Review Article

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Recovery in water polo: how much do we have to know? A systematic review

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Water polo (WP) is a high-intensity intermittent aquatic sport, with a predominance of swimming skills and nonswimming activities and incomplete recovery periods. Consequently, recovery after exercise is a fundamental part of sports performance. The main purpose of this systematic review was to evaluate the effects of different recovery strategies in WP performance. The studies were found by searching in the databases of PubMed, Web of Science, and Scopus. Methodological quality and risk of bias were assessed in accordance with the Cochrane Collaboration Guidelines samples. A summary of results including five studies was followed. The results show that supplementation with cherry juice before training does not imply improvements in recovery; the full-body photobiomodulation therapy reduces muscle damage; reducing training load during the season increased the natural logarithm of the root mean square of successive differences and perceived state of recovery, and the heart rate variability stabilizes and could progressively increase at the end of a tournament; and when an increase in internal training load is less than 60%–70% autonomic cardiac disturbances during preseason training do not occur. Recovery in WP is a very limited field of study that needs future research in active recovery, hydrotherapy, massage, rest and sleep to help coaches formulate recommendations.

Keywords: Recovery, Performance, Systematic review, Water polo

INTRODUCTION

Water polo (WP) was born in England at the end of the 19th Century and it has been played internationally for more than a century (Paris Olympic Games, 1900) (Madera et al., 2017). The WP is a sport that places high strength and high-intensity and endurance demands on the athlete because it is a high-intensity intermittent sport with and incomplete recovery periods, with a predominance of sprint swimming and wrestling (Sáez de Villarreal et al., 2015; Smith, 1998). Smith (1998) observed intense efforts with durations less than 15 sec and efforts at a lower intensity below 20 sec, with a density in a match of 5:2. The decisive actions in the WP are mostly dynamic and explosive (throws, jumps, changes of direction, snatches, etc.). Consequently, the combination of swimming, with throws and fight elements, determine that WP is a sport of great physical, mental, and technical-tactical demand (Botonis et al., 2019; Smith, 1998).

A relationship between athletic performance and morphological characteristics has been demonstrated in WP athletes. In particular, elite players have more mass and height compared with nonelite players (Tan et al., 2009). Similarly, senior players present a greater total mass, higher muscle percentage and greater body perimeters compared to adolescent (Barrenetxea-Garcia et al., 2019) and junior players (Ferragut et al., 2011; Kondrič et al., 2012). Precisely, Tsekouras et al. (2005), highlighted that body size is essential in WP given that a greater body volume leads to better

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positions in the water, and to achieve and control passes more adequately during matches. Furthermore, strength performance is proportional to muscle size (Kubo et al., 2006). In this sense, some authors (Ferragut et al., 2011; Kondrič et al., 2012; Tan et al., 2009) have demonstrated that there are statistically significant differences depending on the playing position regardless of gender. Concretely, center backs have greater body and muscle mass, body mass index and foot length compared to driver and wing players; the center forward player has a greater height and body mass compared to the other positions; and the outside positions (drivers and wings) do not require a very tall stature or a great body mass (Lozovina et al., 2009). In general, WP players have showed a balanced mesomorphic. However, an endo-mesomorphic profile case has been observed in center back and center forwards players, with higher levels of fat in their bodies (Ferragut et al., 2011).

In relation to physiological factors, WP players require the simultaneous use of aerobic and anaerobic energy metabolism during competition (Melchiorri et al., 2010; Platanou and Geladas, 2006). On the one hand, as a result of short actions at high speed and intensity such as: movements, jumps and throws; and on the other hand, to sequential and cumulative actions, of long duration and of moderate to high intensity (Smith, 1998). In this sense, during a WP competition, the aerobic system provides approximately 50%–60% of energy needs, the alactic anaerobic system 30%–35% and the lactic anaerobic system 10%–15% (Smith, 1998). In addition, differences in aerobic and anaerobic metabolism have been demonstrated among WP players of international and national level (Botonis et al., 2018). In case of the goalkeeper, due to the specificity of the position, the aerobic demand is quite small, and the anaerobic demand is fundamental (Platanou, 2009). Likewise, maximum oxygen uptake (VO_{2max}) values have been described between 57.9±7 mL/kg/min and 61 mL/kg/min (Smith, 1998; Tsekouras et al., 2005), with an average during the matches of 80% VO_{2max} (Pinnington et al., 1998; Platanou and Geladas, 2006). At the same time, an anaerobic threshold of 7.7 mmol/L has been observed in elite players during an international tournament (Melchiorri et al., 2010).

The WP has showed the highest rates of injuries amongst other aquatic disciplines during competitions (16.2% to 19.4%) (Mountjoy et al., 2019). Throwing volume, range of motion, scapular dyskinesia, force imbalance, proprioceptive deficit, and altered throwing kinematics have been associated with an increased risk of injury in the WP (Miller et al., 2018). In fact, it has been found that 74% of shoulder pain in WP players could be explained by the total volume of the throws and the reduction of rest between them (Wheeler et al., 2013). Greater fatigue in the rotator cuff muscles has also been demonstrated as a result of the numerous movements derived from swimming to move with and without the ball (Colville and Markman, 1999), this musculature being fundamental in throws and blocks (Jerosch et al., 1993). In addition, the 'eggbeater' float technique, to achieve a stable throwing position, can cause hip dysfunction (Franić et al., 2007; Mosler et al., 2006).

The recovery of the athlete has been showed to be at least as important as the training (Hynynen et al., 2006). In this regard, high-intensity training without adequate recovery periods causes a detrimental effect on performance. In view of all the above, the level of accumulated fatigue requires adequate recovery, since recovery after exercise is a fundamental part of sports performance (Calleja-González et al., 2016). Adequate recovery has been shown to be necessary to prevent health problems and achieve maximum performance (Bishop et al., 2008). However, athletes face a large number of stimuli on a daily basis that can lead to incomplete recovery (Barnett, 2006); in addition to the decreases in physical performance related to the physiological fatigue of the normal training process (Halson and Jeukendrup, 2004) and during matches (Mohr et al., 2005). In this sense, ergonutritional, water therapy, massages techniques, stretching compression garments, sleep strategies and psychological implements have been the most used methods (Calleja-González et al., 2018; Kim et al., 2017). Thus, a proper recovery showed to be an essential parameter for coaches and physical trainers of sports clubs, with respect to the preparation, control and performance of athletes. In sports such as soccer (Altarriba-Bartes et al., 2020), basketball (Calleja-González et al., 2016), volleyball (Calleja-González et al., 2019b), rugby (Calleja-González et al., 2019a), futsal (Nemčić and Calleja-González, 2021), and combat sports (López-Laval et al., 2021) different types of reviews have been made on this issue. However, for the best of the author's knowledge, no previous review has been published on WP and besides the number of posts are very limited nowadays.

Therefore, the main objective of this systematic review was to evaluate the effects of different recovery strategies in WP performance, and to present the published updated literature on recovery strategies in WP; in order to help coaches and improve the performance of the players.

MATERIALS AND METHODS

Study design and search strategy

This review describes the recovery methods in WP. It has been done by following the preferred reporting elements for the reviews

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guidelines (PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Liberati et al., 2009). We searched for studies that were published before October 1st 2021 and that were based on original scientific research. Several information databases were used: MEDLINE (PubMed), Web of Science, and Scopus. The search equation used as a means to select research-relevant articles includes medical topics (MeSH) and free text words (using Boolean operators). The equation used included: "creatine supplementation" [All Fields] AND (("sports" [MeSH Terms] OR "sports" [All Fields] OR "athletic" [All Fields]) OR ("sports" [MeSH Terms] OR "sports" [All Fields] OR "sport" [All Fields])) AND "performance" [All Fields] AND "body composition" [MeSH Terms] OR ("body" [All Fields] AND "composition" [All Fields]) OR "body composition" [All Fields] AND (("female" [MeSH Terms] OR "female" [All Fields] OR "females" [All Fields]) OR ("women" [MeSH Terms] OR "women" [All Fields])); as well as some authors' names that appeared in the bibliographic references of several articles. Two authors (JBG and JCG) searched the information, identified the studies, and searched the titles and abstracts of all articles. Besides, these same authors searched the reference sections of the selected articles to identify other possible relevant articles. The terms are related to recovery in WP performance in men and women. No filters were used to increase the power of the analysis. Through this equation, we obtained relevant articles in this field applying the snowball strategy (Palinkas et al., 2016). Cross-references were made to all titles and abstracts of the search to identify duplicates and potential missing studies. The titles and abstracts were selected for a latest revision of the full text. The search for published studies was conducted independently by four authors (JBG, AMR, SN, and JCG) and disagreements about all results were resolved by two other authors (JMA and ESV). It was registered in the PROSPERO International Prospective Register of Systematic Reviews on 25th November, 2021 (registration number: CRD42021287273).

Inclusion and exclusion criteria

To define the inclusion criteria, the PICOS model was used (Liberati et al., 2009): P (Population): "WP athletes", I (Intervention): "recovery methods (Cr)", C (Comparators): "same experimental condition OR placebo", O (Result): "physical and/or athletic performance measures" and S (study design): "random or double-blind and random design." The articles in this literature review were to follow the next inclusion criteria: (a) elite or amateur WP; (b) youth women or men and women with separate results; (c) using recovery methods subjects performed in WP; (d) studies examined the effects of recovery methods on physical and/or sports performance, physiological responses and body composition and on the perception of exertion; (e) the designs followed the experimental protocols of the research. No filters were applied to the level, gender, Ethnicity or age of athletes to increase analytical power of analysis.

On the other hand, the exclusion criteria were: (a) studies that were carried out in elderly or sedentary women, population of only men or men and women without separating the results or animals; (b) studies that were carried out for therapeutic purposes; (c) studies with participants with metabolic diseases, cardiovascular or injury pathologies. Once the inclusion criteria/exclusion were applied to each study, the data on the study source (including the authors and the year of publication), the study design, the administration of the method, the sample size, the characteristics of the participants (level, race, and sex). Finally, four authors independently extracted the final results of the interventions using a spreadsheet (Microsoft Inc., Seattle, WA, USA). Subsequently, disagreements were resolved by discussion until a consensus or third-party adjudication was reached.

Study selection

Through the search in the databases, four authors identified the studies included in this systematic review (JBG, AMR, SN, and JCG). From the articles identified by the search strategy, the titles and abstracts were analyzed and then, a complete text review was performed and duplicate essays were identified with the cross-referencing technique. Subsequently, all those publications that, after being evaluated for their eligibility, were considered relevant were recovered and the full report of them was reviewed by peers.

Data extraction and synthesis

The inclusion/exclusion criteria were applied to each article and, subsequently, the following data were extracted: source of the study (author/s and year of publication); population of the sample (number of participants, sex and age), indicating the level of physical activity and sports discipline; intervention); parameters analyzed as a measure of physical/sports performance and body composition; and conclusion, only studies that focus on the effects of recovery on WP were included for the current review (Fig. 1).

Outcome measures

The scientific literature described about the recovery method on WP players using several outcome variables such as heart rate variability (HRV), rating of perceived exertion (RPE). The results

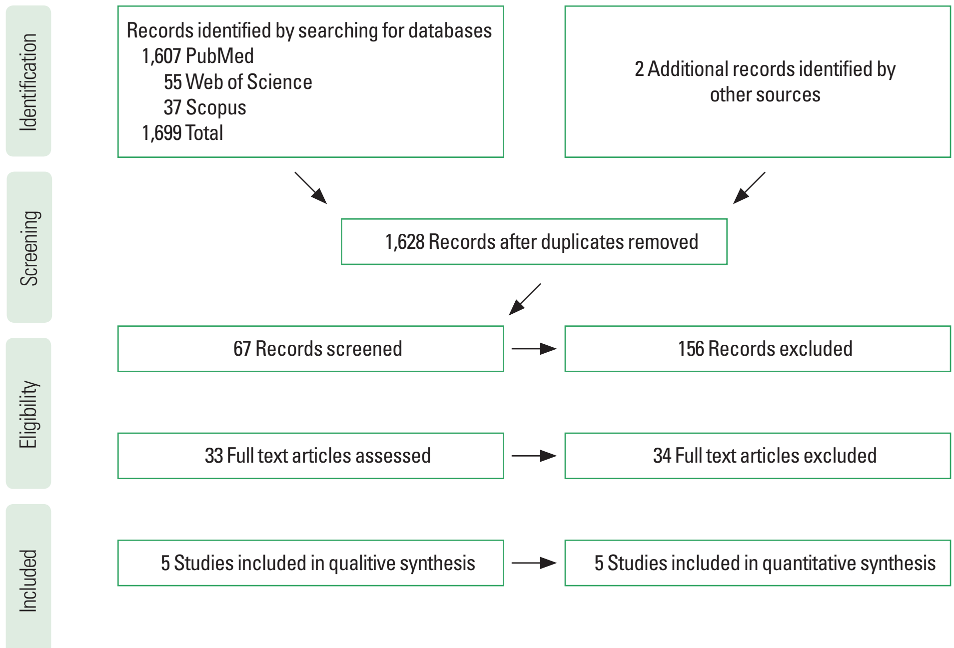

Fig. 1. Selection of studies (elements of the main reports for systematic review and meta-analysis [PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses], 2009 flow diagram).

could be influenced by sample size, supplementation and duration of the intervention. Participant's characteristics, such as age, gender, ethnicity, body composition, training level, differences in training, and health status and ethnicity could also influence the final results.

Quality assessment of the experiments

Methodological quality using a PEDro scale and risk of bias were assessed by four authors and disagreements were resolved by two other authors part evaluation, in accordance with the Cochrane Collaboration Guidelines (Moher et al., 2009). The PEDro scale consists of 10 items and each criterion is rated as present (+) or absent (−) in the evaluation of the study. The final score is obtained by adding the positive responses: studies that achieve a score of 9–10 are considered to have excellent methodological quality; 6–8, good; 4–5, regular; and below 4, poor. In the risk of bias, the items on the list were divided into six domains: selection bias (random sequence generation, allocation concealment); performance bias (blinding of participants and researchers); detection bias (blinding of outcome assessment); attrition bias (incomplete outcome data); reporting bias (selective reporting); and other types of bias. For each research, domains were judged by consensus or third-party adjudication. They were characterized as 'low' if criteria for a low risk of bias were met (plausible bias unlikely to seriously alter the results) or 'high' if criteria for a high risk of bias were met (plausible bias that seriously weakens confidence in the results), or it was considered 'unclear' (plausible bias that raises some doubt about the results), if the risk of bias was unknown. All details are done in Figs. 2, 3.

RESULTS

A total of five studies (Tables 1, 2), were detected from the scientific literature and included (Botonis et al., 2021a; Botonis et al., 2021c; Botonis et al., 2022; McCormick et al., 2016; Zagatto et al., 2020). Two studies were published in 2021 (Botonis et al., 2021a; Botonis et al., 2021c), two in 2020 (Botonis et al., 2022; Zagatto et al., 2020) and one in 2016 (McCormick et al., 2016), which means that they were published in the last 5 years, being current. Besides, a total of 49 athletes participated in the review. In this sense, the competitive level of 21 athletes was semielite U-20 (McCormick et al., 2016; Zagatto et al., 2020) and 27 international elite athletes (Botonis et al., 2021a; Botonis et al., 2021c; Botonis et al., 2022). Among evaluated studies, one proposed an intervention with the intake of supplemental tart cherry juice (McCormick et al., 2016) and another with the full-body photobiomodulation therapy (PMBT) (Zagatto et al., 2020). Moreover, three studies were published in a journal with index factor Q1 (Botonis et al., 2021a, 2022; McCormick et al., 2016) and one in Q3 (Zagatto et al., 2020).

Nutritional strategies and ergogenic supplementation

McCormick et al. (2016) investigated the effect of supplemental cherry juice on recovery and next-day performance for 7 days. Nine elite male players were placed in group cherry juice and placebo. Various venous blood samples were obtained to investigate markers of inflammation (interleukin-6 and C-reactive protein) and oxidative stress (uric acid and F2-isoprostane). Players performed in-water vertical jump test, 10-m sprint test, the repeat sprint test and the WP intermittent shuttle test on the first and last day. In addition, they completed a diary through the total recovery quality scale and delayed onset muscle soreness (DOMS), and training load was calculated by the product of training duration and session RPE (sRPE), after each session. The results showed that on day 6 postexercise interleukin-6 was higher than before exercise and on day 7 ($P < 0.05$); C-reactive protein was higher on day 7 compared to day 6 before and after exercise ($P < 0.05$); F2-isoprostane was lower on day 7 compared to day 1 and day 6 ($P <$ 0.05); and UA was unchanged. No differences were found for any performance or recovery measures.

Fig. 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies. (+), indicate low risk of bias; (?), indicate unknown risk of bias; (-), indicate high risk of bias.

Photobiomodulation therapy

Zagatto et al. (2020) studied the effect of photobiomodulation therapy on recovery. Thirteen young players were placed in the photobiomodulation therapy and placebo group. Before each game the following variables were measured: HRV at rest, blood samples to analyze testosterone and cortisol; creatine kinase and lactate dehydrogenase; tumor necrosis factor alpha and interleukin-6; the maximal isometric voluntary contraction and the squat jump. The results showed only a decrease in the lactate dehydrogenase delta values in the photobiomodulation therapy compared with the placebo group after the first match ($P = 0.004$, *post hoc* $P = 0.038$).

Internal training load (ITL)

Botonis et al. (2022) investigated the effects of participation in an international in vagal-related HRV tournament and recovery. Nine elite players participated and HRV and ITL were assessed during an intensified training period and the subsequent 4-day international tournament. The results showed that natural logarithm of the root mean square of successive differences (lnRMSSD) was suppressed after the first match ($P = 0.03$), compared to the

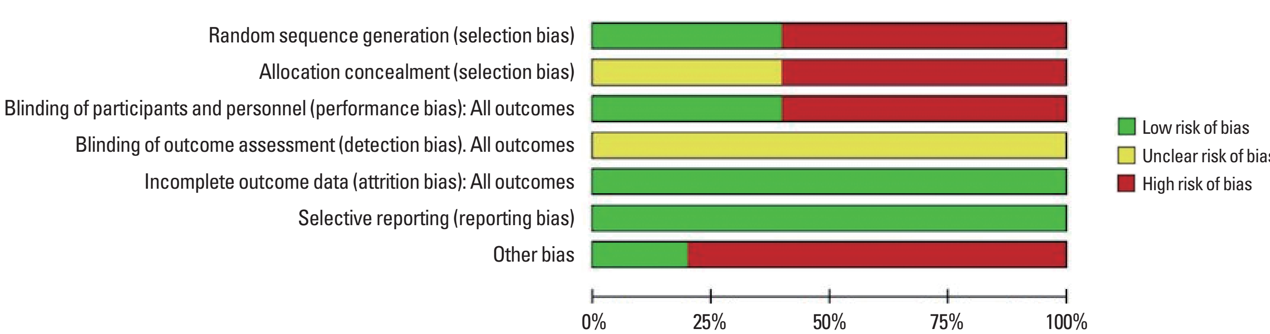

Fig. 3. Risk of bias summary: review authors' judgements about each risk of bias item for all studies included.

Table 1. Quality assessment of included studies (PEDro scale)

Study	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Score	Level of evidence
McCormick et al., 2016	+	+	+	+	+	+	–	+	+	+	+	9	Excellent
Zagatto et al., 2020	+	+	+	+	+	–	–	+	+	+	+	8	Good
Botonis et al., 2022	+	–	–	–	–	–	–	+	+	–	+	3	Poor
Botonis et al., 2021a	+	–	–	–	–	–	–	+	+	–	+	3	Poor
Botonis et al., 2021c	+	–	–	–	–	–	–	+	+	–	+	3	Poor

PEDro, physiotherapy evidence database; +, yes; –, no.
Item 1: eligibility criteria specified. Item 2: random allocation. Item 3: concealed allocation. Item 4: groups similar at baseline. Item 5: subject blinding. Item 6: therapist blinding. Item 7: assessor blinding. Item 8: less than 15% dropouts. Item 9: intention-to treat analysis. Item 10: between-group statistical comparisons. Item 11: point measures and variability data.

Table 2. Recovery methods in water polo with benefits

Study	Sample size and level	Experimental design	Intervention, dose and timing	Outcomes	Results	Journal
McCormick et al., 2016	9 Males; 18.6 ± 0.4 years Highly-trained from the Western Australian Institute of Sport Water Polo squad	Randomized double-blind, repeated measures, crossover design	IG: tart cherry juice concentrate. CG: lime, cranberry and raspberry with food coloring Before training, two doses, 6 days	Inflammation, oxidative stress, DOMS, TQR, VJ (cm), 10-m sprint test (sec), RPS (sec) and WIST (sec).	No differences between both groups	Journal of the International Society of Sports Nutrition
Zagatto et al., 2020	13 Males; 18 ± 1 years Brazilian U-20 water polo Championship	Randomized double-blind, repeated measures, crossover design	Effect of the PBMT use after official matches in the recovery inflammation and muscle damage IG: PBMT. CG: placebo treatment	HRV in rest; hormonal, muscle damage, inflammation, neuro-muscular responses, MVC (ms) and SJ (cm).	LDH concentration ↓	Photobiomodulation, Photomedicine, and Laser Surgery
Botonis et al., 2022	9 Males; 25.7 ± 5.2 years Elite level	1-Group repeated measures observational design	Effect of a pretournament intensified training program 5 days before a international tournament	Vagal-related HRV, LnRMSSD, sRPE and sports performance.	Parasympathetic reactivation ↑ Recovery ↓	Journal of Strength and Conditioning Research
Botonis et al., 2021a	9 Males; 25.7 ± 5.2 years Elite level	1-Group repeated measures observational design	Effect a 2-day light-load and subsequent 2-day heavy-load training after 24 hr	HRR, session-RPE, duration of training sessions and sport performance (4 × 100 m).	HRR ↑	European Journal of Sport Science
Botonis et al., 2021c	9 Males; 25.6 ± 4.7 years Elite level	1-Group repeated measures observational design	Evaluate the association of HRV and perceived recovery status 9 Weeks, 5 weeks in preseason period and 4 weeks in the in-season period	HRV, HR (30 min after waking and before the beginning of the morning training sessions), LnRMSSD, sRPE and scale of perceived recovery status.	Preseason training when an increment of internal training load is higher than 60%–70%: cardiac autonomic perturbations ↑ Reduction of training load in season by 30%: LnRMSSD mean and perceived recovery status ↑	Sports Medicine International Open

IG, intervention group; CG, control group; DOMS, delayed onset muscle soreness; TQR, total recovery quality scale; VJ, in-water vertical jump test; RPS, repeat sprint test; WIST, water polo intermittent shuttle test; PBMT, photobiomodulation therapy; HR, heart rate; HRV, heart rate variability; MVC, maximal voluntary contraction; SJ, squat jump; LDH, lactate dehydrogenase; LnRMSSD, natural logarithm of the root mean square of successive differences; sRPE, session rating of perceived exertion; HRR, heart rate recovery.

first morning of the tournament and increased the following morning ($P = 0.03$). On the last morning of the tournament, the LnRMSSD was higher compared to the first postmatch measurement ($P = 0.002$). Furthermore, the sRPE and ITL were lower on tournament days compared to before the tournament ($P < 0.001$).

Secondly, Botonis et al. (2021a) studied the effects of changes in training load after a swimming test on heart rate recovery (HRR) responses. Nine elite players were tested after a two-day light load

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and two-day heavy-load training. HRR was evaluated after the swimming test (4×100 m). Besides, ITL was measured after training using the scale of perceived exertion and duration of training sessions (sRPE). The results showed that ITL increased in high load training compared to light-load training ($P<0.001$), the difference in HR at end of exercise and after 60s rest and the difference in mean HR during last min of Exercise and HR after 60s rest were higher in light-load training ($P<0.05$) and a correlation was observed between the percentage change of ITL with the %HRR10s ($r=0.67$, $P=0.05$).

Finally, Botonis et al. (2021c) investigated the association of HRV with HRR and perceived recovery status. Nine elite players participated. ITL, LnRMSSD, and sRPE were obtained during one regeneration week, two preseason training mesocycles, and two in-season training mesocycles. The results showed that the ITL in the preseason mesocycles increased by 60%–70% compared to the regeneration week ($P<0.01$) and decreased by 30% in the mesocycles in season compared to the mesocycles in preseason ($P<0.01$). In addition, the LnRMSSD was higher in season compared to the regeneration week ($P<0.01$) and preseason ($P<0.05$), and the perceived recovery was greater in season compared to preseason ($P=0.01$ and $P<0.001$, respectively).

As shown in Table 1, scores on the PEDro scale were 3, 8, and 9 for the selected articles. One study showed excellent quality (McCormick et al., 2016), one was high quality (Zagatto et al., 2020) and three poor quality (Botonis et al., 2020; Botonis et al., 2021a; Botonis et al., 2021c). Besides, of the five studies evaluated, only two had a low risk of bias in most of the domains (McCormick et al., 2016; Zagatto et al., 2020) and three had a moderate to high risk of bias (Botonis et al., 2021a; Botonis et al., 2021c; Botonis et al., 2022).

DISCUSSION

The main objective of this systematic was to evaluate the effects of different recovery strategies in WP performance and to describe the update published literature on recovery strategies in WP, in order to help coaches and staff in their preparation, control tasks, and to improve player performance. At the time of publication, there were only five articles that investigated recovery in the WP (Botonis et al., 2021a; Botonis et al., 2021c; Botonis et al., 2022; McCormick et al., 2016; Zagatto et al., 2020), and despite scientific evidence of the benefits of recovery after exercise on sports performance (Calleja-González et al., 2016), recovery in WP is still an unknown area and much research is needed.

Nutritional strategies and ergogenic supplementation

It has been shown in the WP that nutritional strategies can improve the response to daily training, recovery and performance on the day of competition (Cox et al., 2014). In fact, effective recovery often occurs only when nutrients are supplied (Burke and Mujika, 2014). Furthermore, protein supplementation showed to smooth the rise in creatine kinase and improve recovery (Poulios et al., 2019). However, this recovery strategy should continue to be investigated using protocols that simulate WP matches (Cox et al., 2014). On the other hand, supplementation with cherry juice before training in the WP does not imply improvements in recovery (McCormick et al., 2016), unlike that observed in cyclists (Bell et al., 2014). These same results were observed with an ingestion of β-alanine for 4 weeks in WP players (Brisola et al., 2018). It has also been observed that beet juice supplementation in WP players for 6 days does not improve sprint performance (Jonvik et al., 2018), as in other sports (Conger et al., 2021). However, it has been shown that in high-intensity training in WP a nutritional ergogenic contribution of a daily dose of 5 g of L-Arginine after 4 weeks of treatment can improve the responses of physical training (Gambardella et al., 2021). Other ergogenic aids have been investigated in sport, but not in the WP. For example, turmeric supplementation reduces creatine kinase and muscle pain (Fang and Nasir, 2021). Future studies in WP should take this area into account.

Photobiomodulation therapy

The full-body PMBT applied after WP matches did not induce a faster recovery (Zagatto et al., 2020), as was observed in runners through the perceived exertion scale (Lanferdini et al., 2021). In contrast, PMBT improved sprint performance, decreases the fatigue index and blood lactate levels (Rosso et al., 2018). Likewise, a reduction in muscle damage (decrease in lactate dehydrogenase) has been observed through PMBT in WP (Zagatto et al., 2020). Nonetheless, more studies are necessary in WP.

Internal training load

The recovery evaluation must be part of the training control (Andrade et al., 2021). However, the evidence on recovery in high-intensity training is still limited in team sports (Foster et al., 2001). Dupon showed the recovery time between successive matches was not sufficient for full regeneration, causing the accumulation of fatigue and its decrease in performance (Dupont et al., 2010). It has been shown in WP that HRV stabilizes and can progressively increase at the end of a tournament by reducing training load, compared to a pretournament training period, improving parasympathetic reactivation (Botonis et al., 2022). Similarly, a reduction in training load by 30% during the season, increased LnRMSSD and perceived state of recovery; likely associated with increased parasympathetic activity (Botonis et al., 2021c). Acute changes in training load have also been observed to be sensitive to HRR in WP players (Botonis et al., 2021a). For example, autonomic cardiac disturbances during preseason training in the WP did not occur when an increase in internal training load (ITL) was less than 60%–70% (Botonis et al., 2021c).

Strengths, limitations, and future research lines

This systematic review, as far as we know, is the first conducted on recovery and WP. The great limitation found for the achievement of the work has been the scarce bibliography in relation to the subject of study and the sports modality. In fact, there are only five studies related to this topic. However, the scientific literature validated this methodology both in sports science (Altarriba-Bartes et al., 2020; Fernández-Landa et al., 2019) and in other fields (Kruszecki et al., 2021; Moreira et al., 2019). In relation to other recovery strategies, active recovery after training showed to accelerate the reduction of lactate and creatine kinase levels (Gu et al., 2021). In addition, immersion in cold water or in contrast baths after training improved the perception of relaxation (Ahokas et al., 2019) and massages improved flexibility and the evolution of DOMS (Davis et al., 2020). On the other hand, the quantity and quality of sleep seemed a fundamental recovery strategy since it influenced the performance, physical and psychological aspects of athletes (Roberts et al., 2019). In this sense, factors such as early morning training, increases in training load, trip departure times, jet lag, and altitude can affect athletes' sleep (Roberts et al., 2019). In turn, Botonis et al. (2021b) showed that under conditions of good rest (7–9 hr of sleep), a nap at noon can help athletes improve exercise and cognitive performance after nap and attenuate the performance degradation induced by sleep loss. These same authors (Botonis et al., 2021b) highlighted that a long nap (> 35–90 min) seemed to provide superior benefits to athlete performance. For these reasons, we suggest to take into account active recovery, hydrotherapy, massage, rest and sleep for future WP studies.

In conclusion, research on recovery in WP is very limited compared to other sports such as soccer (Altarriba-Bartes et al., 2020) and basketball (Calleja-González et al., 2016). However, coaches and physical trainers involved in sports clubs should consider: (a) that HRV can be used as a tool to facilitate training planning and recovery; and (b) that reducing the training load by 30% during the season implies an improvement in the perceived state of recovery, so this strategy in the monitoring of the internal load could be necessary and interesting at some moments of the season for the recovery of the players and preparation of the competition Even so, recovery in the WP is a field of study that needs future research to be able to help coaches and physical trainers to formulate recommendations and protocols for action.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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