterpolo Committee has proposed new rules that have been approved by the FINA Technical Congress (Fina, 2022). These new rules have been officially introduced since January the 1st 2023 for national teams, while will be applied since the season 2023-24 for clubs. The new 2022 FINA rules introduce (Fina, 2022):

- **Goal area and 2 meters.** A new goal area is established. It is a rectangular 'red zone' that extends from the goal line to the 2-meter line in depth and for 2 meters beyond each post in width. The 2-meter rule ('offside rule') will apply exclusively for players inside the goal area: a player positioned within the 2-meter zone, but outside the goal area (in a lateral position), is allowed to receive a pass by a teammate.
- **Advantage and penalties.** FINA has clarified the playing advantage rule on a penalty situation: on a penalty foul, referee must delay whistling and see if the attacking player scores a goal; if he doesn't, the referee should sanction the penalty. On the execution of the penalty, all players except the shooter should be outside the 6-meter area and at least 3 meters away from him. The referee might temporarily exclude any player who doesn't respect the distance and use VAR review to assess whether there has been an interference.
- **Yellow and red cards.** The referee can show to warn or exclude players in the water or on the bench as well, in case of act of misconduct or simulation.

- **Brutality foul.** The term 'brutality' disappears, and it is replaced by 'violent action' to refer to violent gestures by players in the water. The sanction for 'violent action' has not changed (a penalty shot and 4 minutes of man-down situation), while the automatic suspension rises from one to 2 games. It's important the rule change about the VAR review, which can be used even during the game to punish any alleged 'violent action'**.**
- **Ball pressure**. FINA has chosen to reduce the ball pressure, accepting requests from players and tests held on Mikasa balls: 7.5-8.5 psi for balls in men's competitions, 6.5-7.5 psi for balls in women's competitions.
- **Definition of goal**. For the first time, the goal line was clearly defined as well as when a goal is scored.

Concluding this part about water polo history and rules, we can affirm that first changes were directed towards the standardization of the game, while the subsequent changes were made to improve the dynamism and attraction of the sport which enabled and encouraged progress both in the matches and in training sessions.

1.4 Playing positions

Water polo is an aquatic team sport that involves different players' specific positions, which can be categorized as follows:

- Goalkeeper (G): The goalkeeper, also known as the 'keeper' or 'goalie', is responsible for defending the goal and preventing the opposing team from scoring. The goalkeeper wears a different coloured cap (red) and has specialized skills in blocking shots.
- Center Defender (CD): The center defender plays a crucial role in water polo by preventing the opposing team's attackers from scoring. He is responsible for guarding the opponent's center forward and marking him closely to oppose his activities. The CD also contribute to the offense by making accurate passes and participating in counterattacks.
- Center Forward (CF): The center forward is positioned in front of the opponent's goal. This player is typically physically strong and skilled in offensive play. The CF role includes holding the ball, creating opportunities for goals, and gain exclusion fouls from opponents.
- Wing Player (W): The two wing players are positioned on the first line (2 meters, both right and left sides) in the attacking placement. They play a supporting role in both offense and defence. Wing player is often skilled at shooting from the sides and assisting the CF. His dominant role in the game is to transfer and pass the ball quickly and prevent counterattacks. Usually, this role is the most skilled in swimming abilities.
- Perimetral Player (P): Perimetral Players are the responsible for creating scoring opportunities and taking shots at the opposing team's goal. They use their speed, agility, passing and shooting skills to assist a teammate (W or CF) or to score a goal. Usually, they are the most skilled in decision making processes and in comprehension of the game.

It's important to note that in a match the playing positions can be based on team strategies, player skills, game situations and coaching philosophy. Players may switch positions during the same match, and some teams may have a different interpretation of the positions depending on their tactics and playing style.
Several studies have measured the fitness and anthropometric characteristics of water polo players according to their playing position (Tan et al., 2009). Lozovina et al. (2004), in a study involving 160 elite male water polo players all members of the top clubs in Croatia, showed that there were statistically significant positive trends in leg, arm, and height measurements of water polo players between the generation of players from 1980 and 1995. Several breadth measures decreased significantly, and a

general decline was observed in soft tissue measures, such as girths and skinfolds. Only the calf skinfold showed an increase, while subcutaneous adipose tissue measurements revealed significant decreases in triceps, subscapular, axillar, and abdominal skinfolds. A significant decrease in body mass index (BMI) and estimated body fat percentage was observed, whereas an increase in body density was observed. Body mass remained statistically unchanged despite an increase in mean height.
A study of Tsekouras et al. (2005), involving 19 male professional water polo elite players from the Greek team in the top four in 2003 World Championship, describe how body size plays an important role during the game, allowing the player to obtain better positions on the field and to have a great advantage in intercepting and receiving the ball. The anthropometric data (table 4), further suggest that their body mass and body length plays a key role in the energy cost required during water activity.

Table 4. Anthropometric characteristics of water polo players (Tsekouras et al., 2005)

Anthropometric characteristics	**mean ± SD**
Age (years)	25.5 ± 5.0
Height (cm)	184.5 ± 4.3
Body mass (kg)	90.7 ± 6.4
BMI ($kg*m^{-2}$)	26.7 ± 1.7
Lean mass (kg)	75.1 ± 4.9
Fat mass (kg)	15.3 ± 4.3
Body fat (%)	16.8 ± 4.4
BMD ($g•cm^{-2}$)	1.37 ± 0.07

A study on youth elite water polo by Kondrič et al. (2012), involving 110 players (17 to 18 years of age), showed that the anthropometric characteristics of the playing positions revealed various variations. The tallest players were the CD, CF and G, followed by the W, while P should be regarded as the shortest. The examinations of these junior water polo high level players discovered very comparable results about variances in body length dimensions. Centers (CD + CF) were believed to be the largest of all players in terms of body length and body mass because of the frequent contact that occurs during the game. The CF were the heaviest and had the highest BMI of all playing positions. It appeared that their greater BM and BMI were connected to higher body fat, but not fully.
Nowadays, the anthropometric characteristics could characterize top water polo players, as confirmed by more recent studies in relation to water polo playing positions (Nikšić et al., 2020).

1.5 Model of water polo performance

Water polo is therefore a demanding aquatic team sport, in which players must move their body inside a fluid (water) and often in opposition to their opponent (Smith, 1998). Water polo is also considered one of the most physically and psychologically demanding team sport since the various playing situations require fast decision-making processes, anticipation skills, and problem-solving skills. These characteristics are the result of the evolution of the rules, of refereeing and consequently of the improvement of the game itself (Li & Graham, 2021). In an early study, Smith et al. (1998) explain precisely how during a competition, the water polo player swims in all directions, accelerating and braking, with the opponent nearby, underlining this aspect as the main factor that distinguishes the commitment of the water polo player from that of the swimmer athlete. Nowadays, several physical parameters have become indispensable, making the physical training of the water polo player decidedly more complex. Consequently, the physical preparation is assuming a decisive role also for the technical-tactical development of players (Madelénat, 2019). In fact, in modern water polo, athletes who do not have good physical abilities (strength, flexibility, mobility, and endurance) find difficult to effectively execute and repeat specific gestures during a performance (Madelénat, 2019). To make water polo training more tailored to the match demands, it is necessary to study the performance model in depth analysing the game from a technical, tactical, physical and psychological point of view. The purpose of this approach is to improve the athletes' performance through training optimization, developing a training methodology based on individual needs and in relation to the internal and external load of the training session (Lupo et al., 2014[a], Lupo et al., 2015). Therefore, it is evident that anything can be changeable when considering differences in factors like players' age and sex, their competitive level, as well as their playing position and ball techniques used. There are several studies that analyse the difference in this factors through notational analysis or time-motion analysis, giving useful information to water polo coaches for technical, tactical, and methodological purposes.

According to the physiological structure, water polo is classified as an aerobic-anaerobic sport (Dal Monte, 1983). Dal Monte (1983) suggested that in water polo the 30% of energy derived from anaerobic alactic system, 40% from anaerobic lactic process and the rest 30% from aerobic energy process. Despite that, a recent study conducted by Botonis et al. (2019[a]), suggested that the various high intensity activities that occur within a water polo match result in a high intensity of play and although water polo is clearly a sport considered alternating aerobic-anaerobic energy systems, the most decisive actions depend heavily on anaerobic metabolism.

In terms of heart rate (HR), a study conducted by Galy et al. (2015), involving 8 adult elite water polo players, suggested that during a simulation of an official match the registered HR was 79.9 ± 4.2% of the HRmax. This study showed a players' average of 157 ± 14 beats per minute in the first quarter, 156 ± 14 in the second quarter, 153 ± 14 in the third quarter and 153 ± 14 in the last one (Galy et al., 2015). The figure 8 provided by the study of (Botonis et al., 2019[a]) represents HR responses of elite national water polo players according to their kind of activities and skills during a water polo match.

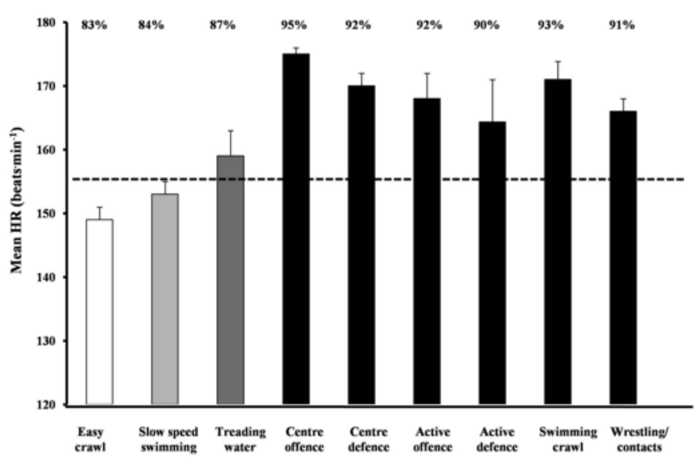


Figure 8. Heart rate (HR) responses of elite water polo players to low, moderate, and high-intensity activities occurring in a water polo match (Botonis et al., 2019[a])

Regarding the use of the various metabolic systems, a study of Melchiorri et al. (2010[a]) involving players of the Italian men national team identified four different blood lactate thresholds (table 5).

Table 5. Percentage distribution of the various metabolic systems used during the match (Melchiorri et al., 2010[a])

Energetic system	%
Aerobic (≤ 2 mmol/L)	23.8
Mix (≤ 4 mmol/L)	22.9
Mostly anaerobic (≤ 6 mmol/L)	24.7
Anaerobic (> 6 mmol/L)	28.5

In relation to the monitoring of players' minutes of play, a study of Melchiorri et al. (2020), involving 352 male elite water polo players (26.3 ± 4.1 years) of 18 different national teams, indicated that P players play an average of 18.3 ± 6.1 playing time per match, while the CD players play 16.3 ± 5.7 and the CF 16.3 ± 6.4, respectively. Platanou (2004) classified elite player's activity in international matches by registering an average of 11 min in vertical position, 9 min in swimming activities and 5 min in a duel. According to the body posture, a previous study of Dopsaj and Matković (1994), suggested that elite players spent 37% of the game in the horizontal position and the rest 63% of the game in the vertical one. As stated by Melchiorri et al. (2010[a]), involving 77 international level men's players (age 25.9 ± 4.5 years), water polo players complete a total of 120 postural adjustments in a match by shifting 4.6 ± 0.6 times per minute from a horizontal to a vertical position. In this vertical posture, Bratuša et al. (2003) demonstrated that water polo players spend 62% of their time in the basic position, which is characterized by the eggbeater kick, 27% of their time in duels, 8% of their time with the possession of the ball, and 3% with their arm raised. Moreover, this study (Bratuša et al. 2003) showed that within a match the passes, performed in both horizontal and vertical floating conditions, are very frequent and almost all the technical actions take place in vertical posture. This fact was confirmed by Lupo et al. 2014[b], that investigating on international female elite matches, suggested that movements in a vertical position are prevalent used for power-play situations because it is required to effectively pass and shoot the ball. Tan et al. (2009), analysing games of female high-level players, showed significant differences in the vertical activity of female players, between (P= 92 ± 31) players and centers (CF + CD= 136 ± 7 times per match). Furthermore, it was observed that players in the center positions (CF + CD) perform more body or grappling contacts than attackers on the perimeter (P= 9.9 ± 9.3 and CF and CD= 18.42 ± 11.1 seconds). Subsequently, in another study concerning international water polo matches, Melchiorri et al. (2016), analysed the differences between men and women according to the time spent in the water in a vertical or horizontal position, suggesting that female players trend to play more a dynamic and horizontal game than males (table 6).

Table 6. Percentage time of maintaining a posture in the match (Melchiorri et al., 2016)

Type of activity	Men % time	Women % time
Duel and vertical position	56.5	40.4
Swimming activities	43.5	59.6

In horizontal posture, the crawl (or freestyle) is defined as the central component of the game and it is used by the players for an average duration of 12.0 ± 0.5 seconds per action (Botonis et al., 2019[a]). This swimming style involves movements at low speed, alternating with sprints of a few meters performed at maximum speed. Previous research conducted by Lozovina et al. (2007) determined that a player in elite water polo matches swim an average of 803 meters, of which 387 meters at a submaximal and maximal intensity. In particular, the author identified differences in quantity and intensity of swimming according to the playing position: the CF covered 800 meters (292 meters at a submaximal and maximal intensity); the CD covered 738 meters (388 at a submaximal and maximal intensity); the wing players covered 856

meters (472 at a submaximal and maximal intensity); perimeter players covered 880 meters (396 at a submaximal and maximal intensity). Nowadays, according to the review of Botonis et al. (2019), the total distance covered in international women competitions average for 1125 ± 298 meters, while in men competitions average for 1603 ± 318 metres, which could be a result of the larger field size of the men rules of play. In terms of swimming velocity, analysing elite water polo matches, Melchiorri et al. (2010[a]) classified the horizontal swimming activities performed in men matches into four speed subcategories: speed 1) low intensity < 0.8 m/s; speed 2) moderate intensity between 0.8 and 1.4 m/s; speed 3) high intensity between 1.4 e 1.8 m/s; speed 4) maximal intensity ≥ 1.8 m/s. The same authors showed that players swam the 33% of the time at low intensity, 24% at moderate intensity, 18% at high intensity and 25% at maximal intensity, respectively (Melchiorri et al., 2010[a]).
Due to the complexity of the motor tasks and the high intensity, especially in the contact and shooting phases, the water polo player's activity is also characterized by a strong activation of the neuro-musculoskeletal and cognitive systems (Smith et al., 1998). Specific tactical or strategic dispositions, applied during a match, are adapted according to the opponent's level, game conditions and situations, modifying the physiological load and continuously requiring metabolic adjustments (Botonis et al., 2019). In the first Greek national division championship, it was measured that the average duration of defensive activities (intercepting, jumping, fouling, and defending against the attacker) and offensive activities (handling the ball, faking, gaining fouls, shooting, and passing) range from 2.7 to 8.0 seconds, and respectively 2.6 to 15.4 seconds (Platanou & Geladas 2006). The same study (Platanou & Geladas 2006) reports that, especially during men's play, numerous body contacts or fighting situations occur between opponents, lasting an average of 9.8 seconds. The figure 9 illustrates the different match activities of elite water polo players according to playing positions and sex (Botonis et al., 2019).
Coaches must therefore consider the high specificity of all aspects related to the game of water polo, trying to take advantage of current scientific knowledge to better interpret the technical and tactical aspects of water polo in relation to the level of the competition. From a technical-tactical point of view, the study conducted by Lupo et al. (2010) demonstrate that there are significant differences between elite water polo matches (Euro League and Italian Serie A1) and sub-elite ones (Serie B). In particular, the frequency of occurrence of even situations resulted to be higher in elite competitions than in the sub-elite, while number of counterattacks and power-play situations showed no significant differences between the two levels of play (figure 10).

			Inactive	Low-intensity activity	Moderate-intensity activities		High-intensity activities					
Author	Positions/ Gender	Experimental conditions	Bench, interval	Easy crawl	Slow speed swimming	Treading water	Center offence	Center defense	Active offense	Active defense	Swimming crawl	Body contacts/ wrestling
Smith (55)	All, M	Official matches		13 ± 4	30 ± 10		12 ± 10	7 ± 6	16 ± 11	23 ± 13	18 ± 7	
	P			9 ± 2	28 ± 13		3 ± 2	2 ± 1	25 ± 9	25 ± 19	18 ± 10	
	CF + CD			15 ± 4#	31 ± 9§		19 ± 8#	11 ± 4#	9 ± 5#	21 ± 11§	19 ± 6§	
Platanou (40)	All, M	Official matches		22 ± 3		82 ± 16			60 ± 16	30 ± 3	50 ± 6	32 ± 9
Platanou and Geladas (43)	All, M	Exhibition matches		22 ± 1‡	26 ± 4	97 ± 3			28 ± 3	36 ± 3	38 ± 2	15 ± 1
D'auria and Gabbett (12)	All, W	Official matches									14 ± 11.6	
	P										9.9 ± 9.3	
	CF + CD										18.4 ± 11.1¶	
Tan et al. (60)	All, W	Official matches	5 ± 2	61 ± 30	28 ± 12	116 ± 64					15 ± 10	29 ± 14
	P		4 ± 1	63 ± 36	27 ± 14	136 ± 77					20 ± 11	25 ± 13
	CF + CD		6 ± 2¶	58 ± 20	29 ± 10	92 ± 31¶					9 ± 4#	33 ± 14‖

*CF + CD = center forwards and center defenders; P = peripherals; M = men; W = women.
†Values are expressed as mean ± *SD*.
‡Combined easy crawl and swimming backwards or forwards without urgency.
§Small effect size between positions.
‖Moderate effect size between positions.
¶Large effect size between positions.
#Very large effect between positions.

Figure 9. Activities of elite water polo players according to playing positions and sex (Botonis et al., 2019[a])

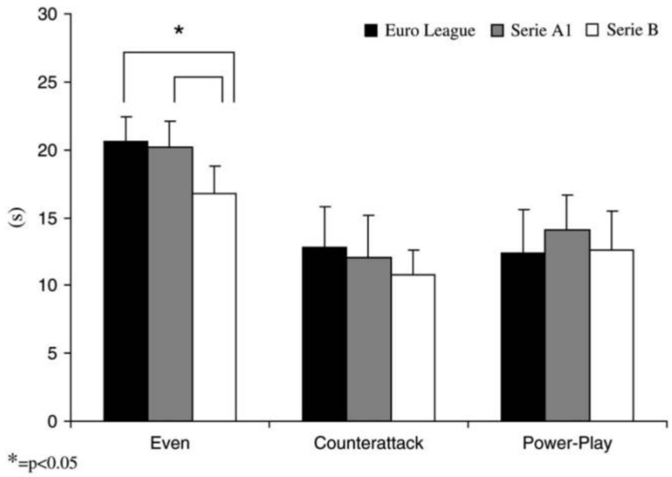


Figure 10. Means and SDs of duration (s) of the offensive actions performed during Euro League, Italian Serie A1, and Italian Serie B championships in relation to the playing situations (Lupo et al., 2010)

In another study, Lupo et al. (2012[a]) demonstrated how the same indicators depend on the result and difficulty of the match. This research analysed all the matches of the 2009 World Water Polo Championship, which had a winning team within the regular playing time (42 matches out of 48). Significant divergences emerged on the technical and tactical indicators between matches considered balanced (with a difference of no more than 3 goals in the final result) and unbalanced matches (with a difference of more than 3 goals), underlining and consequently suggesting to the coaches that water polo matches must be analysed considering specific margins of victory or defeat, not only considering the final 'winning' or 'losing' result of the match itself (figure 11).

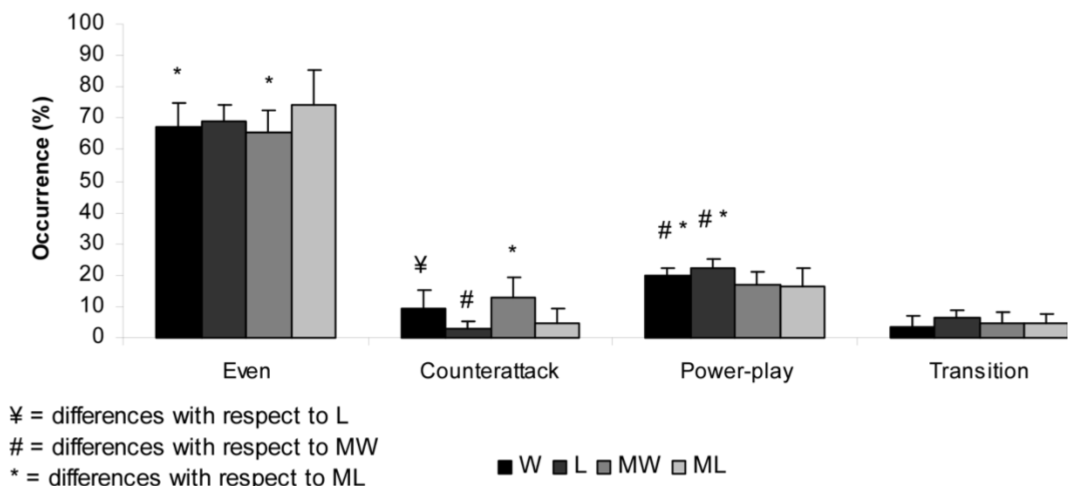


Figure 11. Means and standard deviations of the frequencies of occurrence (%) of actions of the W (not more than three goals winning team), L (not more than three goals losing team), MW (more than three goals winning team), ML (more than three goals losing team), in relation to the playing situations (i.e., even, counterattack, power-play, transition) (Lupo et al., 2012[a])

1.6 Water polo ball techniques

The performance profile of water polo should also include the individual activities with the ball. In this regard, there are several key techniques that are important in managing a water polo ball. Ball technique is divided into the basic elements of ball handling and ball throwing technique (passing and shooting) (Hraste, 2021). Below, there are listed some fundamental ball techniques used in this sport:

- **Stopping and controlling the ball.** The player has to stop and catch the ball by using the hand with joined or slightly extended fingers;
- **Protection of the ball.** Keeping the ball away from defenders by positioning it out of reach or defending it with the body can help player to maintain the control of the ball;
- **Swimming with the ball.** The player has to swim by leading the ball and by holding the ball (both crawl or trudgen styles) (Perazzetti et al., 2022);
- **Dribbling.** Dribbling in water polo involves maintaining control of the ball while swimming and manoeuvring through defenders. It helps players create space and gain exclusion fouls;
- **Passing.** Passing the ball accurately and quickly is essential for maintaining possession and creating scoring opportunities for teammates;
- **Shooting.** Scoring goals is the ultimate objective in water polo, and shooting techniques play a vital role;
- **Block.** Block is the technique of preventing or protecting an opponent shoot or pass.

2. THEORETICAL FRAMEWORK AND PREVIOUS RESEARCH

2.1 Scientific literature

Since the beginning of 2000 the interest of the scientific literature for water polo has been increasing every year. Table 7 and table 8 show a list of studies published on different topics derived from a review of Melchiorri et al. (2016) that covers the period from 2002 to 2015 and a personal search on Scopus, Pubmed and Scholar that covers the period from 2016 to 2022, respectively.

Table 7. Scientific literature published from 2002 to 2015 (source: Melchiorri et al., 2016)

Topic	M	W	M + W	Total Papers
Motor Skills	4	0	1	5
Match Analysis	6	4	4	14
Medicine	8	9	8	25
Test and Evaluation	33	12	1	46
Training	6	2	1	9
Total	**57**	**27**	**15**	**99**

Table 8. Scientific literature published from 2016 to the end of 2022 (source: personal search on on Scopus, Pubmed and Scholar)

Topic	M	W	M + W	Total Papers
Motor Skills	4	2	4	10
Match Analysis	4	1	3	8
Medicine	6	4	5	15
Test and Evaluation	6	4	7	17
Training	5	2	2	9
Total	**25**	**13**	**21**	**59**

2.2 Water polo swimming and dry-land test

In literature have been studied the evolution of the players physical capacities in relation to the changes of rules and level of competitions. The results of these studies have helped to fix different protocols to evaluate the players' swimming abilities during specific phases of the the water polo match. In fact, the swimming tests have been the most common instrument used by water polo practitioners to monitor the fitness status of players (Chirico et al., 2021). The basic skills of horizontal swimming in water polo are mainly tested in order to (Dopsaj et al., 2007):

a) verify and evaluate the gap between novice players compared to more experienced players;
b) compare individual differences between playing positions;
c) evaluate training techniques to improve horizontal swimming with and without the ball in novice water polo players.

In a review on swimming test for water polo players, Chirico et al. (2021) indicated that the physiological assessment of water polo players might be divided into two areas concerning the swimming evaluation: swimming sprint tests and endurance swimming test. In particular, the swimming sprint tests cover a broad area of test to assess the efficiency of the alactacid anaerobic system. Table 9 depicts the most common swimming sprint tests used by water polo practioners.

Table 9. Swimming sprint tests for water polo players

Sprint tests	Authors
10m	Botonis et al., 2016
15m	Dimitric et al., 2022
20m	Botonis et al., 2019[b]
25m	Aleksandrović et al., 2011
30m	Tsekouras et al., 2005

These types of traditional tests could underestimate the players ability to swim leading the ball, which is an ecological condition and that requires specific tests. Indeed, during a water polo match players continuously change position from a vertical to a horizontal one and vice versa (Lupo et al., 2009). To cope with horizontal phases, players perform technically skilled movements with and without ball, which require different swimming abilities, such as crawl, crawl with the head above water, crawl while leading the ball, as well as more variants of the specific water polo crawl (Dopsaj et al., 2007). Different trudgen styles, combining arm-work in front crawl and legwork in breaststroke, are also required (Dopsaj et al., 2003). In this regard, Perazzetti et al. (2022), in a study on youth water polo, comparing U14 and U16 teams, have highlighted the importance of assessing the sprint velocity using tests that start without pushing from the wall (of the swimming pool), finding a significant difference between the classic start with pushing from the wall. The 25 meters distance was used by the authors to investigate on difference between crawl style and crawl with the ball, and between trudgen style and trudgen with the ball. For crawl and crawl while leading the ball the results showed a gap of 8.2% and 6.7% in U14 and U16, while for trudgen and trudgen while leading the ball was found a gap of 5.6% for U14 and 1.6% for U16. Finally, it was registered a gap of 16.2% for U14 and 12.2% for U16 between trudgen and trudgen while holding the ball. In line with previous findings (De Jesus et al., 2012), the study of Perazzetti et al. (2022) confirmed that for water polo players a specific training for both crawl and trudgen is needed, demonstrating that over the years of practice, young water polo players show improvements in their skills to leading the ball, reducing the gap with tests investigating the swimming styles without the ball.

A study of D'Ercole et al. (2013), focused the attention on the various horizontal swimming skills for the identification of a young talent comparing expert and novice water polo players. The tests were organized through 4 different executions: crawl at maximum linear speed for 20 m (called test A); 20 m head-up swimming at maximum speed in slalom (called test B); 20 m slalom swimming head-on carrying the ball at maximum speed (called test C); slalom swimming head-up carrying the ball verbally indicating the colour indicated by a tool placed on the side of the pool in front of the players at a height of 40 cm from the surface of the water (called test Y). In particular, the main differences between expert and novice players were found in test Y, in which the visual task was present during the test trial.

Regarding the aerobic endurance test submitted by the coaching staffs, the one performed on a single distance of 200m (Tsekouras et al., 2005) and repetitions (7 or 5 ones) of 200m distance (Pyne et al., 2001; Botonis et al., 2016) seems to be the most used in water polo. Furthermore, to test this kind of ability also the multistage shuttle test has demonstrated to be a valid tool to evaluate water polo players. Despite there are several versions of this test (Rechichi et al., 2000; Mujika et al., 2006), one of the most common test requires to perform two trials of 120m, each one composed by 1x40m, 2x20m and 4x10m, with a recovery period between repetitions equivalent to the time spent in the previous effort (Melchiorri et al., 2009, Melchiorri et al., 2010[b]). Talking about swimming anaerobic-endurance tests, the table 10 represents the most common tests used by water polo practioners.

Table 10. Swimming anaerobic-endurance tests for water polo players

Anaerobic-endurance tests	Authors
8x15m	Claus et al., 2017
4x25m	Tucher et al., 2014
50m	Varamenti and Platanou, 2008
4x50m	Platanou and Varamenti, 2011
100m	Falk et al., 2004

According to Falk et al. (2004) the process of early detection and development of talented young athletes should include three aspects of measurement and evaluation: physiological, psychological, and sociological. Falk et al. (2004), assessing 24 water polo players aged between 14 and 15 and submitted a series of tests three times during a 2-year period. The swimming tests consisted of 50-, 100-, 200- and 400-meters crawl, 100 meters breaststroke swim; 100 meters of 'butterfly' (dolphin stroke with breaststroke leg movement). A comparison of these players, subsequently selected or kept out for the Israel youth national team, showed that, two years before the selection, the selected players were already superior in most of the tested swimming activities. This 'superiority' was maintained for two years. The prediction of a future talent, for 67% of the players, was therefore in agreement with the final selection for the national youth team.

According to Platanou et al. (2005), in relation to their position and degree of competition, players' abilities to move their bodies vertically on the water also depend on their level of competitiveness outside the water. For this reason, dry-land tests could play an important role in the field of water polo testing procedures. De Villarreal et al. (2015) proposed that pre-season water polo training should include a combined training program that contains dryland and in-water–specific strength and plyometric training to optimize the water polo preparation for competition. In particular, Keiner et al. (2020) suggests that maximal strength parameters are important predictors of the performance capacity of water polo players testing 1RM of squat and bench press in addition to medicine ball throw, which are usually the most common gym exercises used by water polo strength and conditioning coaches.

2.3 The figure of water polo coach

The enlargement of the coaching staff carried out a new culture of management of trainings and competitions, which is also influenced by the coaches’ personal ‘coaching philosophies’, as well as by the traditions of the different national water polo coaching schools. Indeed, the training methodologies are largely influenced by the personal coaching philosophy of the coach, which consists of his/her major objectives and values, beliefs, and principles they want to achieve in their coaching career (Martens, 2012). The coaching national schools reflect the cultural diffusion of the sporting environment, which exerts a large influence over coaches in socially and sporting terms, through their attitudes to coaching moulded by the national background of common values and experiences. In this regard, the specific coaching programs provided by the sport federations are an essential part of the coaches' education.

Returning to the data published by FINA in 2019, about the number of water polo coaches, 24482 coaches were counted in the world and 22960 referees, of which 8155 and 19113 respectively in Europe. The research revealed that only 38% of the 209 national federations have educational programs of water polo dedicated to them, a percentage that in swimming instead rises to 73% (FINA, 2019).

The promotion of scientific research or educational programs provided by a specific federation is an essential practice for the development of any coach's coaching philosophy. Despite there is still a general perception that sports research does not meet the needs of coaches, a study commissioned by the Australian Institute of Sport and involving coaches of several sports disciplines, showed how scientific findings provided through appropriate forums, using simple and accessible language, were likely to be useful for coaches' professional development (Williams & Kendall, 2007). Previous studies, especially of other sports disciplines, have been dedicated to physical trainers (also called strength coaches) philosophies of training. Sutherland and Wiley, (1997), in a study carried out in Canada and United States, interviewed 118 general managers of professional baseball (PB), American football (NFL and CFL) and basketball (NBA) teams, showing that 74% of the teams had a physical trainer present full-time during the training sessions. Most of the respondents of this study stressed the importance of carrying out physical tests, especially during the pre-season phase, to better organize individual training programs for each player. Regarding the educational background of the professionals involved in this survey, respondents showed to possess at least a three-year degree in Sport Science or similar studies.

On the other hand, Durell et al. (2003), evaluated the extent to which scientific research influences physical preparation coaching practices in American colleges and to determine the training methods managed by the fitness coaches. Specifically, were sent 321 surveys with a response rate of 42.7% (137 out of 321 surveys), indicating that fitness coaches interviewed had a bachelor's degree, while 75% were also certified Strength and Conditioning Specialists (CSCS). Among the professional sources of information respondents indicated the Journal of Strength and Conditioning (94%) and collegiate training courses (93%), while 47% of respondents also declared to be reliant on other coaches and their programs as a source of information, as well as in various daily situations they tended to use proven methods as athletes.

Still on the methodologies used by American physical trainers, three other studies were conducted by Ebben et al. (2001) on professionals working in the NFL; by Ebben et al. (2004) on NHL professionals and by Simenz et al. (2005) on professionals working in the NBA field. All these three studies were based on a survey examining: baseline information; physical tests; development and maintenance of flexibility; development and maintenance of speed; plyometrics; development and maintenance of strength and power; comments and open questions on more information.

Specifically, in water polo, only one study was conducted on the physical trainers of men's and women's teams in the Spanish first division. The purpose of this research (Reverter-Masia et al., 2012) was to determine the services available to physical trainers during the regular course of the competitive season, showing that most of the physical trainers of the men's teams had a degree in Sports Science (80%), unlike the trainers of the women's teams (50%). Regarding the coaches of women's teams, 75% were in possession of a certificate issued by the Spanish federation, while only 70% of the men's coaches possessed this certificate. The main differences between men's and women's teams were given by the presence or absence of physiotherapists, doctors, physical trainers, technical assistants (80% present in the men's teams). The table below (table 11) shows the main results of this survey.

Table 11. Data expressed as a percentage by coaches (Reverter-Masia et al., 2012)

	Male water polo teams (n= 10)	Female water polo teams (n= 12)	Mean (n= 22)
Strenght Material	40.0	75.0	57.5
training Facilities	60.0	83.3	71.6
Fitness Evaluation Equipment	20.0	25.0	22.5
Time Devoted to Physical Conditioning	20.0	50.0	35.0
Physical fitness Assistants	20.0	33.3	26.6
Trips	40.0	50.0	45.0
Players' Availability	20.0	41.6	30.8
Fitness Evaluation Experts	60.0	75.0	67.5
Basic Equipment	30.0	33.3	31.6
Relationship with the Coaching Body	20.0	25.0	22.5
Recovery Measures	10.0	25.0	17.5
Other Aspects	40.0	41.6	40.8

In response to the question about availability and workspaces, more shortages and complaints were observed by the coaches/trainers of the women's teams (54.4% were not satisfied with the space available in their club). Of all respondents, only 9% declared that their team had the right and optimal environment for conditional training. The study also showed that a very low percentage of professionals have continued their academic training in the sports field and in the same way almost no one continues to update themselves through scientific journals. After listing the various differences between the interviewed, the study concludes by emphasizing the importance of not underestimating the training environment, defining it as a determining factor which includes: time and space necessary for the development of physical conditioning; access to essential and necessary training facilities, materials and equipment; traveling in optimal conditions during travel or training trips; being part of a team of professionals who, in addition to promoting the maximum performance of the players, allows each coach to concentrate exclusively on his/her work (Reverter-Masia et al., 2012).
However, in water polo, to the best of our knowledge, except for this survey of Reverter-Masía et al., (2012), there are no studies investigating the characteristics of coaching philosophies and training methodologies from national water polo schools of different countries.

2.4 Performance Analysis in Water Polo

To reproduce a training activity like the game demands of competition (Passos et al., 2016), coaches usually use Performance Analysis as a specialized discipline to provide objective information that helps them understanding the performance characteristics (Lupo et al., 2014[b]). The match analysis fully responds to these needs of knowledge of the performance model (Hughes et al., 2003) through its two main areas of study: Time Motion Analysis (TMA) and Notational Analysis (NA). The TMA represents the analysis of movement through a process of classification of activities that considers the different intensities of movements (Strudwick et al., 2016). The main elements on which this analysis is based are the intensity, duration, distance, and frequency of actions (Williams et al., 2005). The notational analysis aims the methodical analysis of behavioural events that occur during a match, through the study of tactical behaviours (with and without the ball) and technical skills in relation to the different game situations (Ademovic et al., 2020).
The last two decades have seen an increase of studies focused on tactical learning in team sports. Based on the assumption that students construct and learn tactical knowledge in relationship with motor skills

the Team Sport Assessment Procedure (TSAP, Grehaigne et al., 1997) has been proposed as a useful tool to assess players' progress in terms of tactical skills and offensive efficiency (how the ball possession is gained and how the ball is disposed) (Gréhaigne and Godbout, 1998). Furthermore, regarding Match Analysis, several water polo studies on technical and tactical aspects have been provided in terms of collective actions (Lupo et al., 2011), playing positions efficacy (Lupo et al., 2012[b]), rules evolution (Lozovina et al., 2019; Argudo et al., 2021), competition levels (Lupo et al., 2010), and influence of match outcome (Mirvić et al., 2011; Ordóñez et al., 2021). The basic idea of this kind of assessment (TSAP) is to observe players' behaviours during the game and to summarize the data collected either under the form of total occurrences or under the form of three performance indexes: the Volume of Play, the Efficiency Index, and the Performance Score (Grehaigne et al., 1997). To date, studies regarding the Team Sport Assessment Procedure have been published in soccer (Blomqvist et al., 2005; Ortega-Toro et al 2019), basketball (Otero-Saborido et al., 2015), ice-hockey (Nadeau et al., 2008) and volleyball (Richard et al., 2002; Sgrò et al., 2018; Sgrò et al., 2020), while its application on water polo is still lacking. To the best of our knowledge, the first study to use the TSAP in water polo has been provided by Perazzetti and Tessitore (2021) to assess youth elite competitions (U20), demonstrating how this instrument produce an objective indication of teams' offensive performance in water polo. The findings from this study, which analysed the FINA Junior Water Polo World Championships, suggest that the TSAP could help to guide the training process along a tournament or an entire water polo season.

2.5 Monitoring of water polo performance

Considering the increased of water polo game demands, to plan a monitoring strategy of players' efforts is crucial to ensure athletes are exposed to adequate training loads to minimize the risk of undergoing excessive workloads and maximize their performance (Thornton et al., 2019). In this regard, also the monitoring of players' recovery has been showed to be at least as important as that for training and matches (Hynynen et al., 2006), to avoid that a high-intensity activity without adequate recovery periods could cause a detrimental effect on performance. Performance in team sports is the expression of complex and dynamic multidimensional and interactive processes, for this reason, it is important to evaluate the effects of different efforts and recovery strategies to help coaches to tailor players' individual programs (Thorpe et al., 2017).

In team sports, to reach this goal, coaching staff (often also helped by sport scientists) collect a wide range of monitoring data that relate to external and internal workloads undergone by their players', as well as physiological and psychological assessments of fatigue (Kelly et al., 2007). The Internal load represents the players' relative physiological response to the training or match workloads performed, and is related to both positive (i.e., fitness and preparedness) and negative (i.e., fatigue, non-functional overreaching, and injuries/illness) training-related outcomes (McLaren et al., 2017). External load is defined as the work completed by the athlete, measured independently of his/her internal characteristics. As both external and internal loads are useful for understanding the athlete's training load, a combination of both may be important for training monitoring (Halson, 2014), even if, the ability to relate external and internal loads in team sports is difficult due to the inherent variability in physical performance during sport-specific training drills and match-play (Thorpe, 2017).

A popular and effective system to quantify internal Training Load (TL), based on the session–rating of perceived exertion (RPE), was proposed by Foster et al. (1996, 1998, 2001) and validated over the years to monitor the load of several different modalities of training (technical, tactical, endurance, speed, and strength). With this system, players are required to provide an RPE for each exercise session that is then multiplied by the training session duration (min) to determine the training load.

The intensity, duration, and frequency of trainings can place a heavy strain on athletes' biological systems; then coaches are urged to adopt effective recovery strategies (Tessitore et al., 2007). To achieve an optimal balance between exercise load and recovery is required to maintain a high physical performance and minimize the risk of injury (Tessitore et al., 2008). In this regard, recovery is regarded as a multifaceted (e.g., physiological, psychological) restorative process relative to time (Kelmann et al., 2018), highlighting the importance of a carefully monitored recovery process (Kenttä and Hassmén, 1998). For this reason, in recent years the post-match recovery status of team sport players has been measured and taken into more consideration (Thorpe et al., 2017). Tracking the post-match recovery of team sport players requires monitoring tools that are sensitive to match induced fatigue. One method used to measure the recovery process became very popular is the total quality recovery (TQR) which, by using a TQR scale, structured around the scale developed for ratings of perceived exertion (RPE), allow to assess the recovery process (Kenttä and Hassmén, 1998). Among the other tools, the Hooper-Index and/or its subsets (i.e., sleep quality, stress, fatigue, and muscle soreness) (Hooper and Mackinnon, 1995) has recently been shown as promising tool for monitoring fatigue in team sports players (Thorpe et al., 2015; Fessi et al., 2016; Rabbani and Buchheit, 2016; Clemente et al., 2017). This method is based on the relevance that daily logs of training and measures of athletes' well-being may assist in programming appropriate training loads during intense training and tapering (Hooper and Mackinnon, 1995).

In accordance with Hooper and Mackinnon (1995), subjective ratings using scales of 1–7 from ‘very very low-or-good’ (point 1) to ‘very very high-or-bad’ (point 7) have been suggested as one of the most cost-effective strategies for early detection of overtraining syndrome (Angeli et al., 2004). Furthermore, according to the psychological mood of players, two studies demonstrated the reliability and validity of the Physical Activity Enjoyment Scale (PACES). The original version of this scale consists of 18 items, preceded by the sentence ‘When I am active...’, and evaluates the enjoyment from the highest level (e.g. ‘I enjoy’, ‘It is very exciting’, ‘I find it enjoyable’) to the lowest (e.g. ‘I am bored’, ‘I do not like it’, ‘It frustrates me’) (Kendzierski & DeCarlo, 1991). The possible influence of mood and pre-fatigue states on RPE and TQR could be hypothesized (Haddad et al., 2013).

The assessment of internal training load (ITL) using the session rating of perceived exertion (session RPE) has been demonstrated to provide valuable information in water polo training and matches (Lupo et al., 2014[a]). This study confirmed the session-RPE method as an easy and reliable tool to evaluate ITL also in water polo, allowing coaches to efficiently monitor their training programs. Further research concerning this issue were conducted in water-polo by Botonis et al. (2019[b]), suggesting that an appropriate post-season manipulation of the external training load is effectively reflected by ITL changes inducing important improvements in general well-being and considerable gains in sport-specific performance measures. Furthermore, the same authors examined the association of perceived recovery status of nine elite water polo players with the fluctuations of their ITL (Botonis et al., 2021).

3. PROBLEM, PURPOSE, AIMS AND TASKS OF THE STUDY

3.1 Defining the problem

First, to the best of our knowledge, there are no studies investigating the characteristics of coaching philosophies and methodologies of water polo coaches from different countries. For this reason, the most common training methodologies used among coaches and the differences between different water polo national schools are still unknown. Second, in the field of match analysis till today no studies have used the TSAP instrument to analyse water polo matches (both in tournaments or during an entire season) in different age categories, sex and level of competitions. Finally, in terms of monitoring of players' well-being status, there is no literature to prove if enjoyment, sleep quality, fatigue, stress, and muscle soreness can influence the perception of effort and perceived recovery in water polo players.

Based on the literature state of art showed above, it can be speculated that the research on water polo is still affected by the following limits:

- There are no studies investigating the coaching philosophy and training methodologies of coaches belonging to different national water polo schools;
- There is still few research assessing the progress of teams and players in terms of tactical skills and offensive efficiency;
- There are no studies monitoring the perceived effort, recovery and well-being status during and after water polo matches of an entire season in elite players.

3.2 Purpose of the study

The purpose of this PhD dissertation is to apply an ecological and multidimensional approach to investigate the coaches' coaching philosophy and monitoring the physical and technical-tactical performance, recovery and well-being of elite water polo player.

3.3 Aims of the study

The aims of this PhD dissertation are related to elite water polo level and are defined according to the following issues:

- To investigate the coaching philosophy and methodologies of water polo head coaches belonging to different national schools;
- To provide a specific methodology for technical and tactical analyses of elite water polo players by means of a specific notational analysis tool (TSAP);
- To monitor players' match loads, recovery and well-being status during an entire elite water polo season.

3.4 Tasks of the study

Based on the defined problem, purpose and aims, the research of this PhD dissertation has accomplished the following tasks:

- Defining groups and size of participants and their characteristics;
- Data collections;
- Defining the coaching philosophy of water polo coaches belonging to different national schools;
- Defining TSAP parameters and indexes of water polo teams and players;
- Defining perceived scales to monitor elite water polo players;
- Analysing data using specialized software for statistical analysis, SPSS;
- Describing the analysed variables, and interpreting the results;
- Provide helpful and easily accessible instruments for water polo practitioners.

4. HYPOTHESES

Based on the literature analysis and the defined problem, purpose, aim and tasks of this PhD dissertation, the following hypotheses have been defined:

4.1 General hypothesis

H_G - A multidimensional approach based on the understanding of the coaches' national coaching philosophy, integrated by the assessment of the individual and collective tactical skills, as well as the monitoring of players' workload and recovery status, can positively affect the coaching staff's analysis and interpretation of water polo performance.

4.2 Supporting hypotheses

H_1 – The adherence to a national water polo schools will show differences in coaching philosophies and professional backgrounds among coaches belonging to different national water polo schools.
H_2 – Coaches' training organization and competition management are influenced by their own national water polo school.
H_3 – In youth water polo matches, the tactical analysis by means of the TSAP instrument will show significant differences in water polo teams' collective behaviours and decision making according to the zones of the fields and balanced/unbalanced final score difference of the match.
H_4 – In elite water polo matches, the tactical analysis by means of the TSAP instrument will show significant differences according to the match location, balanced/unbalanced final score difference of the match, season phase, individual playing time and players' playing positions.
H_5 – Significant differences in training loads, recovery and Hooper index responses will be found according to players' playing positions, minutes of play in competition, match location (home or away), balanced/unbalanced final score difference and season phase.

5. MEASUREMENT METHODS

This PhD dissertation includes cross-sectional and longitudinal observational design studies with the submission of questionnaires and match analysis tools. Data collection took place in three steps, making four different studies and testing five different hypotheses. The first step has been to investigate national water polo coaching schools, the second step to accomplish the TSAP instrument, the third step to monitor players' match loads, recovery and well-being status. Analytical and basic descriptive, univariable, and multivariable statistical methods have been used as the main tools for cognitive reasoning and qualitative defining of the investigated phenomena.
This research can be characterized as a fundamental and applied research since it provides a novel and multidimensional approach within the general knowledge that already exist in water polo performance. Current studies are also practically applicable for water polo coaches.
The research protocols are recognized in the Declaration of Helsinki, and they were approved by the Ethical Committee of The Faculty of Sports and Physical Education of the University of Belgrade (number 484–2) and by the Ethical Committee of the University of Rome 'Foro Italico' (number 27/202 and number 99/2021).

6. RESULTS

6.1 STUDY #1 - Perazzetti, A., Dopsaj, M., Nedeljković, A., Mazić, S., & Tessitore, A. (2023). Survey on coaching philosophies and training methodologies of water polo head coaches from three different European national schools. Kinesiology, 55(1), 49-61. https://doi.org/10.26582/k.55.1.6

6.1.1 Introduction

Water polo is a very stressful body-contact aquatic team sport played all over the world. It combines high-intensity short-duration efforts and low-duration actions (Ruano et al., 2016). The latest worldwide survey, published in 2019 by the Fédération Internationale de Natation (FINA) and based on data supplied by the national federations, shows a number of 24482 coaches and 22690 referees, out of which 8155 and 19113 are involved in European competitions at all levels, respectively (FINA, 2019). These data pose Europe as the most important geographic area for this sport in terms of the relevance of elite national (e.g., the Italian 'Serie A1', Serbian 'Prva A liga', Hungarian 'OB I', Spanish 'División de Honor', Croatian 'Prva hrvatska liga', Montenegrin 'Prva liga Crne Gore', and Greek 'A1 Ethniki') and elite continental (e.g., Champions League, LEN Euro Cup, and Adriatic Water Polo League) water polo championships. All these championships include the best European water polo players and clubs, showing a variety of water polo cultures belonging to different parts of Europe. In the last years, the Italian national team won the 2019 World Championship held in Gwangju and the Serbian national team won the last two Olympic Games (Rio de Janeiro in 2016 and Tokyo in 2020). As well, in the history of European tournaments, the Italian clubs won twenty-four and the Serbian eleven editions in both the Champions League and the LEN Euro Cup. At the same time, Greece has currently reached a very high level of water polo development, achieving noticeable results with both the senior national team (silver medal at Tokyo in 2020) and youth national team (gold medal in 2019 at the U20 World championships). Also, Greek clubs usually compete in the final eight of European cups. For this reason, in our study, we surveyed head coaches from these three countries. However, Europe is also the home of other water polo prestigious countries that are very important for this sport, based on the history of their international trophies (i.e., Hungary, Croatia, Spain, Montenegro), and that have highly contributed to the development of water polo in Europe along the years, as we are going to explain in the next paragraph.

Regarding the evolution of the game, two studies have identified five historical stages of its development, characterized by changes in the rules of play, the need for higher levels of physical condition and technical skills, imposed by increased matches' demands, and the coaching philosophies employed by the technical staffs (Donev and Aleksandrović, 2008; Hraste et al., 2013). The first stage of water polo evolution (from 1869 to 1907) has been marked as the search for identity and unified rules of the game, which was characterized as a sort of an 'unattractive' game played exclusively in conjunction with swimming or rowing competitions. The second evolution stage (from 1908 to 1949) can be considered as the period of restructuring and internationalization of the game, distinguished by a relevant improvement of players' individual technical skills. The third stage (from 1950 to 1969) saw a faster development of both defensive and offensive play phases determined by new game rules. In particular, the defensive phase was characterized by the first forms of man-to-man defence, while the role of the centre forward was significantly changed who became the organizer of the attacking phase. The fourth stage (from 1970 to 1986) transformed the water polo performance by introducing a new attack limit of 35 seconds, thus making it a more dynamic, fluid, and high-tempo game. The fifth and final stage (from 1987 to 2012) can be considered as the period of evolution of the high-intensity game. The new rules allowed the goalkeeper to score, and the team ball possession phase was limited to 30 seconds. Consequently, the total volume of swimming activities increased considerably in both training and matches. Furthermore, due to the rise of the number of contacts and tougher struggling in the duels between players, training with weights and exercise equipment gained much relevance. Nowadays, with the latest changes in the rules of play, established by FINA in 2019 (FINA, 2020), which have had a relevant impact on the core elements of play, we can affirm that water polo is experiencing the sixth phase of its history.

To face the new requirements of game play, in addition to the traditional figure of coach, such continuous game evolution also requires the contribution of other professional figures within the coaching staff, such as strength and conditioning coaches, technical collaborators, goalkeeper coaches, and match analysts.
Consequently, the enlargement of the coaching staff has carried out a new culture of management of training and competitions, which is also influenced by the coaches' personal coaching philosophy and the knowledge and traditions of different national water polo schools. The training methodologies are largely influenced by the coaching philosophy of the head coach, which consists of his/her major objectives and values, beliefs and principles he/she wants to achieve during the coaching career (Martens, 2012). The coaches' national schools reflect the cultural diffusion of the sporting environment, which exerts a large influence over coaches in social and sporting terms, through their attitudes to coaching moulded by a national background of common values and experiences. In this regard, specific coaching programmes provided by sports federations are an essential part of the coaches' education. A study commissioned by the Australian Institute of Sport and involving coaches of several sports disciplines, showed how scientific findings provided through appropriate forums, using simple and accessible language, were likely to be useful for coaches' professional development (Williams & Kendall, 2007). However, in water polo, to the best of our knowledge, except for a survey on physical trainers of male and female Spanish First League teams (Reverter-Masía et al., 2012), there are no studies investigating the characteristics of coaching philosophies from national water polo schools of different countries. Indeed, such a kind of study, exploring the real identity of national water polo schools and the coaches' profiles belonging to them, would bring valuable information to professionals by defining what kind of methodologies and educational programmes are used in different areas of the world, how players are selected and sustained, as well as the composition of roasters and coaching-staffs.
Therefore, the purpose of this study was to survey the coaches of three main national water polo schools to identify and compare their coaching philosophies.

6.1.2 Materials and methods

6.1.2.1 The research sample

In reporting this survey study, a Consensus-Based Checklist for Reporting of Survey Studies (CROSS) was followed with the aim of strengthening the quality (Sharma et al., 2021). All the participants surveyed in this study were head coaches, during the season 2019-2020, of their respective teams playing in the first and/or second divisions of the national championships of the three worldwide recognised water polo national schools of Italy, Serbia and Greece. After the authors elaborated on the survey's first draft, it was sent to one elite water polo coach from each of the three countries (Italy, Serbia and Greece) to gather information about the questionnaire's clarity and format, as well as to receive any other feedback. These coaches were chosen because their qualifications and experience and they closely resembled the actual study participants' profiles; however, they were not included in the actual study.
The final version of the survey was composed of 38 close-ended questions, divided into five sections of inquiry: 1) Technical staff composition (15 items); 2) Team roster (5 items); 3) Weekly periodization (8 items); 4) Testing and monitoring (4 items), and 5) Tactics and strategies (6 items) (see Appendix A).

6.1.2.2 Measurement methods

Forty male head coaches from the Greek (n=12), Serbian (n=14) and Italian (n=14) national first (n=22) and second division (n=18) teams were recruited for this study.
The study was approved by the Ethical Committee of the University of Rome 'Foro Italico' (number CAR 27/202).
The questionnaire was built in digital format through the Google Docs platform and translated into the Italian, Serbian and English language. After receiving their agreement to participate in the study, the link was sent to the head coaches by email.

6.1.2.3 Statistical analysis

Descriptive statistics of all the parameters, including means, standard deviations and frequencies for all the participants and pooled data were calculated. Because nominal data were gathered in this survey study, a non-parametric Kruskal-Wallis' test was conducted to examine the differences in the answers according to the water polo national schools of the coaches. Descriptive data of the three groups is provided in the report that clearly showed the difference between each pair of groups. The statistical analyses were conducted using the statistical package SPSS (version 26.00; Institute, Inc., Cary, NC), and the criterion for significance was set at a 0.05 alpha level.

6.1.3 Results

Section 1. Technical staff composition

Even 92% of the surveyed head coaches reported being a former water polo player and no significant differences were found regarding their competitive level as former players. The pooled data showed that 52.5% of head coaches (n= 21) played in the second division of their respective national water polo leagues.

Regarding their experience as head coaches, the pooled data showed an average of 12.3 ± 9.7 years of coaching experience. In particular, 50% of respondents indicated being in charge as a head coach for up to 10 years [<5 years (n= 8): 20% and 5-9 years (n= 12): 30%, respectively], while the rest 50% of them showed over 10 years of experience [10-14 years (n= 6): 15%; 15-20 years (n= 8): 20% and > 20 years (n= 6): 15%, respectively].

No differences were found between the groups (national water polo schools) regarding their highest level of education. Specifically, 32.5% of respondents (n= 13) declared to have a high school degree, 25% (n= 10) a bachelor's degree, 35% (n= 14) a master's degree and two head coaches earned the Ph.D. Out of the 67.5% of coaches with higher education, only four of them (all from the Serbian school) answered to have a degree in sports science.

When head coaches were asked 'Which of the following aspects have most influenced your current coaching philosophy?' (multiple choice answers), their answers showed 'had other coaches as mentors' (n= 29 head coaches), 'my own experience as a player' (n= 21), 'years of continuous practice as a water polo coach' (n= 18), 'education from my water polo federation' (n= 15), 'the club's philosophy' (n= 13), 'having a degree in sport science' (n= 4) and 'education from other sports federations (different disciplines)' (n= 2). The most frequent head coaches' answers describing the ways of their continuing learning were the following: 'sharing ideas with other coaches' (n= 15); 'refresher training courses' (n= 14); 'research and courses on the internet' (n= 11). Regarding the investigation of whether sports disciplines different from water polo might have influenced their training methodologies (Figure 12), data showed team sport of basketball was their answer with the highest score (n= 22).

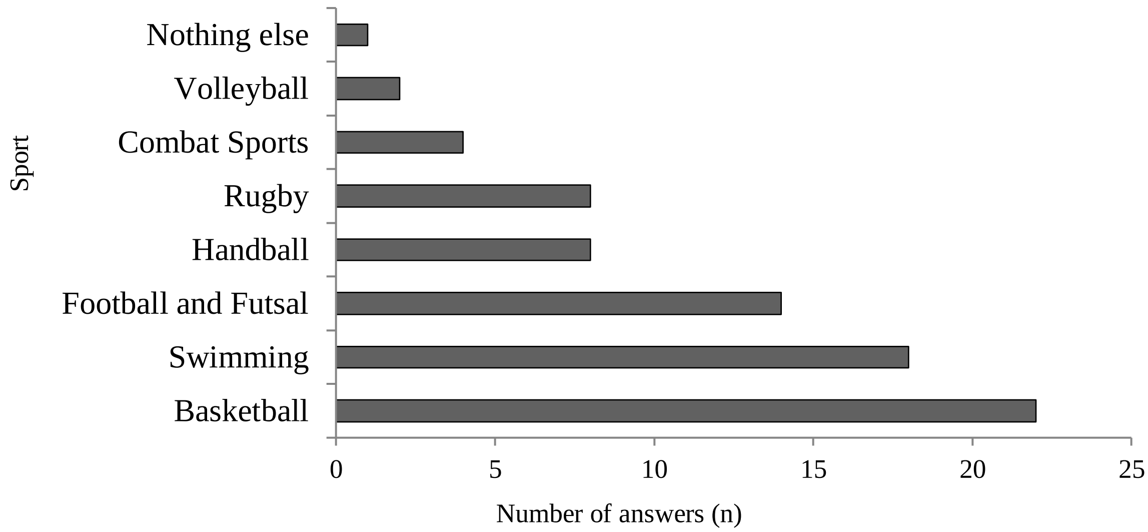


Figure 12. ‘In addition to water polo, which of the following sports has influenced your training methodology?’

Furthermore, 62.5% of head coaches (n= 25) stated that water polo was their main professional activity, compared to 37.5% of coaches to whom it was a hobby or a secondary profession. In particular, the Kruskal-Wallis’ test showed a significant difference between the three groups (Figure 13).

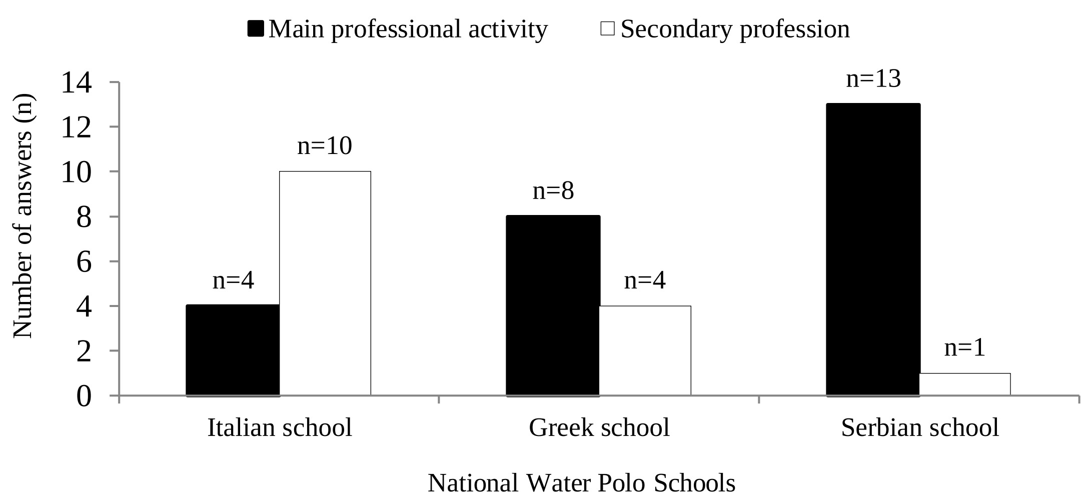


Figure 13. Number of coaches for whom coaching is their main profession

In the item ‘Does your team have a full job technical collaborator (helping the head coach)?’, most of the respondents (n= 31) indicated to have at least one technical assistant in their professional staff. Also, in this case, there was a significant difference between the three national water polo schools (Italian school: yes= 9, no= 5; Greek school: yes= 8, no= 4; Serbian school: yes= 14). Figure 14 shows the item investigating whether their own coaching staff included three specific figures of professional collaborators: a goalkeeper coach, strength and conditioning coach, and match analyst.

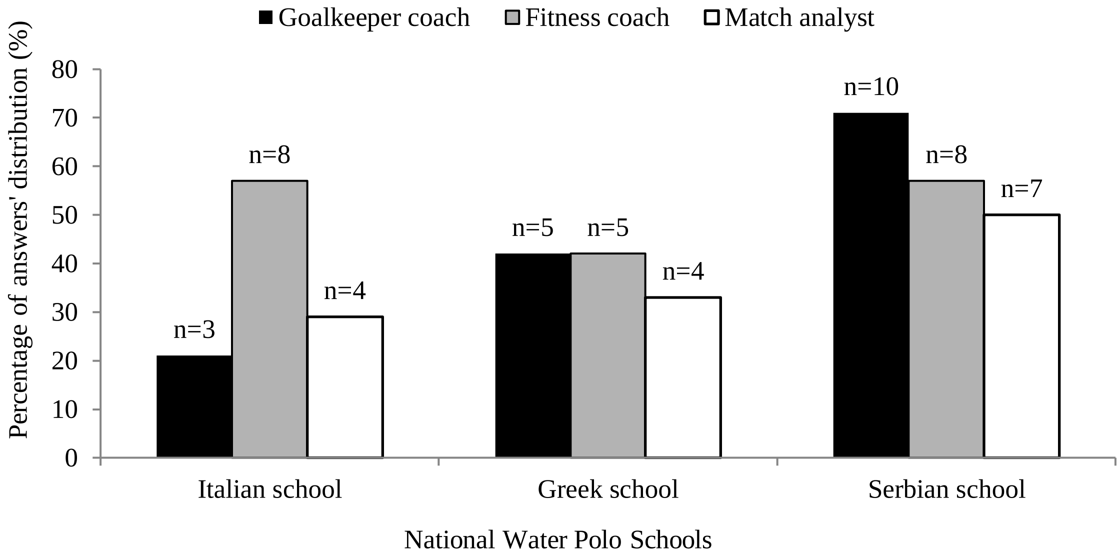


Figure 14. Percentage of professional collaborators for each water polo national school

Two items investigated the selection of youth players for the first team. The Kruskal-Wallis' test showed no differences between the three national water polo schools, so the results are shown as pooled data. The answers to item 'Who should reach the decision of selecting a player from the youth team to be employed with the first team' showed that 50% of respondents (n= 20) indicated that the decision was reached 'as a collaborative choice of the entire technical staff, 23% (n= 9) answered the decision was made by the head coach, 25% (n= 10) by 'coaches and clubs', while only one answered 'by the club'. When head coaches were asked what kind of skills related to a tactical phase (defensive or offensive) of the game was preferred when determining to select a youth player for their senior team, most of them answered that they considered more the defensive skills (62.5%) than the offensive (5%) ones, while 32.5% of respondents answered that their choice was equally influenced by both types of skill. Finally, 30 head coaches indicated an average age of 16 years (16.1 ± 0.9 yrs) to be considered as the right age for directing a player from the youth team to train and compete in a senior team.

Section 2. Team roster

The survey's second section inquiries about the roster's composition in terms of the total number of players in it, the number of players in the roster coming from the youth team, employment of foreign players, age (range of years) and the number of professional players in the roster (table 12). The Kruskal-Wallis' test showed a significant difference between the three national schools only in the number of youth players included in the roster of the senior team.

Table 12. Characteristics of teams' rosters

Items	Number of players (n)	National water polo schools ITA	GRE	SRB
		Number of teams (n)		
Number of players in the roster	< 13	1	0	1
	13-15	6	5	4
	16-18	5	2	5
	>18	2	5	4
Number of players in the youth squads team's roster	<6	2	1	0
	6-10	7	5	4
	11-15	5	6	4
	> 15	0	0	6
Number of professional players employed (players that can live on the club's salary)	Not at all	8	7	8
	1	2	1	5
	2-4	1	4	0
	5-7	1	0	0
	> 7	2	0	1
Players' age distribution	Age (years and range of years)	ITA	GRE	SRB
	< 21	4	4	3
	21-25	8	5	10
	26-30	2	3	1
	> 30	0	0	0
Presence of foreign players in the roster	Yes/No	ITA	GRE	SRB
	Yes	5	3	6
	No	9	9	8

Section 3. Weekly periodization

The third section investigated the weekly periodization. The pooled data showed an average of 6 ± 2 sessions and 14 ± 4 hours of training per week. No significant differences between the groups were found for the number of two daily training sessions (average of 1 ± 1.5 per week) and for the days of rest (average of 1 ± 0.5 per week). Most of the head coaches declared to play the official match on Saturday (n= 33; 82.5%) and to have a day of rest on Sunday (n= 32; 80%). Figure 15 shows the main activities performed during a typical week (microcycle) according to their answers.

All the head coaches (n= 40) declared to perform at least one session of strength training in the gym. The Kruskal-Wallis' analysis showed a significant difference between the groups regarding the number of sessions conducted in a gym and the number of injury prevention during a typical microcycle (table 13).

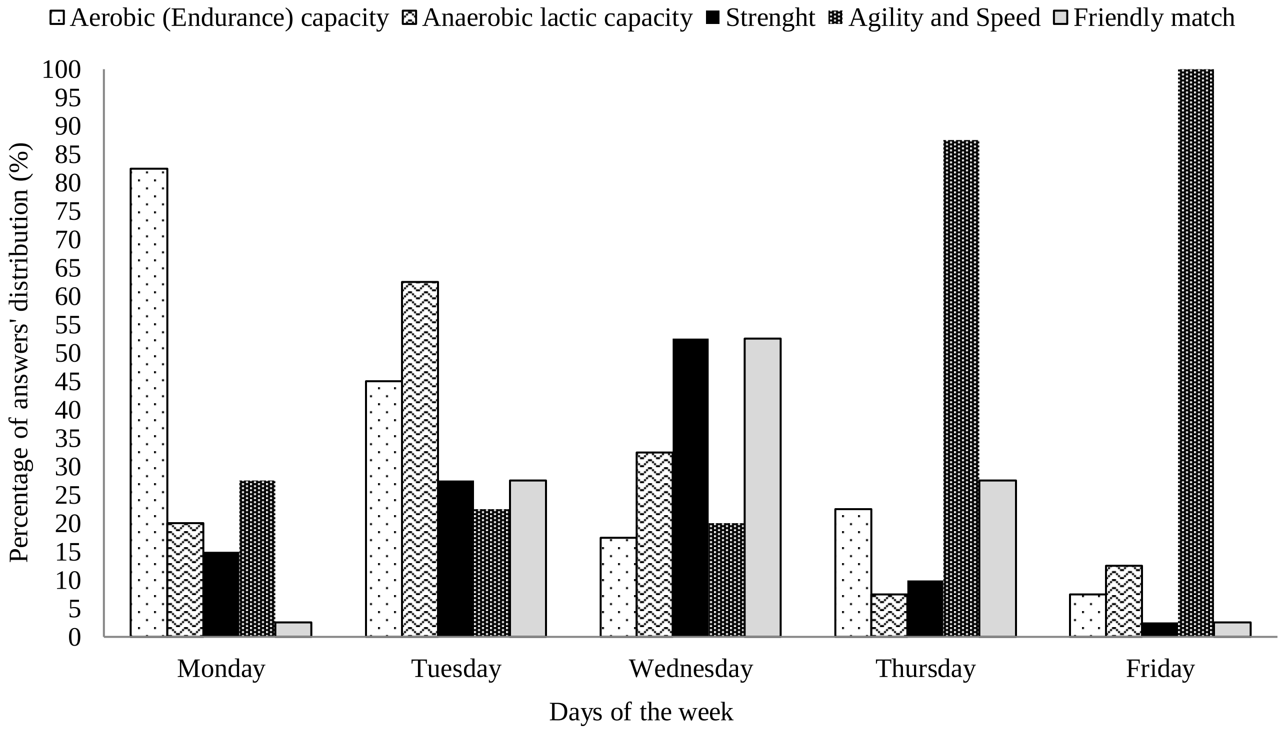


Figure 15. Typical training contents being components of every working day in a week

Regarding the meeting with players to prepare for an upcoming match, no significant differences among the head coaches of the three national schools were observed. Based on their coaching philosophy, head coaches declared to schedule their pre-match preparation meeting as follows: 40% on the day of the match (n= 16), 40% on the day before the match (n= 16), 10% on any previous day (n= 4), while 7.5% answered that they did not fix the day but decided according to the difficulty of the game (n= 3). Furthermore, regarding the pre-match meeting preferrable duration, seven head coaches considered effective meetings to last up to 10 minutes, 19 head coaches said between 10 and 20 minutes, nine head coaches between 20 and 30 minutes, and only four head coaches believed that the meeting should last more than 30 minutes.

Table 13. Planning of strength and injury prevention training sessions during a typical week

Questions	Answers	ITA	GRE	SRB
	Number of sessions	Number of teams (n)		
Strength training sessions	Only body weight load	0	2	2
	1	2	2	0
	2	11	6	2
	3	0	2	10
Injury prevention sessions before training sessions	Never	1	0	0
	1	3	0	0
	2	3	2	0
	3	4	3	0
	4	0	0	0
	5	0	2	1
	Every session	3	5	13

Section 4. Testing and monitoring

The fourth section of the survey focused on the use of physical fitness tests and monitoring of training. The pooled data showed 55% of the head coaches (n= 22) used only one tool for monitoring, 27.5% two tools, only one head coach used three monitoring tools, and six head coaches were not monitoring at all training effects. Regarding the specific system of monitoring, a common tool used by 85% of the head coaches was a manual pulse check (n= 34), while only three head coaches also used heart rate (HR) monitors. Surprisingly, only four head coaches (10%) pointed out the use of the session-RPE method (and then the use of a modified RPE Borg scale), six head coaches the use of a sort of questionnaire of self-evaluation and only one head coach used a time motion analysis evaluation. Regarding the use of field tests, 31 head coaches (77.5%) declared to test players during the competitive season; however, only six of them did it regularly each month, whereas the others indicated a range from one to four testing sessions per year.

Turning to match analysis, Figure 16 shows which kind of analysis was carried out in their respective teams.

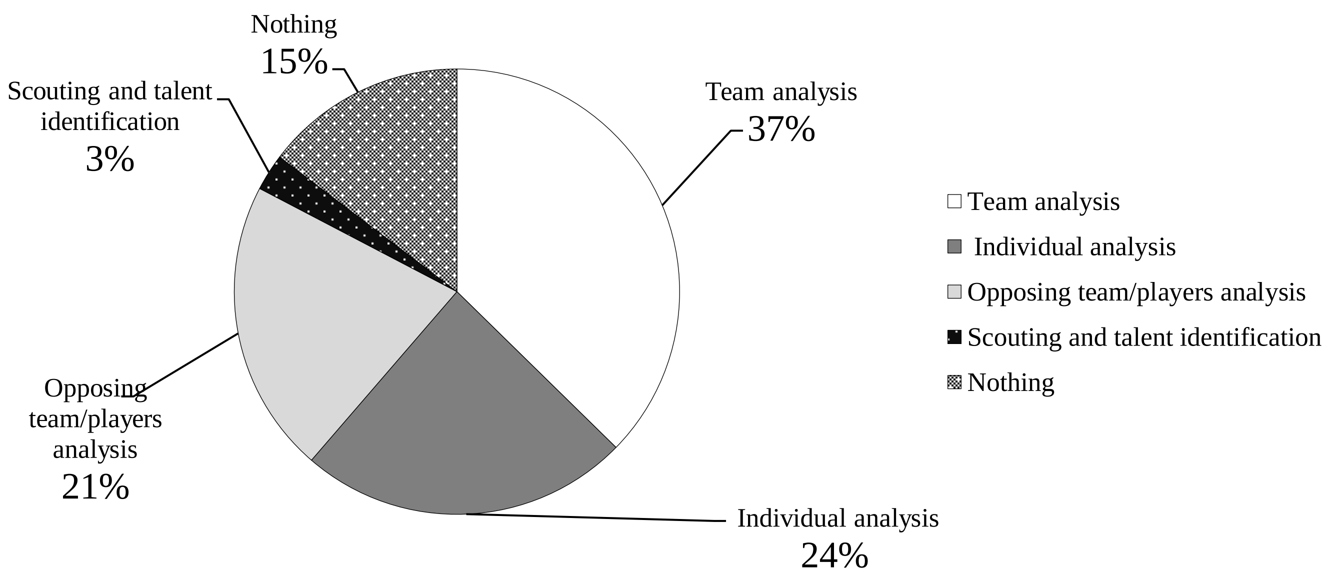


Figure 16. Type of match analysis carried out by the teams

Section 5. Tactics and strategies

The last survey's section focused on teams' tactics and strategies. In this regard, head coaches indicated carrying out 2±1 tactical training sessions per week. Specifically, 27.5% of the head coaches (n=11) declared to give more importance to the defensive phase, while 72.5% of them (n=29) considered both (defensive and offensive) phases of play equally relevant.

In relation to the weekly periodization, Friday (which is the day before the match for most teams) was the day most used by coaches for their tactical sessions. In particular, table 14 shows the numbers of schemes of play (pre-configured strategies) organized for the three water polo schools in consideration with different game situations: even in offensive phase (6vs6); even in defensive phase (6vs6); power-play (6vs5), and player-down (5vs6). A significant difference between the three national schools was found in the schemes for the even defensive situation and extra-player (table 14).

Table 14. Tactical and strategical schemes

Situation	Number of schemes	ITA	GRE	SRB
		Number of teams (n)		
Even offensive phase	No scheme	1	1	0
	1-2	1	3	2
	3-4	7	8	9
	5-6	3	0	1
	>6	2	0	2
Even defensive phase	No scheme	0	0	0
	1	0	2	0
	2	6	7	2
	3	4	3	10
	4	3	0	1
	>4	1	0	1
Power-play	No scheme	2	1	0
	1-2	2	6	2
	3-4	6	5	9
	5-6	2	0	2
	>6	2	0	1
Man-down	No scheme	1	5	0
	1	6	4	1
	2	5	2	6
	3	2	1	7
	4	0	0	0
	>4	0	0	0

6.1.4 Discussion

Using a 38 close-ended questions survey, this study aimed to survey the head coaches of the three national water polo schools (Serbia, Italy, and Greece) to identify and compare their coaching philosophies. The survey was based on five sections: 1) Technical staff composition (15 items); 2) Team roster (5 items); 3) Weekly periodization (8 items); 4) Testing and monitoring (4 items), and 5) Tactics and strategies (6 items). The main differences between the three national water polo schools investigated reflect various cultural and environmental aspects of coaching philosophies.

Regarding the section investigating the technical staff, the Kruskal-Wallis' test showed a significant difference between the three schools in terms of the professional and employment status of head coaches. For the majority of Serbian (93%) and Greek (67%) head coaches the profession of water polo head coach was their main job, while in Italy this percentage drops to a threshold below 30%. Another significant difference between the national schools in terms of staff composition is that in Serbia, all the teams' staff investigated employed at least one assistant coach. Based on this result it can be speculated that this country is more prone to value the water polo coach profession.

Regarding the different figures (specializations) of technical collaborators, 52.5% of the pooled sample indicated having a strength and conditioning coach. Such a percentage is still lower compared to the presence of strength and conditioning specialists revealed in surveys from studies covering the period of 25 years in other team sports (Sutherland & Wiley, 1997; Weldon et al., 2021). The full-time employment of strength and conditioning coaches helps head coaches to better understand some physical aspects and plan weekly training strategies, as well as to better interpret data provided using time-motion analysis

(Dopsaj & Matković, 1994; Melchiorri et al., 2021; Platanou, 2004). Furthermore, the percentage (45%) of respondents indicating the presence of goalkeeper coaches in their teams was even lower than the percentage of the strength and conditioning ones. In this case also Serbia showed to be the national water polo school with the highest number of employed goalkeeper coaches. Only 37.5% of total respondents declared to have a match analyst in their teams, which is an emergent professional figure that helps to produce and interpret technical and tactical indexes for both their own and opponent teams (Casanova et al., 2020; Ordóñez et al., 2016; Perazzetti & Tessitore, 2021; Takagi et al., 2005).

In terms of water polo coaches' education, the latest FINA general survey (FINA, 2019) shows that only 38% of the 209 national federations affiliated with the international federation provide specific water polo educational programmes. All the head coaches surveyed in our study declared to have a water polo specific certification delivered by their national federations (Greece, Serbia and Italy), whilst 37.5% of the pooled sample also stated that having attended these courses has been fundamental to driving and expanding their coaching skills. Indeed, considering the fundamental role of learning as a lifelong process, it is also very important to promote education initiatives for coach developers, to focus on proper planning of coach developer courses, which are in turn responsible for conceptualizing formal coach education courses (Ciampolini et al., 2020), to face new challenges posed by the coach profession that emerge from dealing with new generations of athletes.

Another important aspect of the profession of coaching is to develop its own coaching philosophy, which provides a set of principles to guide its decision-making to overcome practical problems and to favour consistency in coaching (Cassidy et al., 2009; Lyle, 2002). A coaching philosophy changes over time as coaches' life experiences impact their practice. To inquire about this aspect, we asked the head coaches in our study how relevant, to build their own coaching philosophy, it had been '*to have other coaches as mentors*' (72.5%), '*to rely on their own experience as a player*' (53%), as well as what was the influence of '*years of continuous practice as a water polo coach*' (45%), in terms of positive influence, respectively. Moreover, we also investigated whether other sports disciplines different from water polo might have influenced our head coaches' training methodologies. Surprisingly, with respect to the well-known habits of water polo coaches that included frequent use of methodologies based on swimming distances (Reed, 2019; Smith, 1998), the head coaches of our survey indicated to be more influenced by methodologies driven by other team sports.

The section of our study that investigated the teams' composition, showed a significant difference between the groups in terms of the number of players in the first team coming from the youth teams of the same club. In particular, six head coaches from Serbian teams indicated having more than 15 players from the youth teams in their current rosters, which is a relevant number. For youth players, the opportunity to debut in the first team of their club could bind the players in a very strong way to the club, the head coach's philosophy, and teammates, tremendously improving their sense of belonging. In turn, the clubs that employ many players from their youth teams might receive advantages in terms of economic sustainability by reducing the budget for expensive players from other clubs or foreign players. In this regard, we also asked our head coaches the following question '*Based on your coaching philosophy, at which age a young talent is ready to play and train with the first team?*'. The answers to this question showed that most head coaches from Serbia and Greece suggested a specific age as opposed to most Italian head coaches (n= 8) who argued (in a generic way) on the necessity to wait until the youth player 'is ready'. Such generic decisions could slow down the young athletes' process of growth and lead to a situation in which the club is forced to buy and find other players. Generally, grouping by players' chronological age is a common strategy in sports competitions for organizing and managing young talents of the same categories and January the 1st is often used as the cut-off date for each selection year (Boccia et al., 2017). This aspect, also named the relative age effect (RAE), has been investigated in different fields, including academic and sports performance. The results of previous studies conducted in other team sports by Lupo et al. (2019), suggested that relatively older players had more chances to join senior teams, especially at the beginning of their adult careers. However, in water polo, the RAE has not been revealed either in male or in female elite water polo players, probably due to the lower popularity of this sport (Barrenetxea-Garcia et al., 2019).

In terms of training periodization, despite planning proper training contents that combine loads and recovery might enhance athletes' preparedness (Mujika et al., 2018), information related to the strategies used to plan training in water polo is still limited compared to other team sports (e.g., soccer, basketball, rugby) (Botonis et al., 2019[b]). For this reason, in our study, we investigated the organization of the 'standard' in-season weekly microcycle. All the three national schools indicated to adopt a microcycle periodization characterized by an undulation design of training workloads to reduce loads and prevent the accumulation of fatigue in the days close to the competition (Issurin, 2010). In particular, our head coaches showed training strategies based on endurance activities and aerobic capacity development implemented mainly in training programmes at the beginning of the week; further, anaerobic lactic activities were mainly scheduled on Tuesdays and Wednesdays (away from the match), while alactic activities mainly characterized training programmes scheduled for Thursdays and Fridays, the days close to the competition.

Regarding strength training, all head coaches answered that they plan specific training sessions, most of which are performed using an equipped gym to this scope. In particular, most Serbian head coaches usually planned three training sessions in the gym per week, while most of the Italian and Greek teams planned two sessions. However, it can also be speculated that the number of training sessions scheduled with exercises performed outside the water (as for example some strength training) is also determined by the characteristics of the training facilities, which are frequently available only for limited hours to the water polo clubs (as it is the main case in Italy).

The limited sports science background in coaches' profiles (for instance, only 10% of our entire sample of head coaches, all from Serbia, had a degree in sport science) could also explain a low use of monitoring of training strategies, including physiological, psychological, and tactical parameters (Clemente, 2016; Sansone et al., 2020[a]). Indeed, in our study, most of the respondents declared to use only the manual pulse measurement method, while only a few teams provided regular monitoring using tools and methods indicated by the relevant literature (Lupo et al., 2014[a]; Botonis et al., 2019[a]). Furthermore, most of our respondents showed a lack of regular and calendarized use of physical and swimming tests. This aspect is in contrast with previous literature that suggested choosing different protocols to apply water polo specific tests (Chirico et al., 2021).

To understand how water polo is played at different competitive levels and to investigate the relationship between game demands and players' individual skills, it is useful to use notational analysis (Hughes, 2003), a tool that provides coaches with accurate and comprehensive information on technical and tactical aspects of play demonstrated by own team and the opponents (Lupo et al., 2010; Lupo et al., 2012[a]). However, despite the usefulness of these feedback, the results of our survey showed that 11 out of 40 head coaches were not using match analyses at all.

In the end, in terms of training tactics and strategies, we asked our head coaches which one of game phases, offence or defence (Lupo et al., 2011) received more attention or did they consider of same relevance. Most of the respondents answered that both phases were of same relevance to them, only 11 highlighted defence as more important. None of the head coaches answered that they paid more attention to offence. In support of this choice, most of the head coaches declared that they relied more on the players' defensive skills when selecting young players for their debut in the first team.

Talking about team strategic schemes, significant differences were found in the power-play situation and even defensive phase. In this regard, the Greek school seems to be the one with fewer schemes of play than the other two schools, probably due to the creativity that usually characterizes Greek players, as could be seen in play that Greek youth categories demonstrated during the last youth international competitions.

Based on the survey's results, our research can offer an objective indication of differences and similarities in training methodologies and competition management derived from the coaching philosophies of the interviewed head coaches as well as from the different water polo national schools. Indeed, how a sport discipline develops in a country can be seen in a complex interaction of social relevance, sports achievements, media coverage, financial resources, and so on, in addition to the country's historical link to that specific sport. In the latter respect, for instance, water polo has expanded in Serbia starting from a single Central School in Belgrade and in the main cities of the former Yugoslavia (Bratuša, 2021); in Greece, it has developed from the main clubs in the Greater Piraeus area, while in Italy, it could be speculated that the Italian school has been developed in parallel with different and original features between the various Italian regions (mainly Liguria, Lazio, Campania and Sicily).

6.1.5 Conclusion

To further improve this line of research, the sample must be expanded involving more head coaches from water polo clubs all over the world and including the head coaches of the U18 and U20 teams. In fact, in our opinion, the same questions posed to a wider audience of head coaches from different countries and from different national water polo schools would expand the scientific data available to researchers and favour the transferability of knowledge to the coaches of this discipline.

6.1.6 Appendix A

Section 1: Technical staff composition

1. Is water polo coaching your main job?
2. Does the team you train have technical collaborators to help the head coach?
3. Does the team you train have a goalkeeper coach?
4. Does the team you train have a fitness coach?
5. Does the team you train have a match analyst?
6. Based on your coaching philosophy: who should reach the decision of selecting a player from the youth team to be employed with the first team?
7. Based on your coaching philosophy: considering a player from the youth team, which one of the following game phases could determine his/her higher employment in the first team?
8. Based on your coaching philosophy: at which age is a young talented player considered 'ready' to play and train with the first team?
9. Have you been a water polo player?
10. If your answer is 'Yes': which one of the following has been your highest competitive level?
11. How many years have you been coaching in water polo?
12. Which is your highest educational level?
13. Which one of the following aspects has mostly influenced your coaching philosophy?
14. In addition to water polo, which one of the following sports has influenced your coaching philosophy in regard to training methodologies?
15. Based on your personal experience: indicate the most used way for continuing learning.

Section 2: Team roster

1. Indicate how many players are in the roster of your first team.
2. Indicate how many players of the roster of your first team were in the youth teams of your club the year before.
3. Indicate the range of players' age of your first team.
4. How many foreign players has the roster of your first team?
5. For how many players in the roster of your first team is water polo the main job?

Section 3: Weekly periodization

1. Indicate the weekly hours of training of your first team (including also the workouts performed in the gym).
2. Indicate how many times per week your team has two training sessions a day.
3. Indicate how many times per week your team has a full day rest (without training).
4. Considering the typical training week of your team: indicate how many resistance training sessions per week are performed in the gym.
5. Considering the typical week of your team: indicate how many times per week injury prevention or pre-activation activities are performed.
6. Considering the typical week of your team: indicate which is the main workload of each daily training session.
7. Based on your coaching philosophy: indicate on which day of the week the pre-match meeting with players is scheduled.
8. Based on your coaching philosophy: indicate how long should the pre-match meeting last.

Section 4: Testing and monitoring

1. Which ones of the following methods are used to monitor training loads?
2. Does your team use tests to assess players' fitness?
3. Considering the entire water polo season: indicate the period in which tests are usually executed.

4. Indicate what kind of match analysis is carried out in your team.

Section 5: Tactics and strategies

1. Which phase of play (defensive or offensive) receives more attention in your training periodization?
2. Based on your coaching philosophy: indicate how many strategies and tactics (pre-configured) has your team to attack in a power-play situation.
3. Based on your coaching philosophy: indicate how many strategies and tactics (pre-configured) has your team to attack in a common situation with equal number of players.
4. Based on your coaching philosophy: indicate how many types of defense (pre-configured) has your team to defend in a player-down situation.
5. Based on your coaching philosophy: indicate how many types of defense (pre-configured) has your team to defend in a common situation with equal number of players.
6. Considering the typical week of your team: indicate on which days the focus of a training session is mainly on game strategies and tactics.

6.2 STUDY #2 - Perazzetti, A., Dopsaj, M., & Tessitore, A. (2023). Technical and tactical evaluation of ball possession in international youth water polo matches using the Team Sport Assessment Procedure (TSAP) instrument. Montenegrin Journal of Sports Science and Medicine, 12(2), Ahead-of. https://doi.org/10.26773/mjssm.230901

6.2.1 Introduction

Water polo, which originated in the late 1800s, is one of the oldest team sports of the modern Olympic Games, being part of the Summer Olympics program since the second games, in 1900. Since 1973 the Federation Internationale De Natation (FINA) also organize the Men's World Championship, with the last edition (the 19th) held in Hungary (Budapest). This competition has been also extended to the youth categories, with the Men Water Polo World Junior Championships (currently named U20) played since 1981. The tournament consists of a preliminary group stage phase, with teams divided into two groups and playing once with each other, followed by a knockout phase (eight-, quarter-, semi-final, and finals). Despite the situational nature of water polo, like other team sports, makes difficult the game analyses in terms of replication (Lupo et al., 2010), in literature are present different types of investigation, including physiological characteristics (Botonis et al., 2019[a]; Smith, 1998), monitoring of training (Lupo et al., 2014[a]; Botonis et al., 2019[b]), as well as swimming capabilities (Dimitrić et al., 2022; Perazzetti et al., 2022). Regarding the technical and tactical aspects, specific studies have been provided involving men and women collegiate teams (Lupo et al., 2011), playing role efficacy (Botonis et al., 2018), game rules evolution (Borges-Hernández et al., 2022), different competitive levels (Lupo et al., 2012[a]), and influence of match outcome (Ruano et al., 2016). However, from our point of view, in water polo, the absence of a valid and reliable instrument to objectively assess the players' level of tactical awareness and game knowledge, to use on both match and training contexts, is responsible for the paucity of studies on these topics.

The Team Sport Assessment Procedure (TSAP) instrument has been used in both sport and physical education by students, teachers, coaches, and researchers (Grehaigne et al., 1997) to assess performance in games as the integration of tactical understanding, decision-making and skill performance. Its primary objective is to provide coaches with objective data on players' offensive performance in different invasion and net games, while avoiding standardized tests which do not provide tactical behaviours of players (Richard et al., 2002). Indeed, the basic idea of this procedure is to consider the players' and teams' specific behaviours during the game and to summarize the data collected either under the form of total occurrences or under the form of some performance index. For that reason, the TSAP method is focused on the offensive ball aspects of the game, assessing how a player or team gains the ball possessions, and how a player or team disposes the ball (Grehaigne et al., 1997). In current literature, studies regarding the use of TSAP instrument have been published in soccer (Blomqvist et al., 2005), basketball (Catarino et al., 2017), ice-hockey (Nadeau et al., 2008) and volleyball (Richard et al., 2002). However, in water polo, to the best of our knowledge, only one study was conducted using this instrument, showing how the TSAP could be a valid procedure to evaluate the performance of international youth teams during international water polo competitions (Perazzetti & Tessitore, 2021). Therefore, the present study aimed at providing the TSAP analysis of the last Men's Water Polo World Junior Championships organized by FINA and played in Kuwait at the end of the 2019, before the spread of coronavirus pandemic.

6.2.2 Materials and methods

6.2.2.1 The research sample

Twenty-nine matches of the 2019 FINA World Men's Junior Water Polo Championships (Kuwait City, Kuwait), involving the national teams of Greece (n= 7), Serbia (n= 7), Italy (n= 7) and Croatia (n= 8) were selected for the analysis.

6.2.2.2 Measurement methods

The TSAP instrument (Grehaigne et al., 1997) was used to assess Received Balls (RB) and Conquered Balls (CB) as variables for gaining possession of the ball; and Offensive Balls (OB), Successful Shots (SS), Neutral Balls (NB) and Lost Balls (LB), as variables for disposing of the ball. Then, the Volume of Play [VP: RB+CB], Efficiency Index [EI: (OB+SS)/(10+LB)] and Performance Score [PS: (VP/2)+(EI*10)] were calculated as performance indicators (table 15). The EI used in this study is the adapted version of Richard et al. (2000), which differs from the original version of Grehaigne et al. (1997; EI: (VP)/(10+LB)) and poses an emphasis on the ball possession management (i.e. pass or shoot on goal) (Light et al., 2008).

Table 15. TSAP Components in Water Polo*

GAINING POSSESSION OF THE BALL	
Receiving the ball (**RB**)	The player receives the ball from a partner and does not immediately lose control of it.
Conquering the ball (**CB**)	A player is considered having conquered the ball if he or she intercepted it, stole it from an opponent, or recaptured it after an unsuccessful shot on goal or after a near-loss to the other team.
DISPOSING OF THE BALL	
Playing a neutral ball (**NB**)	A routine pass to a partner or any pass which does not truly put the other team in jeopardy is considered a neutral ball.
Losing the ball (**LB**)	A player is considered having lost the ball when he or she loses it to the other team without having scored a goal (Shot, Passages, Lost Ball, Contrafoul).
Playing an offensive ball (**OB**)	An offensive ball is a pass to a partner which puts pressure on the other team and, most often, leads to a shot on goal (Assist, Offensive passages, Center Ball) or a gained exclusion with the ball in the hand
Executing a successful shot (**SS**)	A shot is considered successful when it scores or possession of the ball is retained by one's team (Goal and Shots)
PERFORMANCE INDICATORS	
Volume of Play (**VP**)	VP: RB+CB
Efficiency Index (**EI**)	EI: (OB+SS)/(10+LB)
Performance Score (**PS**)	PS: (VP/2)+(EI*10)

*Adapted from Grehaigne et al. (1997). Journal of teaching in Physical Education, 16(4), 500-516

Through the LongoMatch Pro software (LongoMatch By Fluendo, Windows version 1.7) we customized a specific water polo dashboard to collect TSAP parameters during all ball possessions for each observed team. For the CB, LB, OB and SS parameters has also been provided an analysis of their frequency of occurrence in relation to the zone in which they took place. The field was divided in twelve zones according to the ususal classification used by water polo coaches and adopted in a previous study by Perazzetti and Tessitore (2021). In particular, the field was divided in a ‘defensive half’ (DH) (left zones: -1 and -2; right zones: -4 and -5; and central zones: -3 and -6) and an ‘offensive half’ (OH) (right zones: 1 and 2; left zones: 4 and 5; and central zones: 3 and 6) (Figure 17).

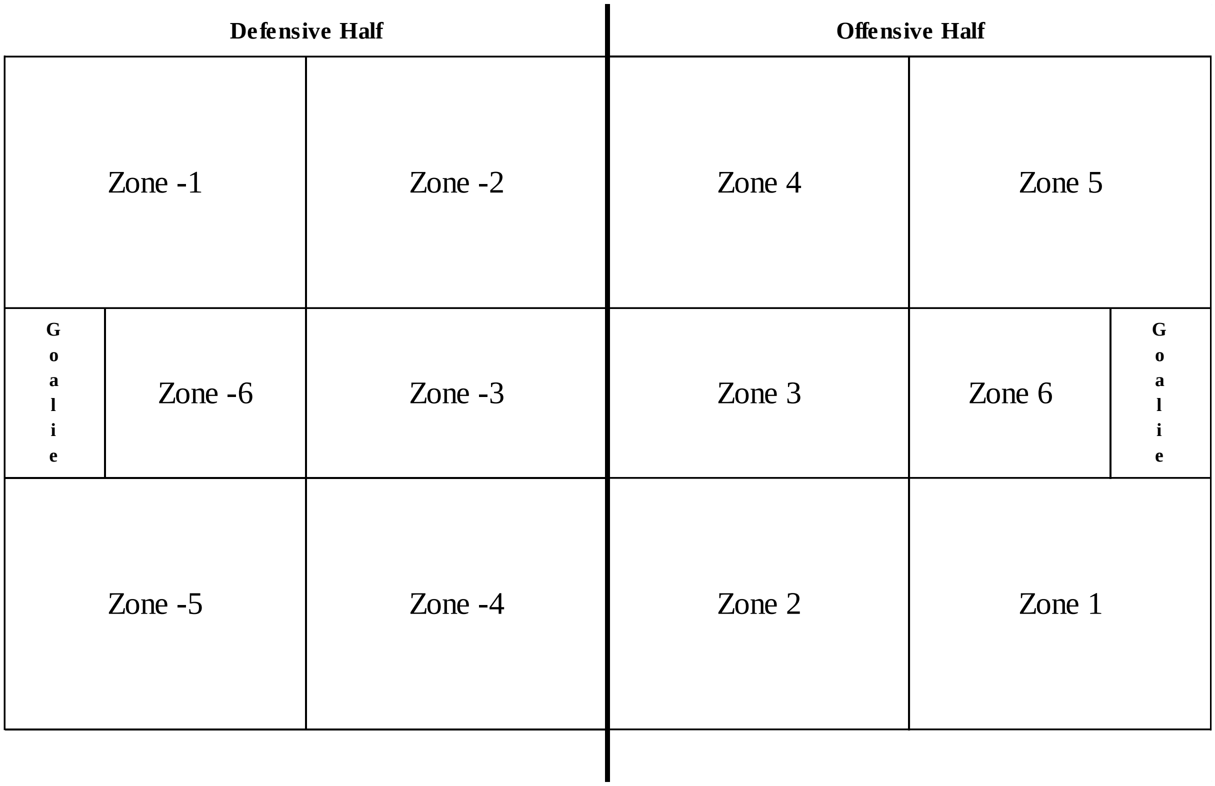


Figure 17. The division of the water polo field in twelve zones

6.2.2.3 Statistical analysis

The Shapiro–Wilk test was applied to ascertain the normal distribution of data. Descriptive statistics of all TSAP parameters, including means and standard deviations, for Greek, Serbian, Italian and Croatian teams and pooled data were calculated. The one-way ANOVA was used to analyse differences between teams for all parameters and according to the zones of the field, while the independent t-Test with pooled data was used to analyse differences, for the same parameters, between tournament phases (preliminary round vs final round) (García-Marín et al., 2017) and match status in relation to the difference of number of goals scored by the two opponent teams [balanced (≤3 goals) vs unbalanced (>3 goals)] (Lupo et al., 2012[a]). A Pearson correlation was used to characterize the association between TSAP’s parameters and total amount of gained exclusions, gained penalties, goals conceded, and goals scored. The correlation coefficients were defined as follows: small 0.1–0.3; moderate 0.3–0.5; strong 0.5–0.7; very strong 0.7–1.0 (Schober et al., 2018).

The statistical analyses were conducted using the statistical package SPSS (version 20.00; Institute, Inc., Cary, NC), and the criterion for significance was set at a 0.05 alpha level.

6.2.3 Results

Table 16 shows the total amount of TSAP parameters of the 29 matches analysed, indicating minimum, maximum, mean and SDs.

Table 16. Descriptive statistics of TSAP parameters (29 matches) with pooled sample (Greece, Serbia, Italy and Croatia national teams)

Parameters	Mean	SD	CV (%)	Min	Max
RB	197.7	34.6	17.5	126	257
CB	9.3	3.6	39.1	3	16
VP	207	33.4	16.1	142	269
NB	135.1	34.3	25.4	70	203
LB	22.7	5.9	26.1	9	33
OB	31.7	7.8	24.5	18	46
SS	17.5	6.2	35.6	7	32
EI	1.6	0.7	43.8	.7	3.5
PS	119.6	17	14.2	84	157.4
Goals Scored	13.1	6	45.3	4	27
Goals Conceded	7.2	3	41.9	2	15
Gained Exclusions	11	4.5	49.2	3	23

Note. RB= received balls; CB= conquered balls; VP= volume of play; NB= neutral balls; LB= lost balls; OB= offensive balls; SS= successful shots; EI= efficiency index; PS= performance score

Regardless the tournament phase, the one-way ANOVA showed no significant differences between national teams (Greek, Serbian, Italian and Croatian) for any of the TSAP parameters (Figure 18).

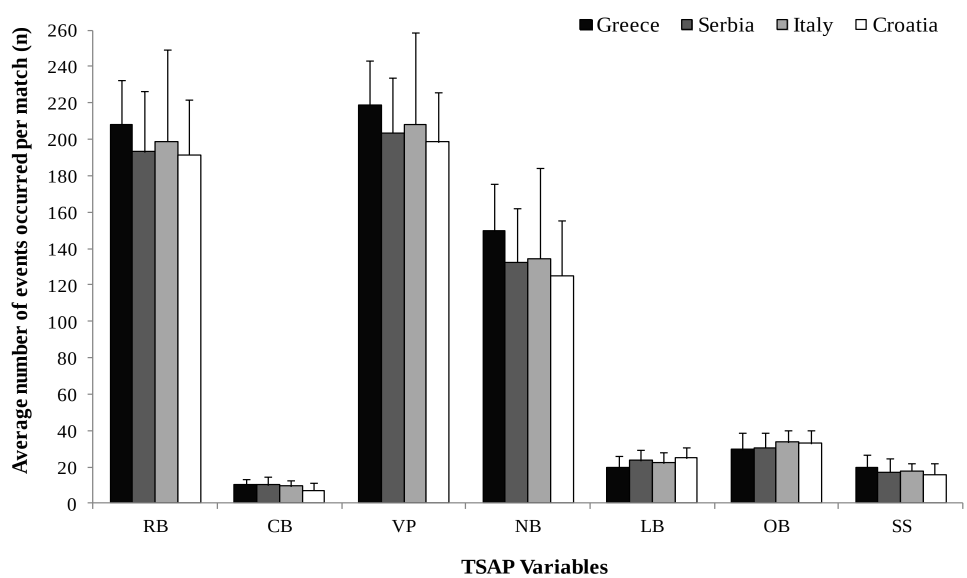


Figure 18. Comparison of the TSAP variables' mean values per match between national teams (Greece, Serbia, Italy and Croatia) ($p>0.05$); *Note*. RB= received balls; CB= conquered balls; VP= volume of play; NB= neutral balls; LB= lost balls; OB= offensive balls; SS= successful shots

Through the analysis of the field zones, the pooled data showed that CB occurred more in the defensive half (n= 270) of the field than in the offensive one (n= 2). Contrariwise, the LB, OB and SS parameters have mainly occurred in the offensive half of the field (LB, n= 647; OB, n= 894; SS, n= 495) compared to the defensive one (LB, n= 11; OB, n= 26; SS, n= 13). Regarding the distribution of the zones of the field, for the defensive half zone -6 showed the highest number of CB occurred per match (n= 5±2), while for the offensive half zone 6 for LB (n= 6±3), zone 2 for OB (n= 7±3), and zone 6 for SS (n= 6±4) showed the highest values. Instead, the one-way ANOVA showed significant differences ($p<0.05$) between the four teams for OB played in zone 1 (p= .019), in zone 2 (p= .014) and in zone 5 (p= .007) and for SS performed in zone 1 (p= .026) and in zone 2 (p= .008) (table 17).

Table 17. Distribution of the frequency of occurance per match for the CB, LB, OB and SS parameters according to the zones of the field

DEFENSIVE HALF							
Parameters	**Teams**	**Zone -1**	**Zone -2**	**Zone -3**	**Zone -4**	**Zone -5**	**Zone -6**
CB	Greece	1.3±1.1	1.3±1.1	1.6±0.8	0.3±0.5	0.1±0.4	6.0±2.0
	Serbia	1.1±1.1	0.3±0.5	1.6±1.8	0.6±0.8	0.9±0.9	5.7±2.6
	Italy	0.8±0.7	1.0±1.0	1.9±1.7	0.4±0.8	0.1±0.4	5.3±2.3
	Croatia	0.7±1.0	0.9±0.8	0.7±1.0	0.1±0.4	0.7±0.9	4.0±2.6
OFFENSIVE HALF							
Parameters	**Teams**	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone 6**
LB	Greece	2.3±2.0	2.9±1.9	5.7±2.8	3.0±1.6	2.6±1.4	3.4±2.4
	Serbia	2.4±1.6	5.3±2.4	5.1±2.6	3.9±2.4	1.6±1.7	4.7±1.9
	Italy	1.7±1.5	3.9±1.0	5.1±3.4	2.4±1.6	0.7±0.5	7.6±3.2
	Croatia	2.9±2.8	5.0±2.9	5.1±3.0	2.1±2.0	2.4±2.0	7.1±4.1
OB	Greece	4.7±1.7	4.9±2.4	7.3±1.9	3.6±2.8	3.6±2.4	5.3±4.1
	Serbia	3.9±2.4	8.7±2.9	6.4±3.3	3.3±3.2	1.9±1.7	4.0±1.5
	Italy	4.7±1.1	6.0±2.3	8.4±4.1	4.1±2.3	4.4±2.2	5.6±3.1
	Croatia	7.0±2.0	8.7±2.5	5.1±3.4	3.9±1.9	1.0±1.0	6.7±1.7
SS	Greece	1.1±1.0	1.7±1.6	5.0±2.8	2.6±1.1	2.1±1.7	6.9±3.0
	Serbia	1.4±0.9	3.3±1.5	4.4±2.4	1.1±0.7	2.4±1.7	4.1±3.2
	Italy	2.1±1.3	1.0±0.8	3.1±1.4	0.9±0.9	3.0±4.0	6.9±3.6
	Croatia	0.4±0.7	1.1±0.9	3.5±2.2	1.4±2.3	2.0±1.2	6.9±5.3

Note. CB= conquered balls; LB= lost balls; OB= offensiveballs; SS= successful shots

The analyses with pooled data (29 matches) by means of the independent t-Test showed significant differences between preliminary round (17 matches) and final round (12 matches) for CB (p= .038), LB (p= .048), OB (p= .013), SS (p= .000), EI (p= .002).

The difference of the number of goals scored by the two opponent teams per match showed that a margin of ≤3 goals (balanced) occurred in 11 matches (38%) while a margin >3 goals (unbalanced) occurred in 18 matches (62%). Regarding the analysis of match status in relation to the tournament phases, data showed that of the 11 balanced matches 18.2 % (n= 2) and 88.6% (n= 9) were registered during the preliminary and final phases, respectively; while of the 18 unbalanced matches 83.3% (n= 15) and 16.7% (n= 3) were registered during the preliminary and final phases, respectively. Moreover, the independent t-Test, showed a significant difference ($p<0.05$) between matches with balanced and unbalanced scores for RB (213±24 vs 188±37), CB (7±3 vs 10±4), NB (153±29 vs 124±33), LB (26±4 vs 20±6), SS (13±4 vs 20±6) and EI (1±0.5 vs 2±1), respectively.
The Pearson correlation with pooled data showed a positive very strong correlation between VP and NB ($r= .957$, $p= .000$) and a negative very strong correlation between LB and Goals Scored ($r= -0.903$, $p= .000$) (Figure 19). Strong correlations were also showed between OB and SS ($r= .605$, $p= .001$), Total Gained Exclusions and RB ($r= .597$, $p= .001$), CB and Goals Scored ($r= .506$, $p= .005$). Moderate correlation was found between Goals Conceded and LB ($r= .387$, $p= .038$), while negative moderate correlation was showed between NB and Goals Scored ($r= .-496$, $p= .006$).

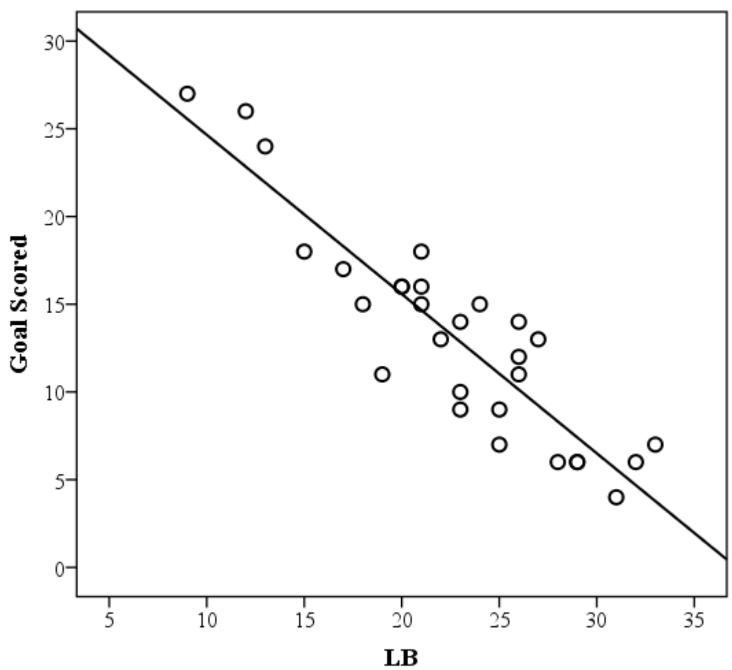


Figure 19. Pearson Correlation between LB and Goal scored ($r= -.903$); *Note.* LB= lost balls

6.2.4 Discussion
This study aimed to provide a technical and tactical analysis of offensive actions during international youth water polo competitions by means of the Team Sport Assessment Procedure instrument. The TSAP analysis has investigated the matches of the youth water polo national teams of Greece, Serbia, Italy and Croatia, which gained the first four placements at the 2019 FINA Men’s Water Polo World Junior Championships (Kuwait City, Kuwait).
The main findings showed that there were no significant differences between the four national teams for all TSAP parameters and indexes. Nevertheless, the winner national team (Greece) showed higher mean scores per match for several parameters and indexes (RB, n= 208±24; CB, n= 11±3; VP, n= 219±24; SS, n= 20±7; EI, n= 2±1; PS, n= 127±10) compared to the other three national teams. Furthermore, Greece showed the lowest score of LB per match (n= 20±6), demonstrating a higher tactical awareness and ball

possession ability compared to their opponents. The results of our winning team (Greek national team) confirm the findings of a previous study on elite and sub-elite men's water polo (Lupo et al., 2010), where the winning teams showed a higher duration of the even actions respect to the losing ones, speculating that winning teams were more able to maintain the ball possession and successively to defend their goal. When the analysis included the data distribution in relation to the different zones of the field, despite only OB and SS were significant, the four teams showed a different distribution of data. Such difference between the four national teams could be explained by the tactical behaviour of their coaches and the players' technical capabilities. In the World Junior Championships analysed in our study, the four national team coaches may have asked a different way to play NB and OB in relation to the gained position of their centre-forwards, and consequently according to the kind of defence adopted from each opponent teams. In fact, as suggested by Canossa et al. (2022), based on the new rules changes occurred at the international water polo level, a national team could adopt a more static or dynamic game that characterize its playing style. Therefore, these coaches' directions might have impacted on the distribution of the number of offensive passes in relation to the zone of the field influencing players' decision making and technical skills. In particular, the main reason of this difference between the four teams could be interpreted by the presence or not of a left-hand player in the game.
Anyway, considering the four national team pooled data, the zone -6 resulted to be the main position in which players conquered the possession of the ball (56% of the total CB). Moreover, in zone 6, occurred the 26% of LB, as well as the 36% off SS, confirming this zone as the most dangerous position to score a goal in youth water polo matches, other than in senior elite level (Lupo et al., 2007). In addition, the 23% of OB took place in zone 2, demonstrating the relevance of this zone that is considered a 'play's construction' zone, where usually play 'perimetral' or 'wing' players.
One of the main findings of this study, in line with previous ones (Lupo et al., 2012[a]), shows that the men's water polo matches of the World Junior Championships have mainly been characterized by the divergence between balanced (closed) and unbalanced games, as well as the comparison between preliminary and final rounds. Thus, it could be speculated that the game aspects of the youth elite men's water polo matches must be analysed in relation to specific margins of results and the tournament phase (preliminary round or final round) and not only considering the winning or losing outcome.
In terms of correlation, the results of this study suggest that for a team performing a higher value of VP doesn't mean to improve the possibility to score a goal compared to the opponent team. In fact, according to our results a higher value of VP improved only the number of NB, which were correlated with a decrease of the number of goals scored. Indeed, in youth water polo matches, the VP does not appear to be always a positive index, due to the strong correlation between RB and the total amount of gained exclusions occurring in a match. In fact, during a water polo match, it is widespread among coaches to ask their players not to rush to complete their attack and try to exchange the ball to find the best solution (Platanou & Varamenti, 2022). Furthermore, this aspect, could be explained by the fact that after an opponent exclusion (6 vs 5) players perform more passes, especially as NB, than during an even situation (6 vs 6). Our findings are in line with those of Platanou and Varamenti (2023), which demonstrated that the number of passes not always affect the scoring, especially in the power-play situations.

6.2.5 Conclusion

The results of our study, provide a useful indication for water polo coaches in terms of LB, showing how a higher number of LB decreases the number of goals scored and increases the number of goals conceded, confirming that the loss of ball possession might denote negative effects on the final outcome (Lupo et al., 2014[b]). Finally, our findings suggest that the number of CB and OB increase the number of goals scored, as in particular demonstrated by the Greece team (gold medal), which registered the highest values of TSAP parameters and indexes between the four national teams.
Based on our results, the use of TSAP instrument appears to produce an objective indication of teams' offensive performance in youth water polo matches. The findings from the analysis of the tournament

could help to guide the training process along a championship or an entire season. In fact, this kind of monitorization could also offer productive feedback to coaches to perceive the different needs of playing, as well as to assess the way the players understand the game collectively or individually, for the purpose of adapt their planning and actions. Therefore, the coaching staff might use this information to establish common goals for trainings and matches of their teams. The coaches could have enough information to organize specific exercises, as small-sided games, in their trainings to better reproduce the match situations (McCormick et al., 2012). Future directions of research could include individual scores and indexes of water polo players belonging the same team during a competitive season to see how all values changes according to the type of match and the period of the season.

6.3 STUDY #3 - Perazzetti A., Dopsaj M., Mandorino M., Tessitore A. Assessing Offensive Phase: The Use of Team Sport Assessment Procedure (TSAP) in Elite Water Polo. Submitted to Internal Journal of Performance Analysis in Sport.

6.3.1 Introduction

Water polo is an intermittent high-intensity and body-contact aquatic team sport (Perazzetti et al., 2023[a]) played by two teams of seven players (1 goalkeeper and 6 field players) with the object to score points by throwing the ball into the opponent team's goal (Hraste et al., 2013).

Although along the years a body of water polo literature has been focused on players' physiological (Smith, 1998), anthropometric (Kondrič et al., 2012), and swimming profiles (Dimitrić et al., 2022), as well as on training and match loads monitoring (Lupo et al., 2014[a]; Perazzetti et al., 2023[a]), the last decade has seen an increasing interests for research lines related to time motion and notational analyses (Hughes, 2003).

A notational analysis approach in water polo has been applied to analyse between-team differences in technical and tactical parameters in relation to different competitive levels (Lupo et al., 2011; Ordóñez et al., 2015; Garcia-Marin & Iturriaga 2017; Ordóñez & González, 2021; Ordóñez et al., 2022). In a study of Lupo et al. (2010) have been compared men's national and international matches, demonstrating positive effects of the competitive level (sub-elite and elite) on the occurrence of even, counterattack, and man-up game situations, suggesting that elite teams performed more elaborate offensive actions than the sub-elite teams. Successively, Pérez et al. (2016) investigated the same game situations during three consecutive seasons of the male Spanish Professional Water Polo League, clustering the teams as 'strong', 'medium' and 'weak' level according to their final table position, and showing as 'strong level teams' made more counterattacks and goals scored than the 'weak level teams'. Additional studies investigated the match's final score difference (i.e., balanced matches= 1-3 goals; unbalanced matches= >3) in elite water polo suggesting that in balanced matches occur more man-up actions (Lupo et al., 2012[a]), while in unbalanced matches has been counted a lower frequency of even actions and a higher number of counterattacks, speculating a limited ability of defensive players in covering the opponents' counterattacks (Lupo et al., 2014[b]). Furthermore, two studies conducted on elite men's matches of the Spanish First League championship investigated the influence of match location, showing a home advantage, especially in the last quarter, on the final outcome of the match (Gómez et al., 2011; Ruano et al., 2016).

According to the 2019 update of the water polo rules of play (Federation Internationale De Natation, FINA), each team can retain a ball possession up to 30 s in a regular action, or up to 20 s in case of an exclusion, corner throw or rebound to the attacking team after a shot (included after a penalty shot). During a ball possession, players' individual skills such as ball technique, accuracy to pass the ball under the opponent pressure and shooting accuracy, are essential to successfully perform this offensive phase (Hraste et al., 2008). Such technical skills are also linked with players' individual tactical knowledge, which represents their capacity to read and react to the match's circumstances (Dong et al., 2023), to execute the most right and fastest decision-making.

However, despite the analysis of the number and duration of ball possessions (Platanou et al., 2023) combined with the analysis of players' tactical decisions (Casanova et al., 2020) could be useful to help the coaching staffs to better understand the offensive behaviour of their own team, there is still a lack of studies on player's decision making. As far as we are concerned, one of the reasons of this scarcity of studies could be the less knowledge of specific tools useful also for water polo to objectively assess the players' tactical awareness and game knowledge.

Initially developed by Grehaigne et al. (1997) in contexts of preassessment and formative physical education class assessment, the Team Sport Assessment Procedure (TSAP) procedure is a valid and reliable tool to assess the offensive elements of the game, which has been used in other invasion team sports. As pointed out by González-Víllora et al. (2015) this tool considers the interaction between tactical and technical efficiency, providing specific performance index and scores (Barquero-Ruiz et al., 2020),

while also including the analysis of how the ball possession is gained and how it is disposed by each player (Rechenchosky et al., 2021). Along the years, this procedure has been used in invasion team sports to conduct mostly studies on soccer (Blomqvist et al., 2005; Ortega-Toro et al 2018; Junior et al., 2020), ice-hockey (Nadeau et al., 2008; Kolstad et al., 2022) and basketball (McCormick et al., 2012; Clemente et al., 2017; Souabni et al., 2023). Furthermore, most of these previous studies have been focused on teaching/learning aims and were conducted on youth teams (Godbout and Grehaigne, 2022). Nevertheless, despite the provided efficacy of the TSAP tool, the existing research in elite water polo senior teams is still very limited. In fact, to the best of our knowledge there are only two preliminary studies conducted by Perazzetti and Tessitore (2021) and Perazzetti et al. (2023[b]) which provide a detailed explanation of how this kind of match analysis instrument could be useful to assess the individual or collective tactical behaviours of players.
Therefore, the aim of this study was to use the TSAP instrument to provide a technical and tactical analysis of offensive actions performed during all matches of an entire season by an elite water polo team participating to the Italian men's First Division championship. The study's main hypotheses were that significant differences of TSAP Performance scores could be found between two phases of the season (regular phase and play-out), between balanced and unbalanced matches and between home and away matches during an entire water polo competitive season (2021-22) and that the TSAP parameters, index and scores could be different between players according to their playing position.

6.3.2 Materials and methods

6.3.2.1 The research sample

The subjects of this study were 15 male players belonging to the Italian elite water polo team 'S.S. Lazio Nuoto'. Players were observed during all 19 official matches of the 2021-22 Italian men's First League championship (Serie A1) and classified according to their principal playing position as: perimetral (or peripheral) players (n= 8); center defenders (n= 3); center forwards (n= 2) and goalkeepers (n= 2) (Dopsaj et al., 2009).

6.3.2.2 Measurement methods

The observed matches have been downloaded from the 'ADrive.com' database (https://www.adrive.com), which is a platform with free public access where all the Italian First League water polo clubs were obliged by the Italian Swimming Federation to upload a professional video (file.mp4, 1920x1080 16:9 HD 1080, 44 khz) of all matches after the public streaming on YouTube or other public platforms. For this reason, since the current study was using data with free public access, no informed consent was required according to the ethical standards outlined by the local research ethics committees.
All matches were classified according to the final score difference, defined as the difference of goals scored between the two teams in a match (balanced: ≤3 goals vs. unbalanced: >3 goals) and match location (home or away) (Perazzetti et al., 2023[a]).
The notational analysis has been provided by means of the TSAP instrument (Grehaigne et al., 1997) with all players' Received Balls (RB) and Conquered Balls (CB) counted as variables for gaining the ball possession; while all players' Neutral Balls (NB), Lost Balls (LB), Offensive Balls (OB) and Successful Shots (SS) were counted as variables for disposing of the ball (table 15). As performance indicators the Volume of Play (VP= RB+CB), Efficiency Index [EI= (OB+SS)/(10+LB)] and Performance Score [PS= (VP/2)+(EI*10)] were calculated from the TSAP variables (Perazzetti et al., 2023[b]).
For the specific purpose of our data collection has been created a proper water polo dashboard using the LongoMatch Pro software (LongoMatch by Fluendo, Windows version 1.9), which allowed to collect the TSAP parameters throughout all offensive actions performed by the analysed team and its players.

6.3.2.3 Statistical analysis

Statistical analyses were performed using Excel version 2016 (Microsoft Office) and SPSS version 26.0 (IBM, Chicago, IL, USA). For each variable, descriptive data are expressed as means ± standard deviations (mean ± SD).

Two multiple linear regressions were generated with VP and PS as dependent variables, while in both analyses playing position, season phase, match location and final score difference were the constant predictors. Then the analysis of covariance (ANCOVA) with playing time as covariate has been applied to assess differences of VP and PS in relation to playing positions. The ANCOVA analysis showed to be robust to violations of either the conditional normality or homoscedasticity assumption in previous studies (Olejnik and Algina, 1984). For this reason, normality assumption was not checked.

Finally, the k-means cluster analysis has been applied to identify 3 groups of players according to the VP and PS indexes. The level of significance was set at $p<0.05$.

6.3.3 Results

The 19 observed matches were divided in regular phase (n= 13) and play-out phase (n= 6) matches, of which 10 matches were played at home and 9 matches were played away. Regarding the final score difference factor, 10 matches registered a balanced result (≤ 3 goals), while 9 matches ended with an unbalanced result (> 3 goals).

Table 18 shows the descriptive statistics (minimum, maximum, mean, SD and %CV) of the team's TSAP parameters calculated on pooled data (19 matches).

Table 18. Descriptive statistics (minimum, maximum, mean, SD and %CV) of the team's TSAP parameters with pooled data

	MIN	**MAX**	**MEAN**	**SD**	**%CV**
RB	160	247	207.1	26.3	12.7
CB	4	16	7.2	3.2	44.7
VP	164	252	214.3	25.6	11.9
NB	115	188	149.1	21.0	14.1
LB	19	36	27.4	4.4	16.2
OB	8	38	25.4	7.3	28.8
SS	5	20	12.3	3.4	27.9
EI	0.9	4.8	2.9	0.8	28.6
PS	90.5	165.9	136.2	18.7	13.7

Note. RB= received balls; CB= conquered balls; VP= volume of play; NB= neutral balls; LB= lost balls; OB= offensive balls; SS= successful shots; EI= efficiency index; PS= performance score

Figure 20-22 show the percentage of technical-tactical components for LB, OB and SS parameters in relation to the pooled data (19 matches). Regarding the average (mean ± SD) of LB technical-tactical components, shots registered 14.2 ± 3.8, passages 5.8 ± 2.5, getting the ball stolen 5.7 ± 3.8 and contrafouls 1.9 ± 1.2 actions per match. For OB components, passages registered 13.4 ± 5.1, center balls 7.7 ± 2.8 and gained exclusions with ball 4.3 ± 2.2 actions per match, while for SS components scored goals registered 8.3 ± 2.6, gained corner 2.6 ± 2, shots at the end of quarter 0.4 ± 0.6 and other kind of shot 1.0 ± 1.2 actions per match.

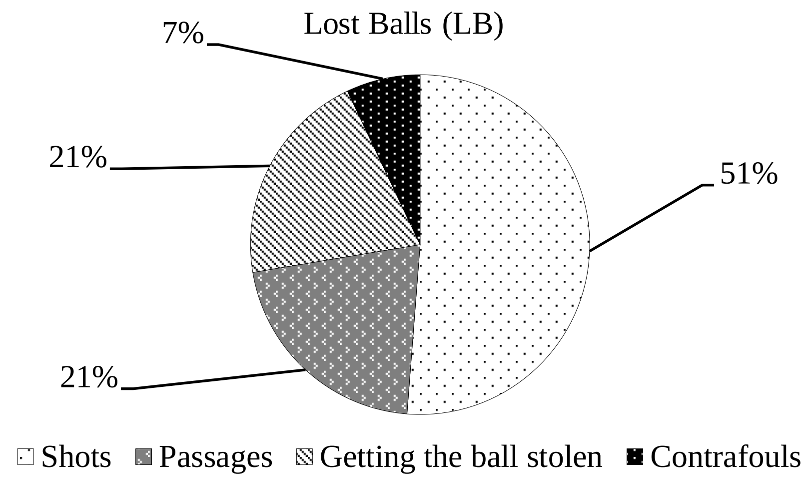


Figure 20. Percentage distribution of technical-tactical components of LB parameter

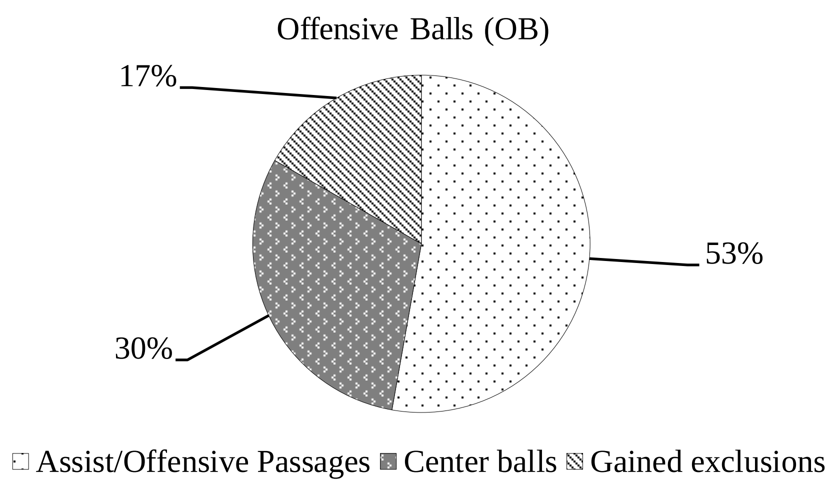


Figure 21. Percentage distribution of technical-tactical components of OB parameter

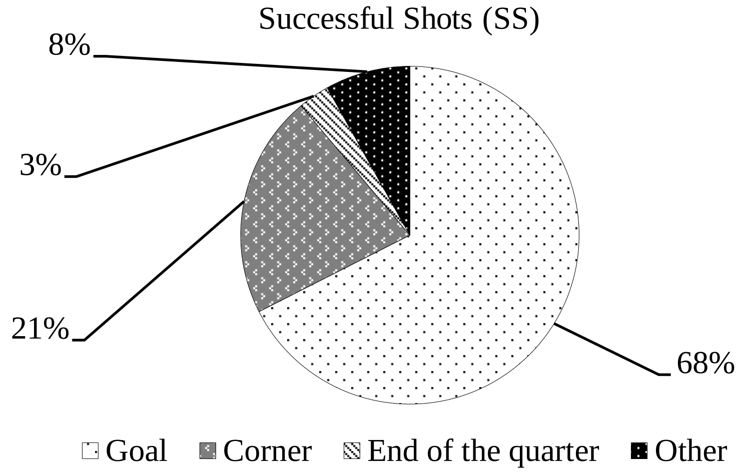
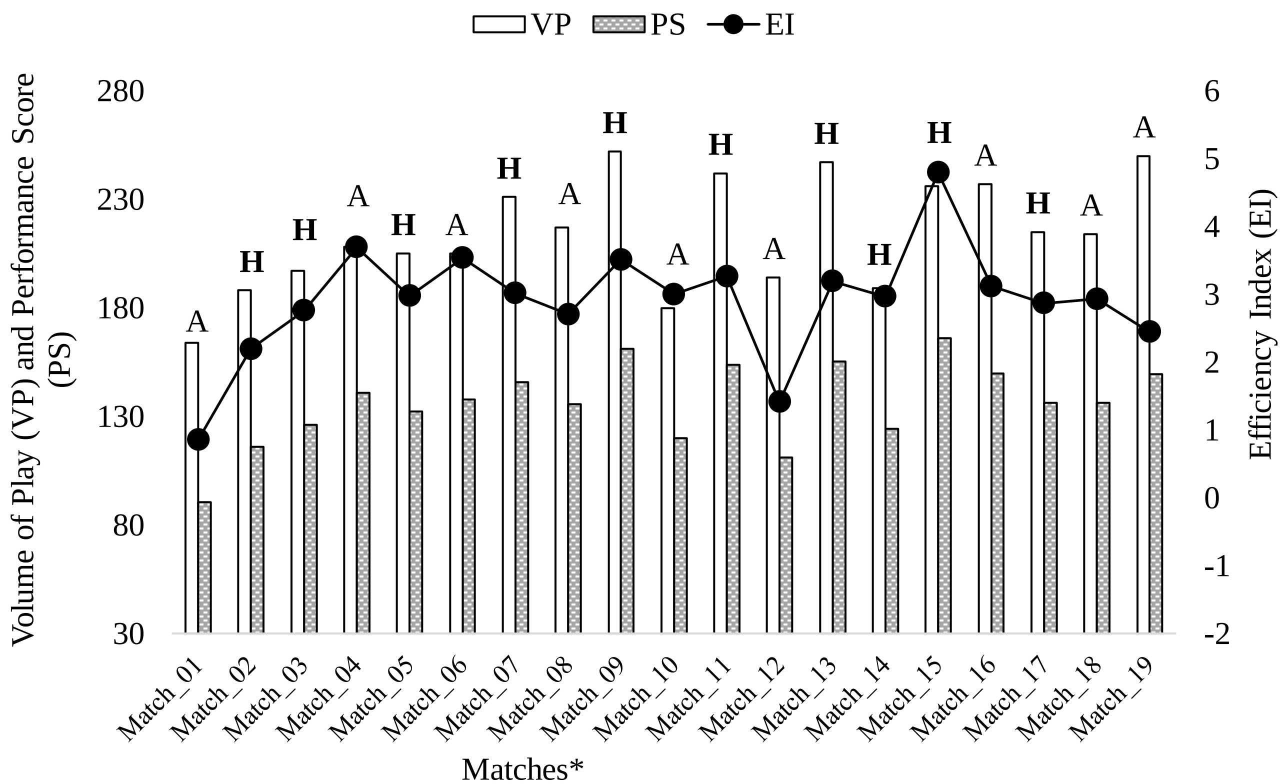


Figure 22. Percentage distribution of technical-tactical components of SS parameter

Figure 23 illustrates the VP, EI and PS indexes values for each match in relation to the match location (home and away).



Note. A= Away; **H**= Home

Figure 23. Distribution of VP, EI and PS values of each match played both away and at home location

The multiple linear regression analyses, except that for playing position, showed no significance for season phase, match location and final score difference for VP and PS indexes (tables 19-20).

Table 19. Multiple linear regression output for VP index

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	23.63	5.23		4.520	0.00
Competition	1.90	2.05	0.07	0.924	0.36
Match location	-0.51	1.74	-0.02	-0.294	0.77
Final score difference	0.03	1.92	0.00	0.015	0.99
Playing position	**-5.08**	**0.97**	**-0.33**	**-5.258**	**0.00**

Table 20. Multiple linear regression output for PS index

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	15.81	3.44		4.597	0.00
Competition	1.12	1.35	0.06	0.825	0.41
Match location	-0.54	1.15	-0.03	-0.473	0.64
Final score difference	-0.55	1.26	-0.03	-0.434	0.67
Playing position	**-2.90**	**0.64**	**-0.29**	**-4.559**	**0.00**

Table 21 shows the descriptive statistics (mean ± SD) of the team's TSAP parameters calculated on pooled data (19 matches) in relation to season phase, match location and final score difference.

Table 21. Descriptive statistics (mean ± SD) of the team's TSAP parameters with pooled data in relation to the contextual factors (season phase, match location and final score)

	Season phase		**Match location**		**Final score difference**	
	regular season	play-out	home	away	balanced	unbalanced
RB	203 ± 28	215 ± 24	212 ± 27	202 ± 27	204 ± 22	210 ± 31
CB	7 ± 2	9 ± 5	9 ± 4	6 ± 1	8 ± 3	6 ± 3
VP	210 ± 27	224 ± 22	220 ± 24	208 ± 27	212 ± 22	216 ± 30
NB	145 ± 22	157 ± 18	154 ± 20	144 ± 22	145 ± 18	154 ± 24
LB	28 ± 4	26 ± 6	26 ± 4	30 ± 4	26 ± 4	29 ± 4
OB	25 ± 8	27 ± 7	27 ± 6	24 ± 9	29 ± 5	22 ± 8
SS	12 ± 3	13 ± 4	14 ± 3	10 ± 3	13 ± 3	11 ± 4
EI	2.8 ± 0.8	3.2 ± 0.8	3.2 ± 0.7	2.6 ± 0.9	3.2 ± 0.6	2.6 ± 0.9
PS	132.8 ± 19.9	143.6 ± 14.6	141.6 ± 17	130.2 ± 19.5	138.4 ± 14.6	133.8 ± 23.1

Note. RB= received balls; CB= conquered balls; VP= volume of play; NB= neutral balls; LB= lost balls; OB= offensive balls; SS= successful shots; EI= efficiency index; PS= performance score

The table 22 provides the descriptive statistics of VP, EI and PS indexes of all players according to their playing position.

Table 22. Descriptive statistics (mean ± SD) according to players' playing position (PP)

Player	PP	N_Matches	Playing Time (min)		TSAP Indexes		
		total	total	average per match	VP	EI	PS
player_1	G	17	783	46.1 ± 10.1	8.1 ± 4.4	0.04 ± 0.09	7.2 ± 2.5
player_2	P	18	645	35.8 ± 7.9	30.6 ± 9.8	0.39 ± 0.24	19.1 ± 6.6
player_3	P	6	197	32.8 ± 8.2	27 ± 14.4	0.25 ± 0.24	16.1 ± 9.1
player_4	CD	17	398	23.4 ± 8.5	12.9 ± 7.4	0.13 ± 0.15	7.7 ± 4.9
player_5	P	19	788	41.5 ± 7.9	40.6 ± 12.2	0.59 ± 0.29	26.2 ± 8.1
player_6	CD	19	299	15.7 ± 6.2	8.3 ± 5.5	0.05 ± 0.06	4.7 ± 2.9
player_7	CD	19	561	29.6 ± 7.6	18.1 ± 8.2	0.19 ± 0.11	10.9 ± 4.6
player_8	P	18	783	43.5 ± 6.9	35.7 ± 4.3	0.55 ± 0.27	23.4 ± 3.8
player_9	CF	18	605	33.6 ± 5.9	9.2 ± 2.1	0.28 ± 0.15	7.4 ± 2.2
player_10	P	16	578	36.1 ± 8.6	17.2 ± 8.6	0.36 ± 0.23	12.2 ± 6.1
player_11	P	19	649	34.2 ± 8.2	18.9 ± 6.5	0.29 ± 0.14	12.4 ± 3.9
player_12	CF	18	304	16.9 ± 8.4	3.4 ± 2.1	0.06 ± 0.09	2.3 ± 1.6
player_13	G	9	224	24.9 ± 17.2	5.3 ± 5.4	0.02 ± 0.04	3.3 ± 3.1
player_14	P	12	70	5.8 ± 4.7	1.3 ± 1.3	0.02 ± 0.04	0.9 ± 1
player_15	P	3	73	24.3 ± 6.4	9.3 ± 1.15	0.06 ± 0.05	5.3 ± 0.6

Note. G= Goalkeepers; P= Perimetral players; CD= Center defenders; CF= Center forwards; VP= volume of play; EI= efficiency index; PS= performance score

According to players' playing position, the highest VP mean values (mean ± SE) were registered for perimetral players (22.9 ± 0.8), followed by center defenders (18.8 ± 1.1), center forwards (9.8 ± 1.4) and goalkeepers (6.5 ± 1.7). The Ancova analysis (with Bonferroni pairwise comparison) showed significant differences for VP index between goalkeepers and perimetral players ($p < .001$; mean difference ± SE= -16.3 ± 1.9), goalkeepers and center defenders ($p < .001$; mean difference ± SE= -12.3 ± 21), perimetral players and center defenders ($p = .031$; mean difference ± SE= 4 ± 1.4), perimetral players and center forwards ($p < .001$; mean difference ± SE= 13 ± 1.7) and between center defenders and center forwards ($p < .001$; mean difference ± SE= 8.9 ± 1.8).

For PS, significant differences were found between goalkeepers and perimetral players ($p < .001$; mean difference ± SE= -12.2 ± 1.2), goalkeepers and center defenders ($p < .001$; mean difference ± SE= 18.8 ± 1.1), goalkeepers and center forwards ($p = .014$; mean difference ± SE= -4.5 ± 1.4), perimetral players and center defenders ($p = .001$; mean difference ± SE= 3.4 ± 0.9), perimetral players and center forwards ($p < .001$; mean difference ± SE= 7.7 ± 1) and between center defenders and center forwards ($p = .001$; mean difference ± SE= 4.2 ± 1.1).

The k-means cluster analysis identified three groups according to the VP and PS indexes (reported as mean and SD). The first cluster included 8 players (VP= 7.2 ± 3.7; PS= 4.9 ± 2.5), the second cluster included 5 players (VP= 22.4 ± 6; PS= 14.1 ± 3.4), while the third cluster included only 2 players (VP= 38.2 ± 3.5; 24.8 ± 2). Figure 24 illustrates the individual bidimensional representation of the three clusters.

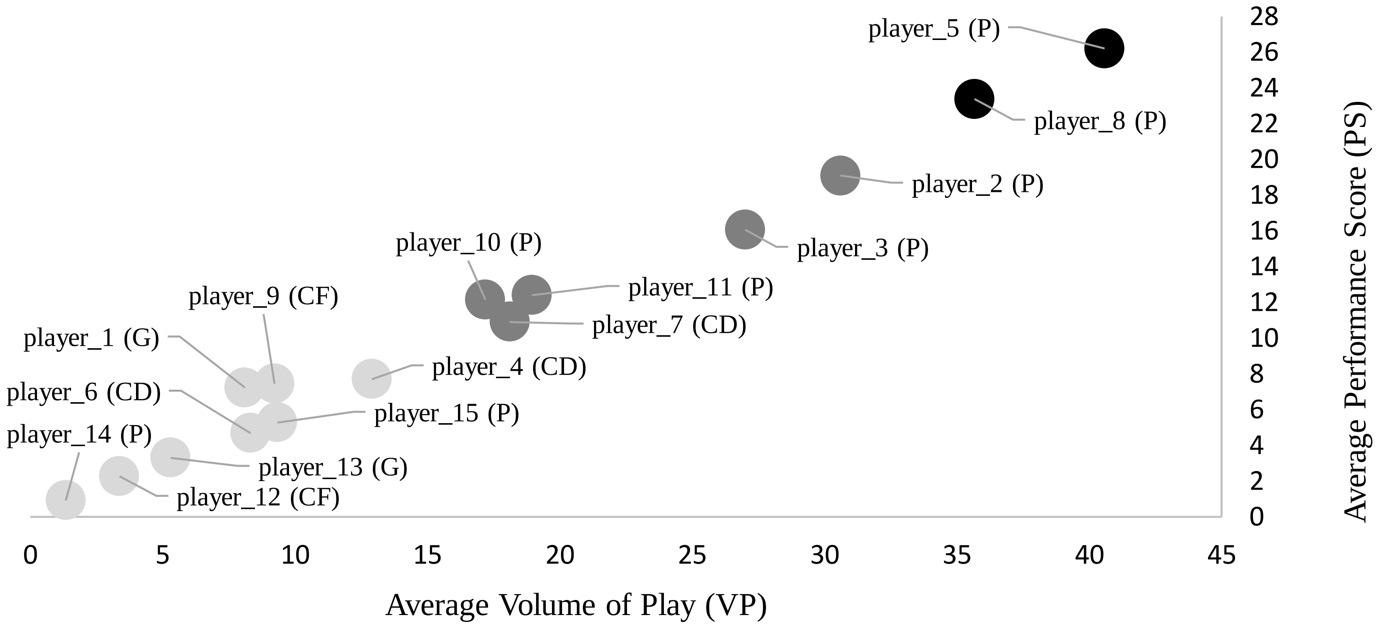


Figure 24. The k-means cluster analysis identifying three groups of players according to the two indexes of VP and PS

6.3.4 Discussion

This study aimed to use the TSAP instrument to provide a technical and tactical analysis of offensive actions performed during all matches of an entire season by an elite water polo team participating to the 2021-22 Italian Serie A1 men championship. The main findings of this study were that the four playing positions registered different values for TSAP parameters, with cluster analysis providing three groups of players for VP and PS indexes.

The analysis of technical-tactical components of TSAP parameters, showed that for LB the 51% was determined by shots, for OB the 53% by assist and offensive passages, while for SS the 68% by scoring a goal. In a water polo match, all these parameters should be considered intertwined since their interactions could provide a positive or a negative outcome for the team. The high number of missed shots registered for LB parameter could be explained by players' technical skills and decision-making. Indeed, a missed shot could lead the own team to concede a counterattack or a goal conceded, as confirmed also by a study of Perazzetti et al. (2021) on elite youth national teams in which was found a very strong negative correlation (r= -0.892) between LB and goals scored.

To investigate our main hypothesis, that significant differences of TSAP scores could be found between season phase, match location and final score difference, an analysis of these three contextual factors has been conducted. The multiple linear regression analysis showed a not significant relationship between season phase, match location, and final score difference, and the VP and PS indexes. Despite this result, the descriptive statistics of the two indexes provides different trends for each contextual factor.

Regarding the season phase, our study shows higher values for VP and PS indexes during the play-out phase (table 21), which is temporally played at the end of the regular phase. Although our study is the first investigating the season phase factor in water polo, this finding is in line with previous literature on other invasion elite team sports, as football and Australian Football, showing an improvement of technical and tactical performances toward the last part of the competitive season (Kempton et al., 2015; and Liu et al., 2016). Indeed, during the 6 play-out (final phase) matches of our study, the observed team played against opponents with a lower developed defensive organization compared to most of the teams faced during the regular phase. In fact, 5 out of 6 of the play-out round matches registered a balanced final score difference.

Considering the entire season our results showed higher mean values for balanced matches compared to unbalanced matches for PS (138±15 vs 134±23). This result could be explained considering the higher percentage of goals scored in power play situation during balanced matches than in unbalanced ones (40% vs 29%, respectively). In fact, Lupo et al. (2012[a]) demonstrated that during this kind of matches there is a higher occurrences of opponent's exclusion fouls to perform power-play actions that could report higher frequency of goals scored, while Medić et al. (2014) indicated that scoring in situations of numerical superiority (power-play goals) is one of the main technical and tactical parameters to consider in balanced matches.

Another explanation that could support the higher TSAP values at the end of the season could be given by the fact that during the play-out round half of the matches were played in home location. As demonstrated by Ruano et al. (2016) the match location affects the match outcome, with negative impact on the teams playing away. Considering the entire season, our results (table 21) confirm this trend for VP and PS indexes registered in matches played at home, even considering the unbalanced matches and the stronger opponent teams. In fact, apart the presence of an audience with local supporters and the missing of traveling, the higher influence on TSAP values is probably given by the fact that in home matches a team plays in the same water polo swimming pool where perform the daily training. In particular, in our study the home matches were played in the historical Olympic swimming pool (the Mosaic pool of 'Foro Italico') which has a smaller width dimension (18 m) and different measures of deep between the two halves of the pool, therefore these characteristics could have brought the observed team to play in a more efficiency way at home than in the away fields.

The playing position variable has been the only one to show significance in the multiple linear regression for both VP and PS indexes. The Ancova analysis showed several significant differences between the different positional roles of players, with perimetral players registering the highest mean values. Although most of the water polo studies do not include the goalkeeper position (Platanou, 2009), we decided to include it given the interesting findings observed. In fact, the results of our study showed that during a match the two players alternating in the goalkeeper position were actively participating to 7.7% of the total amount of VP and 6.5% of PS of the team. The fact to have collective actions where the goalkeeper is much more collaborative with teammates than in the past, has also been demonstrated in another invasion team sport as football (Shamardin et al., 2015, Altavilla et al., 2023). The goalkeeper's ability of being involved in the offensive phase should be more considered also in water polo. In fact, compared to other invasion team sports, in water polo the goalkeeper is very often the first player that builds the offensive actions since most of the times these starts with his/her pass. Such characteristic has also been favoured by the last water polo rules' update (FINA in 2019), which has allowed the goalkeeper to pass beyond and touch the ball past the halfway mark, increasing his possibility to perform OB and SS other than common NB. The highest values for VP and PS indexes showed by perimetral players could be affected by minutes of play. In our analysis the playing time covariate could have influenced the differences registered between playing positions, especially for the higher minutes of play per match registered by perimetral players, compared to center positions (i.e., CD and CF) as showed in other studies (Melchiorri et al., 2020; Perazzetti et al., 2023[a]). Also, in literature the perimetral players showed to be more involved in all offensive phases of play (number of counterattacks, even situation and power-play) (Lupo et al. 2011). Consequently, perimetral players' characteristics could explain the highest value of VP and PS for this playing position, identifying perimetral players players as the most important role for the management of the ball possession in water polo, while center defenders and center forwards could be considered as the main playing positions involved in fighting and wrestling situations with the opponents (Botonis et al., 2019[a]). In fact, usually center defenders perform more duel actions before to perform the offensive phase. In fact, as demostrated by Özkol et al. (2013), the high number of defensive activities of the center defenders limit their possibility to support at their best the teammates' offensive phase. For instance, in our study the center defenders conquered the 30% of the total CB of the team, demonstrating a more defensive approach to the match activities compared to the other playing positions. On the other hand, the center forward has very often to duel in a dyadic relationship with his/her direct

opponent to get the best position on the field to receive the ball, also considering the position of other opponents and teammates. The specific role of center foraward is more inclined to the finalization of the offensive phase than the construction of the play (Lupo et al. 2012[b]). In fact, as showed by Lupo et al. (2007), in elite men's water polo matches (n= 11), this role determined the majority of exclusions fault achieved (around 68%), which in turn lead power-play actions strategies often ended with a goal (around 51%). This fact is in line with our study which indicate how most of the gained exclusion handling the ball (48.1%) were gained by center forwards.
The k-means cluster analysis of this study, applied on pooled data (all players performances in 19 matches) identified three groups of players according to their values of VP and PS. According to the classification suggested by Nadeau et al. (2008), in our study the three groups have been named as 'dominant players' (n= 2), 'good players' (n= 5) and 'less decisive players' (n= 8) in relation to their ability to manage ball possession in the offensive actions. Interpreting this classification, the group of 'dominant player' was determined by two perimetral players, which coincided with the captain of the team (player 5) and the most expertise player of the team (player 8). In the 'good players' group (n= 5) four players were perimetral, while only one was a center defender. In the 'less decisive players' group the analysis identified two center defenders, two center forwards, two goalkeepers and two more perimetral players. In particular, the latter registered less total playing time than the other teammates in the same role (table 22).

6.3.5 Conclusion

This study, based on the observation of all matches of an elite team participating to the 2021-22 Italian Serie A1 men water polo championship, has provided a technical and tactical analysis of offensive actions investigated in relation to the influence of different contextual factors (season phase, match location and final score difference), can be considered an original and useful contribute to a better understanding of water polo match performance. In sum, the result of this research enables the discrimination of performance levels among all players in a match environment as far as their offensive abilities and ball skills whether it is for talent identification, for selecting players or for performance assessment purposes. The current study is limited to one elite men senior team, therefore future research using the TSAP instrument could involve a higher number of water polo team and players and include and analysis of the zone of the field, which were not considered in this study.
Moreover, the TSAP instrument considers only the offensive behaviour of the team, while defence activities are not considered. For this reason, it could be interesting to compare players' TSAP with some defence indexes. In fact, according to a common opinion of most water polo elite head coaches the defensive phase could be more determinant than the offensive one, also in relation to the selection and engagement of young talent players (Perazzetti et al., 2023[c]). According to the present TSAP analysis of water polo players, coaches could plan training sessions considering specific technical and tactical aspects for elite men's water polo teams. Specifically, the use of the TSAP also to regularly monitor training sessions (i.e. during small-sided games) could be an important task for new useful ways of players' monitoring.

6.4 STUDY #4 - Perazzetti, A., Dopsaj, M., Sansone, P., Mandorino, M., & Tessitore, A. (2023). Effects of Playing Position and Contextual Factors on Internal Match Loads, Post-Match Recovery and Well-Being Responses of Elite Male Water Polo Players. Journal of Functional Morphology and Kinesiology, 8(1), 12. https://doi.org/10.3390/jfmk8010012

6.4.1 Introduction

Water polo is an intermittent, high-intensity, body-contact aquatic team sport. Since the end of the nineteenth century, its five historical developmental stages (Hraste et al., 2013) have seen several changes of the play's rules, with an incessant increase in game demands (Botonis et al., 2019[a]). Consequently, water polo players are required to have higher conditioning levels and more advanced technical and tactical skills. The intermittent nature of the game requires the concurrent contribution of anaerobic and aerobic energy metabolism (Botonis et al., 2018). The former supports the high-intensity and short-duration activity, while the latter sustains the low to moderate intensity of longer actions (Smith, 1998; Ruano et al., 2016).

Previous studies on water polo's game demands have shown that two thirds of the playing time is spent above 85% of the peak heart rate (HRpeak), which (approximately) corresponds to the lactate threshold intensity (Pinnington et al., 1988). Therefore, performing high-intensity activities with short recovery periods is crucial, and high strength and power levels are prerequisites for high-standard players (Smith, 1998; Platanou & Geladas, 2006; Barrenetxea-Garcia et al., 2022). Moreover, the current high-level competition system requires water polo players to perform multiple demanding training sessions and games throughout the season, from the high-competitive friendly matches of the pre-season to the official ones of the in-season (Botonis et al., 2019[b]). For this reason, it is essential to carefully manage the players' training and competition loads, allowing the necessary recovery to optimize performance and avoid injury and illness (Halson, 2014; Thorpe et al., 2015; Mandorino et al., 2022[a]).

Monitoring players' training loads, recovery and well-being is becoming a common practice in high-level water polo (Barrenetxea-Garcia et al., 2022). A strategic priority for successful coaching (i.e., focused on optimal training) is to monitor players' psychophysiological internal load responses to cope with the demands elicited by the external loads in both training and competitions (Impellizzeri et al., 2004; Dijkstra et al., 2014; Bourdon et al., 2017), during the different phases of the season (Botonis et al., 2019[b]**)**.

According to the relevant literature, there is not a single or gold standard method to measure the external and internal loads (Impellizzeri et al., 2019). Although the importance of using other subjective measures cannot be underestimated, one of the most used methods to assess the internal load is through the rating of perceived exertion (RPE) (Halson, 2014; Foster et al., 2021). Based on the RPE measure, Foster et al. (1998) developed the session-RPE method, which considers the intensity and duration of the training/competition sessions to calculate the training and competition loads (Foster et al., 2001). Over the years, this method has been validated to monitor the load of different training modalities (technical, tactical, endurance, speed and strength) across multiple sports, during one or more sessions or week(s) (Day et al., 2004; Haddad et al., 2017), including water polo (Lupo et al., 2014[a]; Botonis et al., 2019[b]). In particular, the study by Lupo et al. (2014[a]) that compared the Edwards' heart-rate-based method and the session-RPE method to assess the players' internal load during trainings of a U17 team competing at national level, showed that the s-RPE was a reliable method to evaluate the internal training load (ITL) in youth water polo. The study by Botonis et al. (2019[b]) used the s-RPE method to assess the ITL during two short-duration (2 weeks each) training periods (overloaded vs. reduced training) of a Greek First League water polo team. However, there is a lack of studies to monitor and assess the ITL after the official matches of a First League water polo team during an entire water polo season.

Alongside training load, it is essential to control and optimize players' recovery status to design appropriate training plans that finally leads to positive training adaptations (Brink et al., 2010; Sansone et al., 2020[b]). In this regard, Kenttä and Hassmén (1998) introduced the use of the Total Quality Recovery Scale (TQR), like the ordinary Borg 6-20 RPE scale, which allows the evaluation of a player's recovery

status. Successively, Laurent et al. (2011) introduced a Perceived Recovery Scale based on a 0–10 scalar representation of the individual's level of perceived recovery. Currently, players' recovery in water polo has been investigated only regarding nutritional strategies, ergogenic supplementation and heart rate variability, while there is limited research that uses the Perceived Recovery scale (Barrenetxea-Garcia et al., 2022). Moreover, to the authors' knowledge, there are no studies that investigate the players' perceived recovery after the match during an entire elite water polo season.
Another perceptual wellness measure that has grown in popularity, has been introduced by Hooper et al. (1995). This questionnaire rates the well-being considering indexes of fatigue, stress levels, delayed onset muscle soreness (DOMS) and sleep quality/disorders. The Hooper questionnaire has been widely implemented by team sport researchers, with significant associations found between training loads and the Hooper Index (HI) (Moalla et al., 2016; Clemente et al., 2019). Previous studies on water polo (Botonis et al., 2019[b]), with the addition of the mood measure, showed that players' overall wellness scores were highly correlated to their in- ternal training loads during a training tapering phase before a competition. Altogether, the HI appears sensitive to changes in training loads, and is therefore a potentially useful monitoring tool; however, it has been scarcely implemented in water polo research.
In a team sport invasion game (e.g., water polo), in addition to the physical, technical and mental level of preparedness, the players' match load can be influenced by some contextual factors, and interaction has been progressively studied in recent years (Rago et al., 2021). These factors include both variables related to the game schedule, such as game frequency and game location (home or away), and variables related to the level of opposition between the two teams, such as match outcome, match status and scoreline. Moreover, sport enjoyment has been defined as 'a positive affective response to the sport experience that reflects feelings and/or perceptions such as pleasure, liking, and experienced fun' (Scanlan et al., 1989).
To the authors' knowledge, there is still limited information about how playing positions and contextual factors impact on the players' internal match load, perceived recovery and well-being during an entire water polo season. Therefore, the aim of this study was to investigate the independent effects of the playing position and match-specific contextual factors on the internal match load, the post-match status of perceived recovery and the well-being of players after official elite water polo matches.

6.4.2 Materials and methods

6.4.2.1 The research sample

Seventeen male water polo players (mean ± SD, age= 25.9 ± 6.2 years; height= 185.8 ± 8.3 cm; body mass= 87.6 ± 9.9 kg; total playing experience= 15.1 ± 5.4 years; experience in first teams= 9.1 ± 6.1 years; experience in first division= >5 years), belonging to the first team roster of the 'S.S. Lazio Nuoto' club, which competed in the Italian First League water polo championship (Serie A1), participated in this study. Before the commencement of data collection, all subjects signed a written informed consent form, and the study design was approved by the local research ethics committee of the University of Rome 'Foro Italico' (CAR 99/2021). To classify their activity level and athletic ability, all players were classified as tier 3 'Highly Trained/National Level', according to the 'Participant Classification Framework' of McKay et al. (McKay et al., 2022). All subjects regularly engaged in training and competitions during the season and were classified according to their principal playing position (Dopsaj & Aleksandrovic, 2009): perimetral (or peripheral) players (n= 10); center defenders (n= 3); center forwards (n= 2) and goalkeepers (n= 2).
Furthermore, the following subject inclusion criteria were used for the final analysis:
(a) only data from players employed for at least the mean total duration of a quarter (15 min) of playing time in a match were considered; (b) not presenting any injury or illness that could impair player's performance; and (c) the goalkeepers were excluded from the sample.

6.4.2.2 Measurement methods

This study used an observational longitudinal design to monitor and assess the perception of internal match loads, perceived recovery and well-being in male elite water polo players during 19 official matches (regular phase, n= 13; play-out phase, n= 6) of the 2021-22 water polo season. During these competitive weeks, the team carried out the following weekly microcycle: 3 team-based water polo sessions (250 ± 47 min per week) focused on technical skills and game-based conditioning; 2 physical training sessions (139 ± 30 min per week and 3842 ± 905 m of conventional swim per week, and 133 ± 27 min per week of resistance training in the gym); 2 friendly matches (142 ± 68 min per week); 1 official match (53 ± 3.5 min per match) and 1 day of rest.

To calculate the match internal load through the s-RPE method (Foster et al., 2001; Foster et al., 1996), players' RPE values were obtained by means of the Italian translation of the Borg category-ratio 10 scale (CR-10) (Borg et al., 1987), modified by Foster et al. (1998), asking each player 'How intense was your session?' at the end of each official match. Then, players' perceived recovery and well-being were collected 36 h post-match by means of the Perceived Recovery Scale (PRS) (Laurent et al., 2011) and Hooper Index (HI) questionnaire (Hooper et al., 1995), respectively, before the beginning of the first weekly training session (Duarte et al., 2019). To avoid potential differences in individual recovery conditions, players were asked to abstain from recovery interventions and invited to maintain their usual lifestyle for the 36 h prior to the monitoring of PRS and HI.

Then, players' internal match load, perceived recovery and well-being were analysed in relation to the following contextual factors: (a) playing time, defined as the player's total minutes of play in each official match, which also included the player exclusion during a 'man-down' situation; (b) match outcome, defined as the team's winning, drawing and losing result at the end of the match; (c) final score difference, defined as the difference of goals scored between the two teams in a match (balanced= 3 goals vs. unbalanced= >3 goals) (Lupo et al., 2012[a]); (d) match location (home or away); (e) travel duration, measured in minutes of travel for each match played away; (f) number of goals scored and goals conceded by the observed team in each match; and (g) season phase: based on the Italian water polo First League, which divided the 2021-22 championship schedule into regular season (n= 13 matches) and play-out (n = 6 matches).

Regarding the anthropometric features, players' stature was measured using a SECA 213 Stadiometer (measuring range 20–205 cm, SECA, Hamburg, Germany), while body mass was obtained using a Tanita SECA 762 (measuring range 0–150 kg, SECA, Hamburg, Germany) to assess the players' BMI. Age, years of experience and playing role were also registered.

Players' RPE values were collected about 30 min after the end of the match. To avoid potential interferences of the post-match environment and synchronize the timing of their answers, players were familiarized to use a phone-based online application (proved to be a valid tool in elite sport (Menaspà et al., 2018)), by answering the RPE scale using a customized google forms (www.docs.google.com/forms accessed on 12 September 2021) questionnaire to replicate the printed scale content and formatting, which was sent via WhatsApp on their personal smartphone. The internal match load was then calculated with the s-RPE method (Foster et al., 2001) by multiplying the players' perceived exertion values by the time (in minutes) played into the match. The s-RPE values are expressed in arbitrary units (a.u.). This method has been shown to be a valid method for monitoring water polo players (Lupo et al., 2014[a]; (Botonis et al., 2019[b]).

To individually assess perceived recovery and well-being status, players reported their answers to the same researcher after seeing and filling printed scales every Monday morning prior to the training session. The perceived recovery was assessed using a modified version of the TQR scale (Mackinnon et al., 1996) by means of a 10-point Perceived Recovery Scale (Laurent et al., 2011), ranging from 0 ('very poorly recovered/Extremely tired') to 10 ('Very well recorded/Highly energetic'), which has already been used in team sports (Gjaka et al., 2016; Mandorino et al., 2022[b]) and has shown itself to be a valid tool for water polo (Barrenetxea-Garcia et al., 2022). The players' well-being was monitored through the Hooper Index (Hooper et al., 1995), by means of a 7-point Likert scale for the four Hooper Scale categories; (i) stress; (ii) fatigue; (iii) muscle soreness (DOMS); and (iv) sleep. The subset Likert scales ranged from 1 ('very, very low') to 7 ('very, very high') for stress, fatigue and DOMS, and from 1 ('very, very bad') to 7 ('very, very good') for sleep, respectively. Then, the overall Hooper Index of well-being was provided by summating the four subjective ratings. Finally, the water polo players rated their overall enjoyment of the match activity on a 7-point Likert scale (1= not at all, 7= extremely enjoyed).

Before the commencement of the study, during the first three weeks of pre-season, all players were familiarized with RPE, PRS, HI and enjoyment scales. To individually create awareness of the possible responses, each player received a printed copy of the different questionnaires and was instructed to read and interpret the scales before and after each training session and friendly match.

6.4.2.3 Statistical analysis

Three separate mixed linear models for repeated measures (matches) were performed to evaluate the single main effects of contextual factors on three dependent variables: s-RPE, PRS and HI. The factors included in the three mixed linear models are presented in table 23. The player was included as a random factor (Sansone et al., 2021). Assumption of normality for the variables included in the models was evaluated by residuals plots, which were normally distributed (Sansone et al., 2023). A second mixed linear model was conducted for interaction effects for each dependent variable, considering only those factors that showed a significant main effect in the first model. Statistical analyses were performed using SPSS version 26.0 (IBM, Chicago, IL, USA). For each variable, descriptive data are expressed as mean ± SD. Significance was set at $p<0.05$. Results of the main effect analysis are reported as F and p values, while the estimate value is reported for the statistically significant factors. Post-hoc pairwise comparisons were assessed using the Bonferroni test. Effect sizes (ES) for pairwise comparisons were calculated using Cohen's d, with the following interpretation: 0.2, trivial; 0.2–0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; and 2.0, very large (Hopkins et al., 2009). Results of the pairwise comparisons are described in mean standard error (SE), p-value, mean difference, and ES.

Table 23. Factors included in the main effect analysis

s-RPE	PRS	HI
Playing position	Playing position	Playing position
Playing time	Playing time	Playing time
Season phase	Season phase	Season phase
Match location	Match location	Match location
Match outcome	Match outcome	Match outcome
Final score difference	Final score difference	Final score difference
Travel duration	Travel duration	Travel duration
Goals scored	Goals scored	Goals scored
Goals conceded	Goals conceded	Goals conceded
	RPE	RPE
	Enjoyment	Enjoyment

6.4.3 Results

Descriptive data (mean ± SD) of s-RPE, PRS and HI are presented in table 24.

During the study period, the team played 19 official matches, scoring an average of 8 ± 3 goals and conceding 14 ± 5 goals per match, while a total of 22 ± 4 goals were scored by the two teams per match. Moreover, during the season the team played 9 away matches, with an average travel duration of 218 ± 125 minutes. Regarding perceptual responses, the mean value of each variable was: RPE= 7.3 ± 0.6 a.u.;

enjoyment= 3.8 ± 1.1 a.u.; sleep quality= 3.5 ± 0.4 a.u.; stress= 4.1 ± 0.5 a.u.; Figure 25 shows the trends of RPE, PRS and HI scores across the season.

Table 24. Descriptive data (mean ± SD) of the contextual factors

Contextual factors	s-RPE (a.u.)	PRS (a.u.)	HI (a.u.)
Playing position			
perimetral players (n=10)	296.2 ± 102.7	5.5 ± 1.8	16.1 ± 3.7
center defenders (n=3)	187.6 ± 62.2	6.3 ± 1.4	14.8 ± 3.3
center forwards (n=2)	175.9 ± 72.4	6.4 ± 1.4	12.9 ± 2.7
goalkeepers* (n=2)	293.1 ± 143.4	6.4 ± 2.1	20.2 ± 2.6
Season phase			
all-season (n=19)	246.4 ± 104.9	5.9 ± 1.7	15.2 ± 3.6
regular season (n=13)	246.8 ± 103.4	5.9 ± 1.6	15.5 ± 3.7
play-out (n=6)	245.8 ± 108.4	5.9 ± 1.7	14.55 ± 3.5
Match location			
home (n=10)	257.4 ± 113.1	5.8 ± 1.7	15.4 ± 3.9
away (n=9)	232.3 ± 92	6.1 ± 1.6	14.7 ± 1.6
Match outcome			
win (n=2)	264.1 ± 120.4	5.9 ± 2.2	15.5 ± 3.7
draw (n=2)	258.6 ± 118.6	5.6 ± 1.1	14.5 ± 3.8
loss (n=15)	242.6 ± 101.4	6 ± 1.7	15.2 ± 3.6
Final score difference			
balanced (n=10)	261.1 ± 117.8	6 ± 1.7	15.3 ± 3.7
unbalanced (n=9)	231.1 ± 3.5	5.9 ± 1.6	15 ± 3.5

*Goalkeepers were only included in the descriptive statistic of playing position.

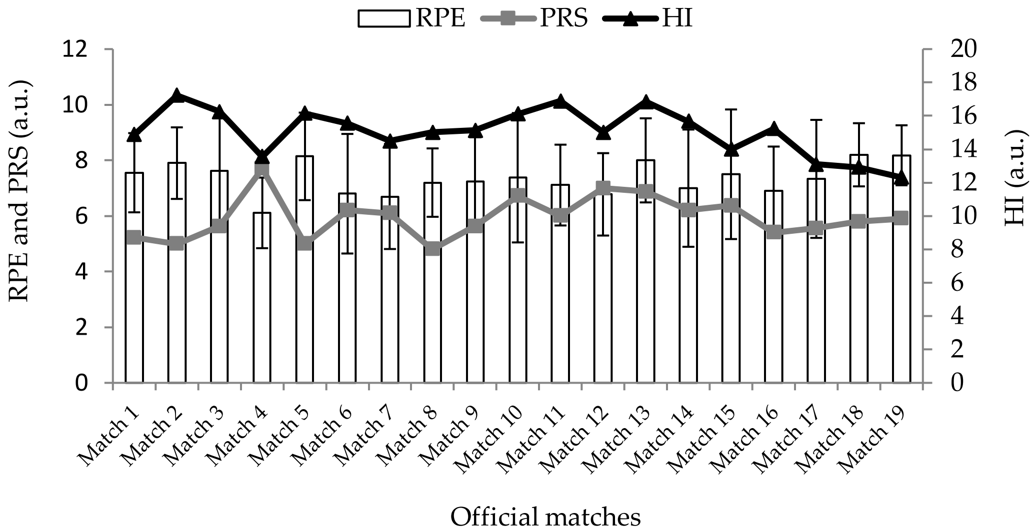


Figure 25. Trends of RPE, PRS and HI scores across the season; *Note.* RPE= Rating of Perceived Exertion; PRS: Perceived recovery scale; HI: Hooper index

Table 25 presents the significant main effects found. For s-RPE, the pairwise comparisons showed significative effects in match outcomes ($p \leq 0.05$), showing that drawn matches led to higher s-RPE (mean SE= 277 ± 17.6 a.u.) than won matches (237.3 ± 20.6 a.u.) (mean difference= 39.7 ± 12.4 a.u.; p= 0.015; ES= 1.46, large). A significant effect of travel duration was found on s-RPE (estimate= -0.148), demonstrating how longer travel duration decreased the s-RPE value. For playing time (estimate= 9.328), it was shown that higher playing times led to higher s-RPE scores, while the higher number of goals scored (estimate= -3.598) led to a lower s-RPE score. No significant effect was found for playing position, season phase, match location, final score difference or goals conceded. Regarding PRS, a significative main effect was found for the final score difference ($p \leq 0.05$), with pairwise analysis showing that PRS was higher after balanced matches (mean ± SE= 6.8 ± 0.3 a.u.) compared to unbalanced matches (5.1 ± 0.4) (mean ± difference= 1.669 ± 0.362; $p < 0.001$, ES= 1.57, large). Significant effects for PRS were also found for playing time (estimate= -0.041), for goals scored (estimate= -0.180) and for perceived enjoyment (estimate= -0.114), showing that higher levels of these factors decreased PRS scores. Differently, goals conceded (estimate= 0.138) had a positive impact on PRS. In this case, no significant effects were found for playing position, season phase, match location, match outcome, travel duration and RPE. For HI, significant effects were found for the season phase and match outcome (all $p \leq 0.05$). Specifically, post-hoc pairwise comparisons demonstrated higher scores of HI in the regular season (mean ± SE= 15.6 ± 0.9 a.u.) compared to the play-out phase (13.5 ± 0.8 a.u.) (mean difference= 2.1 ± 0.5 a.u.; $p < 0.001$, ES = 0.78, moderate), as well as in won matches (mean ± SE= 16.1 ± 1.1 a.u.) compared to lost matches (13.9 ± 0.8 a.u.) (mean difference= 2.3 ± 0.9 a.u.; p= 0.049, ES = 0.90, moderate), and won matches in comparison with drawn matches (13.6 ± 1 a.u.) (mean difference= 2.5 ± 0.8 a.u.; p= 0.009, ES= 1.68, large), respectively. Furthermore, significant effects for HI were found for RPE (estimate= 0.266), showing that a higher value of match RPE led to a higher HI score at the beginning of the week. No significant effects were found for playing position, match location, final score difference, travel duration, playing time, goals scored, goals conceded and perceived enjoyment.

Table 25. Results of the main effect analysis*

s-RPE	F	p	PRS	F	p	HI	F	p
playing position	.106	.900	playing position	.185	.833	playing position	.781	.480
playing time	1173.321	**< .001**	playing time	16.702	**.001**	playing time	.582	.449
season phase	.146	.706	season phase	.016	.898	season phase	16.673	**< .001**
match location	3.424	.076	match location	.217	.645	match location	.439	.515
match outcome	7.176	**.003**	match outcome	.428	.656	match outcome	5.447	**.008**
final score difference	1.147	.290	final score difference	21.258	**< .001**	final score difference	3.849	.059
travel duration	13.873	**< .001**	travel duration	.001	.975	travel duration	1.148	.313
goals scored	4.145	**.050**	goals scored	9.920	**.003**	goals scored	3.879	.054
goals conceded	.246	.622	goals conceded	15.263	**< .001**	goals conceded	.007	.934
			RPE	4.181	.055	RPE	5.225	**.026**
			enjoyment	6.670	**.016**	enjoyment	3.086	.083

*Significant effects in bold

Regarding the interaction effects, no interactions were found for s-RPE, while PRS was influenced by the combination of playing time and final score difference (F= 11.686; p< 0.001; balanced, estimate= -0.106; unbalanced, estimate= -0.098), and by the playing time and perceived enjoyment (F = 7.980; p = 0.006; estimate= 0.017). The first interaction had a negative impact on the PRS, decreasing the value of this variable in both conditions of the final score difference. On the contrary, the second interaction showed that higher playing time in combination with higher perceived enjoyment led to a higher value of PRS. Regarding HI, one interaction was found, namely between season phase and RPE (F= 5.519; p= 0.024; regular season, estimate= -0.055; play-out, estimate= -0.668), suggesting that these factors decreased the value of HI score, especially in the play-out season.

6.4.4 Discussion

This study is the first to monitor First League water polo players after official matches during an entire water polo season (regular and play-out phases), to investigate the independent effects of the playing position and match-specific contextual factors on the perceived internal match load, post-match perceived recovery status and players' well-being.

The first analysis of this study concerned the potential influence of the playing position, playing time, match outcome, final score difference, travel duration, match location, goals scored, and goals conceded on match s-RPE. Among these factors, the results showed that only the playing time, match outcome, goals scored, and travel duration played a significant role on the players' match s-RPE.

Previous studies on water polo showed significant differences in the players' physical fitness levels and match external loads (Dopsaj & Aleksandrovic, 2009; Lozovina et al., 2009; Lupo et al., 2012[b]; Kondrič et al., 2012; Botonis et al., 2018) in relation to their different playing roles. Although not significant, our study confirmed this trend for the s-RPE, with higher mean s-RPE values experienced by perimetral players compared to center defenders and center forwards. Such differences can be explained by the different technical and tactical tasks performed by each water polo role, with perimetral players covering a higher total swim distance than center forwards (Melchiorri et al., 2010[a]) and engaging in longer and more frequent high-intensity swimming than center-defenders (Platanou, 2004; Tan et al., 2009). In fact, compared to center positions (defenders and forwards), the perimetral players are more involved in both defensive and offensive phases of play (e.g., number of counterattacks), which require repeated high-intensity swimming to quickly move between the two sides (i.e., defensive and offensive) of the field (Meckel et al., 2013). This condition could explain why we have higher match s-RPE trend for this playing position.

Regarding the effect of playing time on players' s-RPE, our data showed a significant effect for playing time. Although both the playing time (in minutes) and RPE value contributed to the arbitrary unit amount of the s-RPE (i.e., minutes RPE), the effect of playing time can be explained by the fact that there were between-role differences, with perimetral players registering the highest amount of total playing time compared to the other roles.

Another contextual factor analysed in our study has been the match outcome, which showed a significant effect on players' s-RPE, with higher mean values registered after drawn matches compared to won and lost ones. Although it could be expected to register higher values as a consequence of a lost match, during the season the team lost 15 matches. In this regard, Oliveira et al. (2012) warn that in team sports matches where the opposition of the two teams is unbalanced since the first quarter of the match (Ruano et al., 2016), the intensity of the dispute could lose significance and even determine a lower perception of fatigue. In fact, during drawn matches, both teams remain potential winners until the end of the match, requiring a greater effort from the players in the attempt to subvert the result until the last moment. This explanation might also explain our findings for the scored and conceded goals. In fact, to maintain a balanced status until the end of the match, a team should provide the maximal effort to score goals, while conceding the minimum ones (Lupo et al., 2016). In this regard, our findings showed that a higher number of goals scored led to a higher match s-RPE, while the goals conceded did not influence the match internal load of our subjects. This could be explained by the fact that in our study, the team registered an unbalanced final score (e.g., conceding a lot of goals) in two/thirds of the monitored matches.

In team sports, the game location has been identified as influencing the performance (Sampaio et al., 2008). In water polo, although the exact causes are still not clear, Ruano et al. (2016) demonstrated that the match location influenced the match outcome, with negative effects on the teams playing away. In our study, this contextual factor did not influence the players' s-RPE, while the travel duration showed to be significant. However, contrarily to what could be expected, our data showed that the longer the travel duration, the lower the players' s-RPE. Once again, as we stated above, an explanation of this contradictory result regards the intensity of the two teams in opposition in the match. In fact, of the nine matches played away, our team lost eight matches, most of which after a longer travel (291 ± 95 min), with an unbalanced final score difference and a higher number of goals conceded, which could have determined an even lower perception of fatigue due to this lower 'duel' intensity.

The other main aims of this study concerned the players' perceived recovery and well-being statuses, and to investigate how these two dependent variables were influenced by match contextual factors and demands. Among these factors, the results showed that the players' post-match recovery was influenced by the final score difference, playing time, perceived enjoyment, goals scored, goals conceded, season phase, match outcome and match RPE.

The analysis of s-RPE showed a significant effect only on the match outcome, while the final score difference did not show a significant influence. However, the latter had a significant effect on players' perceptions of recovery 36 h post-match, showing higher PRS mean values registered after balanced matches compared to unbalanced ones. This result could be explained by the fact that our players considered balanced matches more gratifying than the unbalanced ones, which might have had an impact on their mood and/or enjoyment (Sansone et al., 2020[a]). Such consideration can be further supported by the higher values of players' perceived level of enjoyment, which registered higher values after balanced matches (a.u.= 4.2 ± 1.4) compared to unbalanced ones (a.u.= 3.2 ± 1.3). Investigating the technical and tactical aspects of elite water polo matches in relation to margins of victory, Lupo et al. (2012[a]) showed that in balanced matches, a higher number of opponent's exclusions fouls performed led to more power-play actions, which might contribute to bestowing greater match enjoyment in players.

The players’ level of perceived recovery has also been influenced by their amount of time spent in the water during the match, with a higher playing time corresponding to lower perceived recovery scores (the higher the volume of play, the lower the quality of recovery). Additionally, this result could have been expected by the fact that, although not significant, the RPE showed a trend for a negative effect (estimate= −0.114, p= 0.055). Our findings are in line with previous water polo research, showing how reducing training load by 30% led to significant improvements in perceived recovery status (Botonis et al., 2021). Therefore, our study poses the focus on the fact that in a standard microcycle, the status of perceived recovery at the beginning of the week is strongly influenced by the last competition (Botonis et al., 2022). Moreover, proving that some contextual factors are intertwined, we observed that increasing the number of team goals scored corresponded to a lower score of perceived recovery, which is in line with the higher s-RPE values registered for this parameter. On the contrary, in line with our previous statement that the goals conceded did not influence the match internal load, after matches lost with a higher number of conceded goals our players registered a higher score of perceived recovery. Although, this aspect might appear as a contradiction, a technical explanation of this fact is that a clear, unbalanced level between the two opponent teams (which could be related with a high number of goals conceded) leads to a lower frequency of consecutive actions, a higher number of breaks after a goal and consequently, a more frequent use of player substitutions (Melchiorri et al., 2021). In fact, in water polo, there are several occasions when a game is stopped, which allows coaches and players to modify their strategy and tactical behaviour several times during the match (García-Ordóñez et al., 2017).
Moreover, the analysis of players’ well-being was also in line with the previous statements for s-RPE and perceived recovery. In fact, we found a general tendency (non-significant, p= 0.083) to observe higher perceived enjoyment values in relation to a lower HI total score (higher well-being). This fact can be confirmed by the higher HI scores observed during the regular season, when the team lost twelve matches and drew one (in thirteen matches), with the higher number of unbalanced matches.

6.4.5 Conclusion

This study has some limitations that warrant discussion. The RPE (then the derived s-RPE), PRS, HI and enjoyment were only monitored for official matches, while no data were collected during the weekly training sessions. Though we have summarized the team’s typical weekly microcycle, a more detailed external loads monitoring that also includes a time–motion analysis of game-based conditioning and small-sided games, could improve the results interpretation. Based on these limitations, future studies could investigate the correlation between the variables used in this work with weekly external loads data. Furthermore, we did not consider the occurrence of technical and tactical events, which also determine the frequency of players’ direct involvement with the play and could influence both the players’ fatigue and enjoyment. For this reason, in further studies, both the time–motion and notational analysis data could be additionally collected.
Although this study has limitations, it has provided a new strategy to monitor water polo players since, as far as the authors’ knowledge, this is the first work investigating the effects of different contextual factors on s-RPE, PRS and HI values during an entire competitive season in elite water polo. In fact, the findings of this study show the importance of monitoring the s-RPE, post-match recovery and well-being status of water polo players on a weekly basis. In particular, the monitoring of the players’ perceived psychophysiological status during the ‘critical’ days of transition between the last match (i.e., last day of the previous microcycle) and the first training session (i.e., first day of the new microcycle) could help coaching staff to organize accurate and tailored training sessions according to the contextual factors and the overall status perceived by their players.
However, the findings of our study also show that perceived internal load, recovery, and well-being should not be used interchangeably. For this reason, as a practical strategy, the coaching staff are advised to monitor all these parameters since specific contextual factors could determine different responses. In fact, in a match, the intensity of the ‘dispute’ (opposition) between two teams, can mediate the RPE (and then

the s-RPE). For instance, as demonstrated in our study, losing a match with a larger final score difference (unbalanced) determined a lower s-RPE compared to matches that were more balanced (e.g., drawn matches).

6.4.6 Appendix B

Table 26. RPE Borg's scale modified version (Foster et al., 2001)

Rating of Perceived Exertion Scale (RPE)			
English (original)		Italian (translated)	
0	Rest	0	Nessuno sforzo
1	Very, very easy	1	Estremamente leggero
2	Easy	2	Leggero
3	Moderate	3	Moderatamente intenso
4	Somewhat hard	4	Piuttosto intenso
5	Hard	5	Intenso
6	-	6	-
7	Very hard	7	Molto intenso
8	-	8	-
9	-	9	-
10	Maximal	10	Massimale

Table 27. Enjoyment 7-point Likert scale (Stanley & Cumming, 2010)

Enjoyment Scale			
English (original)		Italian (translated)	
1	Not at all	1	Nessun divertimento
2	Very little	2	Molto poco
3	Slightly	3	Leggermente
4	Moderately	4	Moderatamente
5	Quite a bit	5	Un bel pò
6	Very much	6	Molto
7	Extremely	7	Estremamente divertito

Table 28. Recovery scale modified version (Gjaka et al., 2016)

Perceived Recovery Questionnaire (PRS)			
English (original)		Italian (translated)	
0	-	0	Nessun recupero
1	Very, very poor recovery	1	Recupero estremamente basso
2	Very poor recovery	2	Recupero basso
3	Poor recovery	3	Recupero moderato
4	Reasonable recovery	4	Recupero più che moderato
5	Good recovery	5	Recupero alto
6	-	6	-
7	Very good recovery	7	Recupero molto alto
8	-	8	-
9	-	9	-
10	Fully recovered	10	Recupero massimo

Table 29. Hooper Index (HI) scale (Hooper et al., 1995)

		Sleep quality	
	English (original)		Italian (translated)
1	Very, very good	1	Molto, molto buona
2	Very good	2	Molto buona
3	Good	3	Buona
4	Average	4	Nella media
5	Bad	5	Bassa
6	Very bad	6	Molto bassa
7	Very, very bad	7	Molto, molto bassa
		Stress	
	English (original)		Italian (translated)
1	Very, very low	1	Molto, molto basso
2	Very low	2	Molto basso
3	Low	3	Basso
4	Average	4	Nella media
5	High	5	Alto
6	Very high	6	Molto alto
7	Very, very high	7	Molto, molto alto
		Fatigue	
	English (original)		Italian (translated)
1	Very, very low	1	Molto, molto basso
2	Very low	2	Molto basso
3	Low	3	Basso
4	Average	4	Nella media
5	High	5	Alto
6	Very high	6	Molto alto
7	Very, very high	7	Molto, molto alto
		Muscle soreness	
	English (original)		Italian (translated)
1	Very, very low	1	Molto, molto basso
2	Very low	2	Molto basso
3	Low	3	Basso
4	Average	4	Nella media
5	High	5	Alto
6	Very high	6	Molto alto
7	Very, very high	7	Molto, molto alto

7. DISCUSSION

The main aims of this PhD dissertation were: to investigate the coaching philosophy and methodologies of water polo head coaches belonging to different national schools; to provide a specific methodology for technical and tactical analyses of elite water polo players by means of a specific notational analysis tool (TSAP); to monitor players' match loads, recovery and well-being status during an entire elite water polo season. These aims were achieved in four separate studies investigating five hypotheses.

In relation to the general hypothesis, the following discussion can be drawn:

H_G - A multidimensional approach based on the understanding of the coaches' national coaching philosophy, integrated by the assessment of the individual and collective tactical skills, as well as the monitoring of players' workload and recovery status, can positively affect the coaching staff's analysis and interpretation of water polo performance.

Overall, the research of this PhD dissertation has confirmed all the formulated hypotheses and provided a non-invasive, practical, ecological, and reasonably priced strategies to enhance coaching philosophies and training approaches for coaches and water polo strength and conditioning coaches.

In relation to each supporting hypothesis, the following discussions can be drawn:

H_1 – (Study #1) The adherence to a national water polo schools will show differences in coaching philosophies and professional backgrounds among coaches belonging to different national water polo schools.

Creating the own coaching philosophy is a crucial part of the coaching profession because it offers a set of guiding principles for decision-making that can solve real-world issues and promote consistency in coaching (Lyle, 2002; Cassidy et al., 2009). The own coaching philosophy evolves along the coach's career influenced by the coach's professional experiences, having an impact on his/her and work.
Investigating on this hypothesis, the main significant difference found between the three national schools (Greece, Serbia and Italy) has been the number of youth players in the first team roster coming from the youth department of the same club. Indeed, six Serbian head coaches indicated having more than 15 players from the youth teams in their current first team rosters, which was a relevant number respect to the other two national schools. This aspect could speculate that Serbian teams are more inclined to link youth and senior activities to facilitate the debut of young talent players in senior team compared to Greek and Italian teams. However, while most of the Serbian and Greek head coaches have indicated a specific age to which a young talented player is ready to train and play with the first team, most of the Italian head coaches have generically answered 'to wait until the young player is ready'.
Regarding the professional backgrounds of head coaches, since a 37.5% of the pooled sample stated that having attended the federation water polo courses has been fundamental to driving their coaching skills, our study confirmed the importance to promote programs of continued education for coaches and to focus on proper planning of these courses (Ciampolini et al., 2020).
In this area of investigation, the main difference between the three national water polo schools has been found by the profession of head coach. In fact, the majority of Serbian (93%) and Greek (67%) head coaches indicated the profession of water polo head coach as their main job, while in Italy this percentage drops to a lower threshold (30%).

H_2 – (Study #1) Coaches' training organization and competition management are influenced by their own national water polo school.

According to the role of the match analyst, which is an emergent professional figure that helps to produce and interpret technical and tactical indexes for both their own and opponent teams (Takagi et al., 2005; Casanova, et al., 2020; Ordóñez, Pérez, & González, 2016; Perazzetti & Tessitore, 2021) our study showed no significant differences between national schools, as well as for the figure of the fitness coach. In fact, only the 37.5% of total respondents declared to have in their staff the figure of match analyst, while 52.5% to have that of fitness coach.

In terms of technical staff composition, the main difference between national schools showed a higher plurality of professional figures by the Serbian water polo school where most of staffs have included also the figure of goalkeeper coach (Serbian school, n= 10, Greek school, n= 5, Italian school, n= 3), showing a higher professional approach for the training management of this important playing position. About the training organization, most Serbian teams are usual to plan three weekly training sessions in the gym, while most of the Italian and Greek teams showed to plan only two sessions.

Talking about competition management, in terms of team strategic schemes, significant differences were found in the power-play situation and even defensive phase. In this regard, the Greek school seems to be the one with fewer schemes of play than the other two schools, probably due to the creativity that usually characterizes Greek players, as could be seen in the style of play showed by the Greek youth national teams during the last youth international competitions.

H_3 – (Study #2) In youth water polo matches, the tactical analysis by means of the TSAP instrument will show significant differences in water polo teams' collective behaviours and decision making according to the zones of the fields and balanced/unbalanced final score difference of the match.

In this area of investigation, the differences found in our study between the four national teams in relation to the different zones of the field could be explained by the tactical knowledge and strategic decision of the coaches, and players' technical and tactical skills. In the 2019 World Junior Championships analysed in our study, the four national team coaches may have asked a different way to play NB and OB in relation to the gained position of their centre-forwards, and consequently according to the kind of defence adopted from each opponent teams. In fact, as suggested by Canossa et al. (2022), based on the new rules' changes occurred at international water polo level, a national team could adopt a more static or dynamic game that characterize its own playing style.

Therefore, these coaches' directions might have impacted on the distribution of the number of offensive passes in relation to the zones of the field influencing players' decision making and technical skills. In particular, the differences in OB and SS found between the four national teams could be explained by the presence or not of a left-hand player in the game.

H_4 – (Study #3) In elite water polo matches, the tactical analysis by means of the TSAP instrument will show significant differences according to the match location, balanced/unbalanced final score difference of the match, season phase, individual playing time and players' playing positions.

As demonstrated by Ruano et al. (2016) the match location affects the match outcome, with negative impact on the teams playing away. Our results confirm this trend for TSAP parameters, providing better values of TSAP parameters in matches played at home than away, even considering an unbalanced final score difference and stronger opponent teams. Indeed, apart the presence of an audience with local supporters and the missing of traveling, the higher influence on TSAP values in home matches can be explained by the fact that the home team plays in the same swimming-pool where has daily trained its system of play. Considering the entire season, our results showed higher mean values in balanced final score difference matches than in unbalanced ones for PS and SS, respectively. These results could also be explained in light of the higher percentage of goals scored in power play situation during balanced matches than in unbalanced ones (40% vs 29%, respectively). In fact, Lupo et al. (2012[a]) demonstrated

that during this kind of matches there is a higher occurrence of opponent's exclusion fouls to perform power-play actions that could report higher frequency of goals scored, while Medić et al. (2014) showed that scoring in situations of players' numerical superiority (power-play goals scored) is one of the main technical and tactical parameters to consider in balanced matches. The findings of Medić et al. (2014) are in line with our results which showed higher values (execept for LB, whose lower value still has a positive effect) for all TSAP parameters during the play-out phase (table 21), which is temporally played at the end of the season regular phase.
The effect of the covariate playing time influenced the difference between playing positions. In fact, the highest values of VP and PS were identified in P players. In fact, as demonstrated by Perazzetti et al. (2023[a]), investigating on elite water polo players, perimetral players register the highest amount of total playing time compared to the other playing positions, resulting to be more involved in all offensive phases of play (number of counterattacks, even situation and power-play) (Lupo et al. 2011).

H$_5$ – (Study #4) Significant differences in training loads, recovery and Hooper index responses will be found according to players' playing positions, minutes of play in competition, match location (home or away), balanced/unbalanced final score difference and season phase.

Although not significant, our study shows higher s-RPE values experienced by P players compared to CD and CF. Such differences can be explained by the different technical and tactical tasks performed by each water polo role, with perimetral players covering a higher total swim distance than CF (Melchiorri et al., 2010[a]) and engaging in longer and more frequent high-intensity swimming than CD (Tan et al., 2009; Platanou, 2004). Regarding the effect of playing time on players' s-RPE, our data showed a significant effect for playing time. Although both playing time (in minutes) and RPE value contributed to the arbitrary unit amount of the s-RPE (i.e., minutes x RPE), the effect of playing time can be explained the between-role differences, with perimetral players registering the highest amount of total playing time compared to the other roles.
The players' level of perceived recovery has also been influenced by their amount of time spent in the water during the match, with a higher playing time corresponding to lower perceived recovery scores (the higher the volume of play, the lower the quality of recovery). Moreover, the analysis of players' well-being was also in line with the previous statements for s-RPE and perceived recovery. In fact, we found a general tendency (p= 0.083) to observe higher perceived enjoyment values in relation to a lower HI total score (which means a higher players' well-being status). This fact can be confirmed by the higher HI scores observed during the regular season, when the observed team lost twelve matches and drew one (in thirteen matches), with the higher number of unbalanced final score difference matches.

8. CONCLUSIONS

In relation to the general hypothesis, the following conclusion can be drawn:

H$_G$ - A multidimensional approach based on the understanding of the coaches' national coaching philosophy, integrated by the assessment of the individual and collective tactical skills, as well as the monitoring of players' workload and recovery status, can positively affect the coaching staff's analysis and interpretation of water polo performance.

It can be concluded that it was fully accepted because it was established that the water polo national schools influence the coaching philosophies and training methodologies of head water polo coaches (Study #1), the TSAP provides a specific tool to assess tactical behaviour of players showing different values according to zones of the field (Study #2), playing positions and several contextual factors (Study #3) and the monitoring of players' workload provides an ecological tool to supervise the players activities during official water polo matches (Study #4).

In relation to each supporting hypothesis, the following conclusions can be drawn:

H_1 – The adherence to a national water polo schools will show differences in coaching philosophies and professional backgrounds among coaches belonging to different national water polo schools.

It can be concluded that it was fully accepted because it was established that head coaches from three different national schools showed different approaches according to the management of the team roster, the professional backgrounds, and the interpretation of their job (Study #1).

H_2 – Coaches' training organization and competition management are influenced by their own national water polo school.

It can be concluded that it was fully accepted because it was established that head coaches from three different national schools showed a different technical staff organization, different kind of ideas and number of schemes both in offensive and defensive game phases (Study #1).

H_3 – In youth water polo matches, the tactical analysis by means of the TSAP instrument will show significant differences in water polo teams' collective behaviours and decision making according to the zones of the fields and balanced/unbalanced final score difference of the match.

It can be concluded that it was fully accepted because it was established the TSAP parameters and indexes could be different according to the zone of the field and increasing or decreasing them depends by the final score difference of the match (Study #2).

H_4 – In elite water polo matches, the tactical analysis by means of the TSAP instrument will show significant differences according to the match location, balanced/unbalanced final score difference of the match, season phase, individual playing time and players' playing positions.

It can be concluded that it was fully accepted because it was established the TSAP instrument provides different useful indexes according to all contextual factors considered in the hypothesis (Study #3).

H_5 – Significant differences in training loads, recovery and Hooper index responses will be found according to players’ playing positions, minutes of play in competition, match location (home or away), balanced/unbalanced final score difference and season phase.

It can be concluded that it was fully accepted because it was established that the monitoring of players provides different RPE, s-RPE, Recovery and Hooper Index according to the playing positions and all contextual factors considered in the hypothesis (Study #4).

In conclusion, this PhD dissertation aimed to respond the above-mentioned lack of literature on coaching knowledge, match analysis and monitoring procedures in elite water polo level.
In our opinion, the study 1 could offer an objective indication about differences and similarities in training methodologies and competitions management derived by the coaching philosophies of the interviewed head coaches, as well as by the differences between the three water polo national schools. In fact, how a sport discipline develops in a country could be seen as a complex interaction of social relevance, sport achievements, media coverage, financial resources, and so on, in addition to the country's historical link to that specific sport. To further improve this section of the study, could be interesting to expand the sample by involving more head coaches from water polo clubs all over the world, also including the head coaches of the U18 teams. In our opinion the same questions posed to a wider audience of head coaches

from different countries and from different national water polo schools, would expand the scientific data available to researchers and favour the transferability of knowledge to the coaches of this discipline. In studies 2 and 3, the use of the TSAP instrument could offer productive feedback to coaches about the different requirements of play and to evaluate how players understand the game collectively or individually**.** In fact, in our opinion this kind of instrument could be useful in order: to adjust a strategic game profile and establish specificity of training programmes focused on major tactical and technical needs of the team; to record the main offensive activities that emerge from players according to the zones of the field and type of the matches; to verify who is the player with the highest value of indexes (key players), assessing how their parameters change across different matches during a competitive elite season. As we demonstrated in our studies, it could be speculated that the game aspects of the youth elite men's water polo matches must be analysed in relation to specific margins of victory and not only considering the winning and losing outcome, taking into consideration the zone of the fields, while in elite senior team also the contextual factors 'home' and 'away' should be considered for the analysis of the ball possession.

In study 4, we provided how elite water polo players may exhibit different levels of fatigue, well-being, enjoyment, and recovery status in response to official matches, providing helpful and easily accessible monitoring instruments for coaches. A combination of the study 3 and the study 4 could provide a specific profile of a water polo player, useful to monitor during an entire season both technical-tactical and physio-psychological aspects, which could be correlated depending on different contextual factors.

This PhD dissertation provides findings on methodologies that are non-invasive, feasible, ecological, and not particularly expensive, to improve the coaching philosophies and training methodologies of coaches, strength and conditioning coaches and water polo practitioners.

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10. APPENDICES
10.1 Ethic committee approval

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CERTIFIED TRANSLATION FROM SERBIAN INTO ENGLISH

Stamp: Republic of Serbia, University of Belgrade
Faculty of Sport and Physical Education
02 no. 484-2
24 February 2011
Belgrade, Blagoja Parovica 156

UNIVERSITY OF BELGRADE
FACULTY OF SPORT AND PHYSICAL EDUCATION

APPROVAL OF THE ETHICS COMMITTEE OF THE FACULTY OF SPORT AND PHYSICAL EDUCATION, UNIVERSITY OF BELGRADE FOR EXECUTION OF THE PROJECT "EFFECTS OF THE APPLIED PHYSICAL ACTIVITY ON LOCOMOTOR, METABOLIC, PSYCHO-SOCIAL AND EDUCATIONAL STATUS OF THE POPULATION OF THE REPUBLIC OF SERBIA" (No. 47015)

Based on the inspection of the plan of the project "Effects of the Applied Physical Activity to Locomotor, Metabolic, Psycho-Social and Educational Status of the Population of the Republic of Serbia" (No. 47015, project leader assistant prof. Milivoj Dopsaj, PhD), approved by the Ministry of Science and technological development of the Republic of Serbia within the cycle of national scientific projects for the period from 2011 to 2019, the Ethics Committee of the Faculty of Sport and Physical Education of the University of Belgrade considers that both in research conception and execution planning as well as in the application of the obtained results, from its beginning the project has been undertaken based on the principles which comply with ethical standards, ensuring thus protection for human subjects from possible violation of their psycho-social and physical benefit.

In conformity with the aforesaid opinion, the Ethics Committee of the Faculty of Sport and Physical Education of the University of Belgrade has granted the approval for realization of the research planned by the project "Effects of the Applied Physical Activity to Locomotor, Metabolic, Psycho-Social and Educational Status of the Population of the Republic of Serbia" (No. 47015, project leader Assistant prof. Milivoj Dopsaj, PhD) which is approved by the Ministry of Science and technological development of the Republic of Serbia within the cycle of national scientific projects for the period from 2011 to 2019.

For the Ethics Committee
full prof. Dušan Ugarković, signed
associate prof. Vladimir Koprivica, signed
(Stamp)

END OF TRANSLATION

№ 178/11

I CERTIFY THAT this document which has been given to me in Serbian language, has been correctly translated into English.

IN WITNESS WHEREOF I have hereunto set my hand and seal, this 1st day of March 2011 in Beograd.

My appointment is permanent.

GORDANA VEKARIĆ

Gordana Vekarić, Sworn to Court
Interpreter for English and Italian language
Milutina Milankovića 130/33, Beograd, Serbia
tel:++381 11 711 03 38
e-mail:gocaa@eunet.rs

Appointed by the Decision of the Republic Minister of Justice,
Belgrade, Serbia № 74-02-46/91-03

10.2 Published paper (Study #1)

SURVEY ON COACHING PHILOSOPHIES AND TRAINING METHODOLOGIES OF WATER POLO HEAD COACHES FROM THREE DIFFERENT EUROPEAN NATIONAL SCHOOLS

Andrea Perazzetti[1], Milivoj Dopsaj[1], Aleksandar Nedeljković[1], Sanja Mazić[2], and Antonio Tessitore[3]

[1]*Faculty of Sport and Physical Education, University of Belgrade, Belgrade, Serbia*
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Original scientific paper
DOI 10.26582/k.55.1.6

Abstract:

The ability to change swimming styles and body positions, involving continuous shifting from horizontal to vertical posture and performing jumps, as well as technical skills play a fundamental role in water polo performance. To face with these demands, the coaching staff of elite and sub-elite water polo clubs might adopt a variety of training methods, also based on their specific coaching philosophies. This point has led to an enlargement of the staff, with higher head coaches' responsibilities, who may interpret their professional activity according to their own coaching philosophy, education, and their respective national water polo schools. In fact, based on their international sports achievements, some countries can be identified as recognised water polo national schools. For this reason, the purpose of this study was to survey 40 head coaches of three important national water polo schools (Italy, Greece, and Serbia) to identify and compare their coaching philosophies and training methodologies. The survey was based on five sections (Technical staff composition, Team roster, Weekly periodization, Testing and monitoring, Tactics and strategies). Furthermore, using a detailed descriptive statistic, the current study gives interesting information on how 40 high-ranking elite and sub-elite teams of different national championships organize their training during a typical week of the competitive season. A further improvement of this research line could include more national schools, expanding the sample to more countries from all over the world.

Key words: *team sports, team management, coach education, typical training week, competitive season*

Introduction

Water polo is a very stressful body-contact aquatic team sport played all over the world. It combines high-intensity short-duration efforts and low-duration actions (Ruano, Serna, Lupo, & Sampaio, 2016). The latest worldwide survey, published in 2019 by the Fédération Internationale de Natation (FINA) and based on data supplied by the national federations, shows a number of 24,482 coaches and 22,690 referees, out of which 8,155 and 19,113 are involved in European competitions at all levels, respectively (FINA, 2019). These data pose Europe as the most important geographic area for this sport in terms of the relevance of elite national (e.g., the Italian 'Serie A1', Serbian 'Prva A liga', Hungarian 'OB I', Spanish 'División de Honor', Croatian 'Prva hrvatska liga', Montenegrin 'Prva liga Crne Gore', and Greek 'A1 Ethniki') and elite continental (e.g., Champions League, LEN Euro Cup, and Adriatic Water Polo League) water polo championships. All these championships include the best European water polo players and clubs, showing a variety of water polo cultures belonging to different parts of Europe. In the last years, the Italian national team won the 2019 World Championship held in Gwangju and the Serbian national team won the last two Olympic Games (Rio de Janeiro in 2016 and Tokyo in 2020). As well, in the history of European tournaments, the Italian clubs won twenty-four and the Serbian eleven editions in both the Champions League and the LEN Euro Cup. At the same time, Greece has currently reached a very high level of water polo development, achieving noticeable results with both the senior national team (silver medal at Tokyo in 2020) and youth national team (gold medal in 2019 at the U20

10.3 Published paper (Study #2)

OPEN ACCESS

ORIGINAL SCIENTIFIC PAPER

Technical and tactical evaluation of ball possession in international youth water polo matches using the Team Sport Assessment Procedure (TSAP) instrument

Andrea Perazzetti[1,2], Milivoj Dopsaj[1], Antonio Tessitore[2]

Affiliations: [1]University of Belgrade, Faculty of Sport and Physical Education, Belgrade, Serbia, [2]University of Rome "Foro Italico", Department of Movement, Human and Health Sciences, Rome, Italy

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Abstract

In water polo, the playing style of a team is characterized by players' tactical behaviour. The purpose of this study was to provide an analysis of offensive actions, by means of the Team Sport Assessment Procedure (TSAP) of the first four youth national teams during the 20th FINA Junior Water Polo World Championships. Twenty-nine elite youth (U20) water polo matches, involving the national teams of Greece (n=7), Serbia (n=7), Italy (n=7) and Croatia (n=8) were selected for the analysis. The TSAP included: i) two indicators of gaining possession of the ball; ii) four indicators of disposing the ball. Using these indicators, the following indices of technical performance were computed: Volume of Play (VP), Efficiency Index (EI) and Performance Score (PS). The field was divided in twelve zones. The one-way ANOVA showed no significant differences between teams for all parameters (p>0.05), except that for Offensive Balls (OB) and Successful Shots (SS) occurred in specific zones of the field: for OB significant differences were found in zone 1 (p=.019), in zone 2 (p=.014) and in zone 5 (p=.007); for SS significant differences were found in zone 1 (p=.026) and in zone 2 (p=.008). The main reason of between-teams differences could be explained by the presence of a left-hand player in the game, and by the tactical behaviour of coaches and players. The TSAP instrument could offer productive feedback to coaches to perceive the different requirements of playing and to evaluate how players understand the game.

Keywords: *match analysis, offensive phase, performance index*

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EVALUATION OF BALL POSSESSION IN YOUTH WATER POLO
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10.4 Published paper (Study #4)

Journal of *Functional Morphology and Kinesiology*

MDPI

Article

Effects of Playing Position and Contextual Factors on Internal Match Loads, Post-Match Recovery and Well-Being Responses of Elite Male Water Polo Players

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Abstract: This study aimed to investigate the effects of playing position and contextual factors (match outcome, final score difference, match location, travel duration, number of scored and conceded goals) on the internal match load, players' perceived recovery and players' well-being. The session-RPE (s-RPE), Perceived Recovery Scale (PRS) and Hooper Index (HI) of 17 male elite water polo players were monitored during all matches (regular season and play-out) of the 2021/22 Italian Serie A1 championship. Three separate, mixed linear models for repeated measures showed significant main effects: drawn compared to won matches led to higher s-RPE values (mean ± SE = 277 ± 17.6 vs. 237.3 ± 20.6), while longer travel duration (estimate = −0.148) and goals scored (estimate = −3.598) led to lower s-RPE values; balanced compared to unbalanced matches led to higher PRS values (mean ± SE = 6.8 ± 0.3 vs. 5.1 ± 0.4), while playing time (estimate = −0.041) and goals scored (estimate = −0.180) led to lower PRS values; higher scores of the HI were registered for regular season compared to the play-out (mean ± SE = 15.6 ± 0.9 vs. 13.5 ± 0.8). This study marks the importance of ecological and non-invasive monitoring tools to assess internal match load, recovery and the well-being of elite water polo players.

Keywords: team sport; workload monitoring; RPE; perceived recovery; Hooper's Index

check for updates

Citation: Perazzetti, A.; Dopsaj, M.; Sansone, P.; Mandorino, M.; Tessitore, A. Effects of Playing Position and Contextual Factors on Internal Match Loads, Post-Match Recovery and Well-Being Responses of Elite Male Water Polo Players. *J. Funct. Morphol. Kinesiol.* **2023**, *8*, 12. https://doi.org/10.3390/jfmk8010012

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1. Introduction

Water polo is an intermittent, high-intensity, body-contact aquatic team sport. Since the end of the nineteenth century, its five historical developmental stages [1] have seen several changes of the play's rules, with an incessant increase in game demands [2]. Consequently, water polo players are required to have higher conditioning levels and more advanced technical and tactical skills. The intermittent nature of the game requires the concurrent contribution of anaerobic and aerobic energy metabolism [3]. The former supports the high-intensity and short-duration activity, while the latter sustains the low to moderate intensity of longer actions [4,5].

Previous studies on water polo's game demands have shown that two thirds of the playing time is spent above 85% of the peak heart rate (HRpeak), which (approximately) corresponds to the lactate threshold intensity [6]. Therefore, performing high-intensity activities with short recovery periods is crucial, and high strength and power levels are prerequisites for high-standard players [4,7,8]. Moreover, the current high-level competition system requires water polo players to perform multiple demanding training sessions and games throughout the season, from the high-competitive friendly matches of the pre-season

10.5 Biography

Born in Rome (Italy) on 7th of April in 1994, Andrea Perazzetti is the eldest son of Rosetta and Roberto. Andrea and his sister Giorgia were raised by a working family where the mother is an accountant employee, and the father is a taxi driver. During the kindergarten, Andrea started practicing swimming and then kept doing it for 12 years. After this period, he moved to water polo where he successfully competed for other 14 years. These full of sport activities and aquatic disciplines influenced Andrea to continue studying in this field, choosing the faculty of Sport Science. He finished both his bachelor (2017) and master (2020) with the highest score (110 cum laude) at University of Rome 'Foro Italico'. In 2019-20 he participated to Erasmus+ project (KA 107) at the University of Belgrade, working at the Sports Laboratory of the Department of Sports Medicine with Prof. Dr. Sanja Mazić. In the meantime, thanks to the coach Mr. Aleksandar Nikolić, he had the opportunity to work six months as a trainee with the Partizan water polo club, in Banjica sport center. One year later, in 2020-21 he enrolled into the doctoral program 'Experimental research methods of human locomotion' at the Faculty of Sport and Physical Education (University of Belgrade), where he was lucky enough to meet Prof. Aleksandar Nedeljković and his mentor Prof. Milivoj Dopsaj. As a visiting researcher, during the doctoral school year 2022-23 he took again part in the Erasmus+ (KA103) program at the University of Rome 'Foro Italico', where he officialised his previous Italian mentor, Prof. Antonio Tessitore, as a co-supervisor of his PhD project, carrying out research activities in monitoring of training and performance in elite water polo. Currently, Andrea lives in Rome and he is part of the first team technical staff of water polo club S.S. Lazio Nuoto as the head of performance, match analyst and assistant coach. Thanks to the head coach Mr. Claudio Sebastianutti and the technical director Mr. Daniele Ruffelli, he keeps performing research in water polo within this important Italian club. Furthermore, in the academic field, he is teaching practice lessons of 'team sport' as an adjunct professor at the University of Rome 'Foro Italico'. He loves his family, his childhood friends and football. He speaks Italian (mother tongue), English (B2) and Serbian (A2).

10.6 Personal bibliography

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Model for assessment front crawl sprint swimming potential at youth water polo players: international standardisation approach. **14th International Symposium of Biomechanics and Medicine in Swimming, Leipzig University, Faculty of Sports Science, Department Sports Biomechanics (2023, September)** Dopsaj, M., **Perazzetti, A.,** Özkol M. Z., Ošljak A., Novoselac N., Tessitore, A.

Technical and tactical evaluation of ball possession in international youth water polo matches. **1st International Conference on Science and Medicine in Aquatic Sports, University of Split, Faculty of Kinesiology (2022, September) Perazzetti, A.,** Dopsaj, M., Tessitore, A.

Front crawl sprint standards in different technical condition of swimming at youth water polo players: international normative approach. **1st International Conference on Science and Medicine in Aquatic Sports, University of Split, Faculty of Kinesiology (2022, September)** Dopsaj, M., **Perazzetti, A.,** Özkol, M.Z., Ošljak, A., Tessitore, A.

Analysis of different swimming abilities in youth water polo players and its comparison in two age categories. **15th Conference of Baltic Society of Sport Sciences, Lithuanian Sports University (2022, April) Perazzetti, A.,** Dopsaj, M., Tessitore, A.

Use of Team Sport Assessment Procedure (TSAP) in water polo: analysis of youth international teams. **20th International scientific conference contemporary challenges in sport, physical exercising & active lifestyle, University of Belgrade, Faculty of Sport and Physical Education (2021, May) Perazzetti, A.,** Tessitore, A.

10.7 Obrazac 5
образац изјаве о ауторству

Изјава о ауторству

Име и презиме аутора: **Andrea Perazzetti**

Број индекса: **5012/2020**

Изјављујем

да је докторска дисертација под насловом

A MULTIDIMENSIONAL APPROACH TO THE STUDY OF WATER POLO PERFORMANCE

• резултат сопственог истраживачког рада;

• да дисертација у целини ни у деловима није била предложена за стицање друге дипломе према студијским програмима других високошколских установа;

• да су резултати коректно наведени и

• да нисам кршио/ла ауторска права и користио/ла интелектуалну својину других лица.

Потпис аутора

У Београду, 26/06/2023

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10.8 Obrazac 6

образац изјаве о истоветности штампане и електронске верзије докторског рада

Изјава о истоветности штампане и електронске верзије докторског рада

Име и презиме аутора: **Andrea Perazzetti**

Број индекса: **5012/2020**

Студијски програм: **Experimental research methods of human locomotion**

Наслов рада: **A MULTIDIMENSIONAL APPROACH TO THE STUDY OF WATER POLO PERFORMANCE**

Ментор:

Dr Milivoj Dopsaj, Full professor, Faculty of Sport and Physical Education, University of Belgrade; **Dr Antonio Tessitore**, Associate professor, Department of Movement, Human and Health Sciences, University of Rome 'Foro Italico'.

Изјављујем да је штампана верзија мог докторског рада истоветна електронској верзији коју сам предао/ла ради похрањивања у **Дигиталном репозиторијуму Универзитета у Београду.**

Дозвољавам да се објаве моји лични подаци везани за добијање академског назива доктора наука, као што су име и презиме, година и место рођења и датум одбране рада.

Ови лични подаци могу се објавити на мрежним страницама дигиталне библиотеке, у електронском каталогу и у публикацијама Универзитета у Београду.

Потпис аутора

У Београду, 26/06/2023

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10.9 Obrazac 7
образац изјаве о коришћењу

Изјава о коришћењу

Овлашћујем Универзитетску библиотеку „Светозар Марковић“ да у Дигитални репозиторијум Универзитета у Београду унесе моју докторску дисертацију под насловом:

A MULTIDIMENSIONAL APPROACH TO THE STUDY OF WATER POLO PERFORMANCE

која је моје ауторско дело.

Дисертацију са свим прилозима предао/ла сам у електронском формату погодном за трајно архивирање.

Моју докторску дисертацију похрањену у Дигиталном репозиторијуму Универзитета у Београду и доступну у отвореном приступу могу да користе сви који поштују одредбе садржане у одабраном типу лиценце Креативне заједнице (Creative Commons) за коју сам се одлучио/ла.

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Потпис аутора

У Београду, 26/06/2023

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