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Inhibitory control expertise through sports practice: A scoping review

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ABSTRACT

The stopping of a planned motor response is called motor inhibitory control (IC) and allows humans to produce appropriate goal-directed behaviour. The ever-changing environment of many sports requires athletes to rapidly adapt to unpredictable situations in which split-second suppressions of planned or current actions are needed. In this scoping review, the approach of the PRISMA-ScR was used to determine whether sports practice develops IC and, if so, which sports factors are key to building IC expertise. The PubMed, Web of Science Core Collection, ScienceDirect and APA PsycNet Advanced Search databases were searched with predefined combinations of keywords. Twenty-six articles were selected and analysed. Most of the publications ($n = 21$) compared athletes with non-athletes, or athletes from other sports. Only a few articles ($n = 5$) reported results from intra-sport comparison. Overall, the studies reported better IC performance in athletes compared to non-athletes. The correlational link from sports practice to IC improvement is observed but additional longitudinal protocols are needed to prove its direct link. Findings have implication for determining whether IC could represent a marker of performance and thus for supporting the implementation of cognitive training in sport.

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Inhibitory control; sports; athletes; training; synthesis

1. Background

Motor inhibitory control (IC) refers to the ability to stop planned or ongoing motor responses (Aron et al., 2014). In our daily activities, we often deal with unexpected situations requiring the suppression of planned actions to ensure safe and well-adapted behaviour (Wessel et al., 2017). Inhibitory control is thus an essential ability for coping with our living environment and is considered as one of the core executive functions (Miyake et al., 2000).

The literature has shown that motor IC can be improved via specific laboratory-based training protocols involving the regular practice of IC tasks, the most frequently used being the stop-signal task (SST) (Lappin et al., 1966) and the Go/NoGo task (Donders, 1969). IC improvement has generally been indexed by a decreased response time (RT), a decreased stop-signal reaction time (SSRT), and/or fewer errors committed at the end of the training sessions (C. F. Chavan et al., 2015; Hartmann et al., 2016; Manuel et al., 2013; Nicholas et al., 2013; Simonet et al., 2019). While the speed of inhibition processes has been shown to increase after short- and medium-term IC training, the long-term effects of regularly dealing with situations requiring IC are still little known.

Given the dynamic nature of sport, with ongoing interactions between the performers and the time constraints under which decisions must be made, it provides a highly interesting environment to study IC in the long term. First, many sports involve conflict situations in which the fast suppression of planned or ongoing actions is crucial for the highest levels of performance. For example, soccer players evolve in a dynamic and time-constrained environment where they have to decide whether to pass the ball, to stop, to dribble or to shoot, based on their teammates' and opponents' actions. Sports practice might therefore indirectly train and improve IC. Second, due their extensive amount of practice, athletes represent a very interesting population for studying the effects of long-term IC training.

Beyond its fundamental relevance for sport psychology, this review may have important applied implications for sports practitioners. Although practicing sport can lead to enhanced cognitive functions, the converse and crucial question of whether the enhancement of core cognitive abilities leads to improved sports performance (Walton et al., 2018) remains unanswered. The literature suggests that developing perceptual-cognitive ability through exposure to lab-based representative tasks simulating the characteristics of real sports situations might provide an important new avenue for improving IC in athletes (Broadbent et al., 2015).

Although practicing laboratory-based IC tasks has been shown to improve IC (Hartmann et al., 2016; Simonet et al., 2019), it is unclear whether the long-term practice of sports involving IC components would mirror these effects. This scoping review was thus conducted to systematically map the research done in this area.

1.1 Objectives

This scoping review explored the relationship between sports practice (i.e., training in a specific sport during several years) and

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IC performance. We addressed the following questions: (i) Are laboratory-based IC tasks appropriate to consistently assess IC performance? (ii) What are the key factors of sports practice (i.e., type of sport, amount of practice) that develop IC? and (iii) What are the gaps in knowledge that indicate future research directions?

2. Methods

2.1 Protocol

We based our research protocol on the Preferred Reporting Items for Systematic Reviews and Meta-analysis Protocols extension for Scoping Review (PRISMA-ScR) (Tricco et al., 2018).

2.2 Eligibility criteria

We included all papers investigating IC performance in athletes, with no restrictions on the type of cognitive task used to assess IC (e.g., SST, Go/NoGo task, Stroop task, etc.). We included only papers involving adult athletes and written in English, that have been published until October 2021. Cross-sectional and longitudinal studies were included. We excluded studies that had trained non-athletes in a physical activity protocol and then assessed the effect of the protocol on IC performance.

2.3 Information sources

Before identifying relevant journal articles, the three authors of the paper determined the search keywords. The search strategies were elaborated and drafted by the author D.B. and refined through team discussion. Four meetings with the presence of the three authors were dedicated to define the keywords and to elaborate the search strategies.

To collect the relevant literature, the PubMed, Web of Science Core Collection, ScienceDirect and APA PsycNet Advanced Search databases were searched using the following combination of keywords: ("motor inhibition" OR "inhibitory control") AND ("sport" OR "sports") AND ("athletes" OR "experts" OR "expertise" OR "elite"). The database search was supplemented in Google Scholar with the same combination of keywords by reading through the first 30 pages. To produce a more exhaustive scoping review, we combined the name of each sport included in the Olympic Games ($n = 63$) followed by "inhibitory control" in PubMed (e.g., "track cycling" AND "inhibitory control"). This approach allowed us to add other relevant articles that were missing with our initial review strategy.

2.4 Search

The final search strategy for PubMed can be found in Appendix 1.

2.5 Selection of sources of evidence

During screening, the titles and abstracts of the identified studies were reviewed independently by D.B. and M.S. to ensure that all studies matched the inclusion and exclusion criteria. They compared their results during three meetings. Two additional meetings including the third author were dedicated to resolve disagreements on study selection.

2.6 Data charting process

A data-charting form was developed by M.S. to determine which information and variables to extract. The form was approved by D.B. and J.B. M.S. and D.B. independently collected the data from each eligible article and fill in the form. These two authors compared their data-charting form and highlighted the inconsistencies. One meeting including the three authors of the paper was dedicated to discuss the inconsistencies, to verify the data for accuracy and to resolve disagreements.

2.7 Data item

We abstracted data on article characteristics (authors' name and year of publication), sports investigated, participants (sample and sporting expertise), the behavioural tasks used and the main behavioural results.

3. Results

3.1 Selection of sources of evidence

After removing duplicates ($n = 56$), 485 articles were identified and screened for eligibility. After screening the titles, 84 articles were selected. The abstracts of the 84 articles were explored and 52 articles were found to be eligible. In addition to this systematic search, one more article that matched the inclusion criteria was added to the scoping review, and 26 articles were ultimately retained. Figure 1 illustrates the flow diagram for the search inspired by Moher et al. (2009).

3.2 Characteristics of sources of evidence

The main characteristics the selected studies are presented in Table 1. This table summarizes: the study (authors in alphabetical order and year of publication), sports, participants, sample, expertise, inhibition task, main behavioural results. In the section "main behavioral results", we computed a rate of change (RC) for each dependent variable reported. This RC corresponds to the difference between the groups expressed in percentage relative to the poorer result. For example in Bianco et al. (2017), p. 480 ms (RT non-athletes) − 418 ms (RT boxers) = 62 ms. Then, the RC between non-athletes and boxers: $62 \times 100/480 = \downarrow 12.9\%$. Due to methodological considerations, we proceeded differently with four articles (Elferink-Gemser et al., 2018; Heppe et al., 2019; Jack et al., 2021; Martin et al., 2016). In Elferink-Gemser et al. (2018), the data of the group "norm score" were not provided, therefore the RC was only possible to compute for the comparison between elite and sub-elite players. In Jack et al. (2021), due to the five different groups of expertise, we decided to report here only the percentage of variance that the expertise predicts. The authors

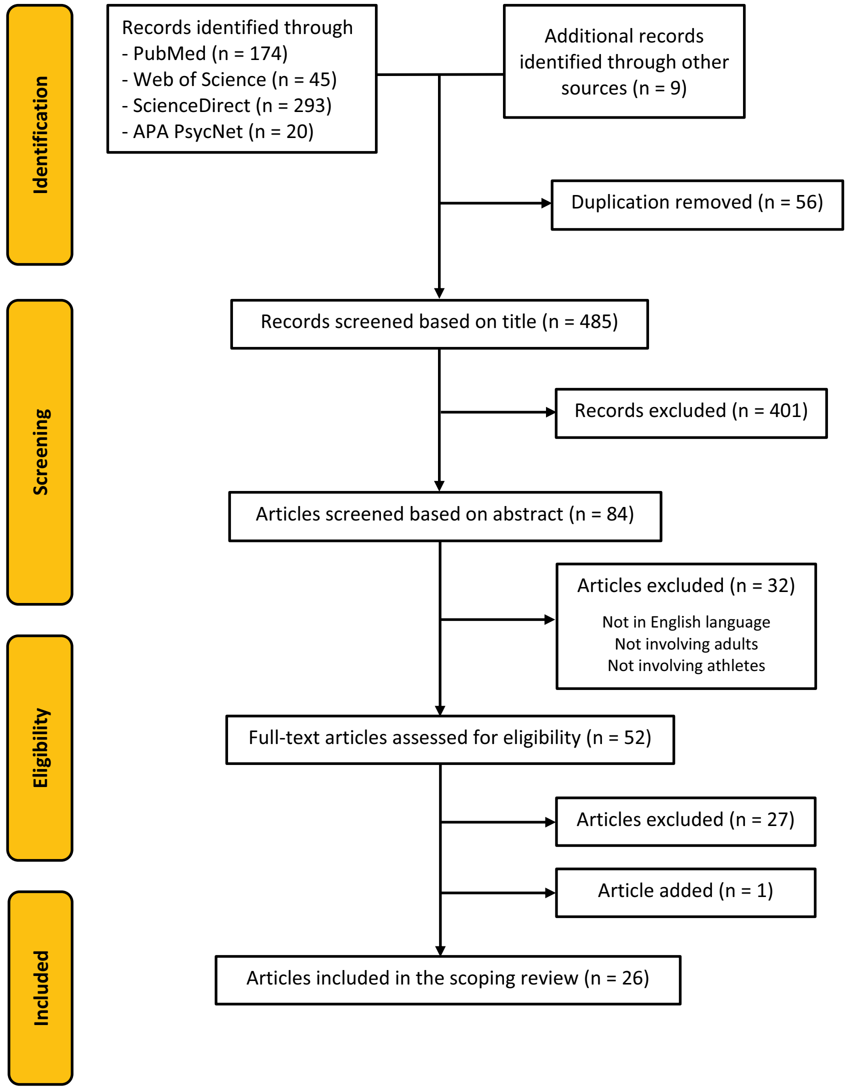

Figure 1. Flow of information through the different phases of the scoping review (inspired by Moher et al., 2009).

indicated that athletes with more expertise demonstrated enhanced IC. They reported that athletic expertise predicted 7% of the SSRT variance, 11% of the successful stops variance, and 9% of the errors variance at Time 1. In Heppe et al. (2019), the mean SSRT was not provided. Finally in Martin et al. (2016), since all the raw data were provided, we were able to compute the difference in RT between the first five minutes and the last five minutes of the task expressed in percentage relative to the last five minutes of the task for each group separately.

3.3 Results of individual sources of evidence

The results of the selected studies can be found in Table 1.

3.4 Synthesis of results

Of the 26 studies included in this scoping review, 11 articles compared athletes from a single sport with non-athletes, 10 articles compared athletes from different sports with non-athletes, and five articles reported intra-sport comparisons (comparison of athletes within the same sport). Overall, 15 sports were identified among the selected studies: fencing (*n* = 6), baseball (*n* = 5), badminton (*n* = 4), swimming (*n* = 3), tennis (*n* = 3), basketball (*n* = 2), taekwondo (*n* = 2), table tennis (*n* = 2), athletics (*n* = 1), boxing (*n* = 1), cycling (*n* = 1), soccer (*n* = 1), handball (*n* = 1), tai chi (*n* = 1), and volleyball (*n* = 1). All the studies were published between 2005 and 2021.

Regarding the tasks used in the articles, the Go/NoGo (*n* = 13), SST (*n* = 10), CST (change-signal task) (*n* = 1), BRIT (badminton reaction inhibition test) (*n* = 1), Delis-Kaplan Executive Function System (*n* = 2) and Stroop (*n* = 1) tasks were chosen to investigate IC. The Go/NoGo and the SST are widely used in the literature to give an index of IC performance (Liisa et al., 2020). Typically, in the Go/NoGo task participants are asked to respond as fast as possible to "Go" stimuli while refraining to respond when "NoGo" stimuli appear (Donders, 1969). In the SST, participants are required to respond as fast as possible to "Go" stimuli, which is occasionally followed by a stop-signal. When this stop-signal appears, participants have to cancel their ongoing response (Frederick et al., 2009).

Table 1. Table of the main characteristics and results of studies included in the analysis. c : compared to; CR: correct response; CST: change-signal task; D-KEFS: Delis-Kaplan Executive Function System; GNG: Go/NoGo task; h/w: hours per week; IC: inhibitory control; ms: millisecond; RC : rate of change; RT: response time; SSRT: stop-signal response time; SST: stop-signal task; SSR: successful stopping rate; t/w: training per week; yp: years of practice; [1]RC was only possible to compute for the comparison between elite and sub-elite players; [2]Due to the high number of groups, we reported only the percentage of variance predicted by the expertise factor in the section "3.2 characteristics of sources of evidence"; [3]the mean SSRT was not provided by the authors; [4]RT difference between the beginning and the end of the task was computed and then expressed in percentage relative to the end of the task for each group separately.

Study	Sports	Participants	Sample	Expertise	Inhibition Task	Measures	Main behavioral results
Bianco et al. (2017)	Boxing Fencing	Boxers Fencers Non-athletes	13 13 13	11.2 yp 11.7 yp	GNG	Behavior EEG	↓ RT in Boxers c. Non-athletes (RC: ↓ 12.9%) ↓ RT in Fencers c. Non-athletes (RC: ↓ 16.25%) ↓ commission errors in Non-athletes c. Boxers (RC: ↓ 52.6%) ↓ commission errors in Fencers c. Boxers (RC: ↓ 44.7%)
Brevers et al. (2018)	Taekwondo Fencing	Taekwondoka Fencers Non-athletes	14 14 25	11.3 yp 10 yp	SST	Behavior	↓ SSRT in Athletes c. Non-athletes (RC: ↓ 15.2%) ↑ proactive motor response inhibition in Athletes c. Non-athletes in Session 1
Chan John et al. (2011)	Fencing	Fencers Non-fencers	30 30	≥5 yp; 5–6 t/w	GNG	Behavior	No difference in RT between Fencers and Non-fencers No difference in commission errors between Fencers and Non-fencers No difference in commission errors between averagely-fit Fencers and averagely-fit Non-fencers ↓ commission errors in high-fit Fencers c. averagely-fit Non-fencers (RC: ↓ 41.5%) and high-fit Non-fencers (RC: ↓ 52.7%)
Chavan et al. (2017)	Fencing	Fencers Non-athletes	19 18	24'000 h over 17.2 yp	GNG	Behavior fMRI	↓ RT in Fencers c. Non-athletes (RC: ↓ 5.2%) No difference in false alarms between groups
J. Chen et al. (2019)	Badminton	Badminton players Non-athletes	19 20	>5 yp, >12h/w	SST CST	Behavior EEG	No difference in stop-accuracy and change accuracy between groups ↓ RT in Badminton players c. Non-athletes in change-RT (RC: ↓ 9.6%) and CSRT (RC: ↓ 7.1%)
Chen & Muggleton (2020)	Tai Chi	Tai Chi Regularly exercising Sedentary	20 20 20	-	SST	Behavior EEG	↓ SSRT in Tai Chi (RC: ↓ 15.3%) and Regularly exercising (RC: ↓ 12.2%) c. Sedentary ↓ Go RT in Tai Chi (RC: ↓ 14.3%) and Regularly exercising (RC: ↓ 12.8%) c. Sedentary ↓ Go accuracy in Sedentary c. Tai Chi (RC: ↓ 2.3%)
Chiu et al. (2020)	Basketball	Guard basketball players Forward basketball players	27 19	7.2 yp; 8.5 t/w; 2.6 h/t 6.3 yp; 7.5 t/w; 2.5 h/t	GNG	Behavior EEG	No difference in RT between groups No difference in accuracy rate between groups
Di Russo et al. (2006)	Fencing	Fencers Non-athletes	12 12	≥4 yp	GNG	Behavior EEG	↓ RT in Fencers c. Non-athletes (RC: ↓ 11.3%) No difference in false alarms between Fencers and Non-athletes
Elferink-Gemser et al. (2018)[1]	Table tennis	Elite table tennis players Sub-elite table tennis players Norm scores from a representative sample	30 30 1750	3'924h total; 14.5 h/w 1'124h total; 3.8 h/w	D-KEFS Design Fluency Test (DFT) D-KEFS Colour-Word Interference test (CWI)	Behavior	Better performance in all tasks in Table tennis players c. to Norm scores ↓ Number of mistakes in CWI in Elite c. to Sub-elite players (RC CWI-3: ↓ 50%; RC CWI-4: ↓ 57.7%)
Hagyard et al. (2021)[2]	**Study 1:** Externally-paced sports Self-paced sports **Study 2:** Externally-paced sports	**Study 1 (Time 1; Time 2)**: Non-athletes Novices Amateurs Elites Super-elites **Study 2:** Novices Amateurs Elites Super-elites	 37; 14 14; 11 15; 9 30; 23 10; 7 29 28 19 15	**Study 2:** Mean playing experience: 10.35y	SST	Behavior	**Study 1:** Enhanced IC performance in expert groups (higher expertise outperformed their lower expertise counterparts) with ↓ SSRT, ↑ successful stop trials and ↓ commission errors in Time 1. ↑ IC performance from Time 1 to Time 2 in expert groups **Study 2:** Positive relationship between Successful Stops and sport performance (sport performance assessed by athlete- and coach-ratings) Negative relationship between SSRT and sport performance (same rating as above)
Heppe & Zentgraf (2019)[3]	Handball	Elite handball players Active controls	30 30	Second league in Germany	SST (hand; foot)	Behavior	↓ SSRT Hand c. Foot ↓ SSRT in Handball players c. Controls

(Continued)

Table 1. (Continued).

Study	Sports	Participants	Sample	Expertise	Inhibition Task	Measures	Main behavioral results
Kida et al. (2005)	Baseball Tennis	Baseball players Tennis players Non-athletes	65 22 106	AAA level or Kansai University team (Japan) Kansai University team (Japan)	GNG	Behavior	↓ RT Baseball players c. Tennis players (RC: ↓ 11.8%) ↓ RT Baseball players c. Non-athletes (RC: ↓ 15.6%) ↓ RT in high-skill c. low-skill Baseball players (RC: ↓ 14.6%) No difference in RT among skill levels in Tennis players
Liao et al. (2017)	Badminton	Professional players Non-athletes	42 5	11.2 yp; 5.7 t/w; 5.5 h/t; starting age: 1.1	SST	Behavior	No difference in SSRT between Badminton players and Non-athletes No differnce in accuracy for the no-signal condition between Badminton players and Non-athletes Significant difference in stop possibility in Badminton players c. Non athletes (Greater likelihood of successfully stopping prepotent responses)
Martin et al. (2016)[4]	Cycling	Professional road cyclists Recreational road cyclists	11 9	>5 yp; >5 t/w 2 yp; ~3t/w	Stroop colour-word task	Behavior	↓ RT over time in both groups Greater ↓ RT over time in Profess. c. Recreat. Cyclists (Profess. RC: ↓ 17.5%; Recreat. RC: ↓ 6.3%)
Meng et al. (2019)	Badminton Volleyball	Badminton players Volleyball players Non-athletes	35 29 27	11.3 yp; 5.8 t/w; 5.6 h/w; starting age: 10.1 11.6 yp; 5.1 t/w; 4.2 h/w; starting age: 10.8	SST	Behavior	No difference in SSRT between groups ↑ SSR in Volleyball players (SSR=50.0%) c. Badminton players (SSR=43.4%)
Muraskin et al. (2015)	Baseball	Baseball players Non-player Novices	9 10	Collegiate Division I	Sport-related GNG	Behavior EEG	↓ RT Baseball players c. Non-player Novices (RC: ↓ 9.7%) ↓ error rate Baseball players c. Non-player Novices (RC: ↓ 23.7%)
Nakamoto & Mori (2008a)	Basketball Baseball	Basketball players Baseball players Non-athletes	20 24 13	High-, Medium-, Low-skill High-, Medium-, Low-skill	GNG	Behavior	↓ Go RT Basketball players c. Non-athletes (RC: ↓ 11.0%) ↓ Go RT Baseball players c. Non-athletes (RC: ↓ 13.6%) No difference in RT between Basketball players and Baseball players ↓ Go RT High-skill Baseball players c. Low-skill Baseball players (RC: ↓ 11.8%) ↓ Go RT Medium-skill Baseball players c. Low-skill Baseball players (RC: ↓ 8.1%) No difference in RT between skill levels in Basketball players No difference in commission errors between groups
Nakamoto & Mori (2008b)	Baseball	Baseball players Non-baseball players	9 9	7–12 yp; 25 h/w 6–15 yp in track and field or gymnastic	GNG	Behavior EEG	↓ index value (GoRT/Simple RT) in Baseball players c. Non-players in the baseball-related GNG (RC: ↓ 5.6%) No difference in commission errors between groups
Van de Water (2017)	Badminton	Elite badminton players Non-elite badminton players	15 9	7 h/w; starting age: 8 2h/w; starting age: 11	Badminton Reaction Inhibition Test (BRIT) Domain-general SST Badminon-specific SST	Behavior	No difference in domain-general RT between groups ↓ badminton-specific RT in Elite c. Non-elite players (RC: ↓ 19.5%) No difference in domain-general IC and badminton-specific IC between groups No correlation between national ranking and badminton-specific RT, domain-general RT and badminton-specific IC Negative correlation between national ranking and badminton-specific IC in Non-elite but not in Elite players
Vestberg et al. (2012)	Football	Soccer higher division (HD) Soccer lower division (LD) Standardized norm group	29 28 -	HD: Swedish highest national soccer leagues LD: Swedish Division I (male) and 2nd National Division (female)	D-KEFS: Design Fluency (DF) Colour-word interference test (CWI)	Behavior	Better score in DF in HD (score:15.52) c. LD (score:13.18) (RC: ↓ 17.8%) Better score (trend) in CWI in HD (11.62) c. LD (10.86) (RC: ↓ 7.0%) Better score in the more demanding CWI in HD (12.17) c. LD (10.79) (RC: ↓ 12.8%) Significant correlation between the result from the executive test and the number of goals and assists the players had scored two seasons later
Wang et al. (2013a)	Tennis Swimming	Tennis players Swimmers Sedentary	20 20 20	5.5 yp; ≥3 t/w; 3 h/t 4.85 yp; 5 t/w; 2.5 h/t	SST	Behavior	↓ SSRT in Tennis players c. Swimmers (RC: ↓ 9.6%) ↓ SSRT Tennis players c. Sedentary (RC: ↓ 11.4%) No difference in SSRT between Swimmers c. Sedentary No difference in noncancelled response rates between groups
Wang et al. (2013b)	Tennis Swimming	Tennis players Swimmers Sedentary	14 14 14	3–11 yp 2.5–9 yp	GNG	Behavior	↓ RT in Tennis players c. Sedentary (RC: ↓ 6.3%), but no difference for other groups comparisons No difference in commission errors between groups ↓ normalized foreperiod effect in Tennis players c. Sedentary (RC: ↓ 8.7%), but no difference for other groups comparisons

(Continued)

Table 1. (Continued).

Study	Sports	Participants	Sample	Expertise	Inhibition Task	Measures	Main behavioral results
Yamashiro et al. (2021)	Baseball Track and field	Baseball players Track and field athletes	10 12	>9 yp >7 yp	Somatosensory GNG Auditory GNG	Behavior EEG	↓ somatosensory RT in Baseball players c. T&F athletes (RC: ↓ 9.5%) No difference in RT between groups in auditory GNG No differnce in commission errors between groups in both GNG
You et al. (2018)	Table tennis	Table tennis players Non-athletes	20 19	≥8 yp; mean 1.7 yp	Conscious GNG Unconscious GNG	Behavior EEG	Conscious: ↓ RT Table tennis players c. Non-athletes (RC: ↓ 15.7%) Unconscious: RT slowing between GO and NOGO in Table tennis players c. Non-athletes
Yu et al. (2021)	Taekwondo Swimming	Taekwondoka Swimmers Non-athletes	12 12 16	≥2 yp; ≥3 t/w; ≥3 h/t ≥2 yp; ≥3 t/w; ≥3 h/t	Flanker/SST	Behavior	No difference in SSRT between groups Post-error slowing in Non-athletes ↓ RT post-error in Taekwondoka c. Non-athletes (RC: ↓ 7.7%) No difference in post-error accuracy between groups
Zhang et al. (2015)	Fencing	Fencers Non-athletes	26 26	≥6 yp	GNG	Behavior EEG	↓ RT in Fencers c. Non-athletes (RC: ↓ 9.0%) ↓ accuracy rate in the NOGO in Non-athletes c. Fencers (RC: ↓ 26.4%)

Overall, the results indicated that sport practice induced better performance in IC. When comparing different sports or when comparing athletes with non-athletes, the RC varies between 2.3% and 52.6%. When comparing different levels of expertise within the same sport, the RC varies between 6.3% and 57.7%.

4. Discussion

The aim of this scoping review was to offer a synthesis of the research on the relationship between sports practice and IC performance. In this section, we present an overview of the main results of the studies included in this review with a focus on the tasks used to assess IC performance in the sports context, the key factors of sports practice (i.e., types of sport, amount of practice) that develop IC and the knowledge gaps that indicate future research directions.

4.1 Are laboratory-based IC tasks appropriate to consistently assess IC performance?

The articles collected for this scoping review used the Go/NoGo ($n = 13$), SST ($n = 10$), the CST ($n = 1$), the BRIT ($n = 1$), Delis-Kaplan Executive Function System ($n = 2$) and Stroop ($n = 1$) tasks.

For example, C. Chavan et al. (2017) showed through a Go/NoGo task that fencers had shorter RTs than non-athletes. Along the same lines, J. Chen et al. (2019) illustrated via the SST and a change-signal task that badminton players were faster at inhibiting motor responses compared to non-athletes. However, the results differed in five other studies. Chan John et al. (2011) found no significant difference between fencers and non-fencers in Go/NoGo RTs and commission errors; Chiu et al. (2020) reported no significant difference between guard and forward basketball players following a Go/NoGo task; Liao et al. (2017) detected no significant difference between professional badminton players and non-athletes in RTs and accuracy after the SST; van de Water et al. (2017) showed no significant difference between elite and non-elite badminton players following the Badminton Reaction Inhibition Test (BRIT; a variant of the SST); and Chia-Chuan et al. (2021) found no significant difference between athletes (taekwondo and swimming) and non-athletes for some of the values analysed after a Flanker/SST task.

These results suggest two interesting points about the relationship between sports practice and expertise in IC. First, it cannot be stated that all Go/NoGo tasks or SSTs show differences between various groups of athletes or non-athletes. Second, there is no clear evidence in athletes that some tests prove differences in IC more than others.

Interestingly, all the articles with the exception of four (Muraskin et al., 2015; Nakamoto et al., 2008a, 2008b; van de; Water et al., 2017) explored athletes' IC performances by selecting standardized cognitive tasks widely used in the field of cognitive psychology. If, for example, a researcher wants to isolate and capture specific processes to evaluate pure motor IC, computer-based tasks in a controlled environment, such as in a research laboratory, are encouraged. Nevertheless, when we seek to capture or train processes that are acquired in complex environments or that are influenced by multiple internal factors (i.e., anxiety, physical and functional constraints, emotion, motivation) and external factors (i.e., context of the situation, opponents, competition setting, level of uncertainty, time constraint), we should prioritize methods that better reflect the multifaceted nature of the sporting situations (Broadbent et al., 2019; Roca et al., 2016). We suggest that designing experimental tasks that are related to the sport being investigated could help triggering the "true" IC expertise acquired over the years.

Only four of the articles collected for this scoping review investigated IC performance with sports-specific stimuli. In Muraskin et al. (2015), the authors compared baseball players to non-player novices on a Go/NoGo task that mirrors an in-game baseball-batting situation of a batter "sitting on a pitch". The stimuli included fixed images of representative ball trajectories. Their behavioural results indicated that the baseball players had faster RTs and committed fewer errors than the novices. In the study of van de Water et al. (2017), the researchers used a domain-general SST and a badminton-specific SST. The first was characterized by a procedure similar to the SST presented by Logan et al. (1984) and made it possible to evaluate domain-general IC. This task involved go-stimuli (cartoon cyclists facing right or left) and stop-stimuli (red crosses) depicted on a computer screen. For the badminton-specific SST, the participants were positioned in front of a wall with three lights and, once the light was on in the centre of the wall (pink or yellow), they had to turn off the correct light on the right (pink) or left (yellow) using badminton-specific movements and positions. However, if, when making a movement right or left, the participants saw all three lights unexpectedly turn red, they had to stop their motor response and not turn off the light. The results of this study showed no difference between the elite and non-elite badminton players, neither in the domain-general SST task nor in the badminton-specific SST. Last, Nakamoto et al. (2008a) compared basketball players, baseball players, and a group of non-athletes on a Go/NoGo task with baseball-specific stimulus-response relations. The authors showed that the basketball and baseball players had shorter RTs than the non-athletes on this baseball-specific task. These same authors conducted another study that compared baseball players to novices on Go/NoGo tasks with baseball batting-specific stimulus-response mapping or without baseball-specific stimulus-response relationships (Nakamoto et al., 2008b). Their results showed that the baseball players had shorter RTs in the baseball-specific task than in the other conditions, while the novice group showed no differences in RT level across the tasks.

4.2 What are the key factors of sport crucial to develop IC?

4.2.1 Do open- versus closed-skill sports affect IC differently?

According to the definitions given by Qian et al. (2019), open-skill sports refer to sports performed in a dynamic and unpredictable environment, while closed-skill sports are performed in a relatively stable and predictable environment. The open-skill sports found in the articles collected for this scoping review include fencing, baseball, badminton, tennis, basketball, taekwondo, table tennis, boxing, soccer, handball and volleyball. Closed-skill sports include swimming, athletics, cycling and tai chi.

In the studies selected for this scoping review, we see that open-skill sports ($n = 11$) predominated compared to closed-skill sports ($n = 4$). It can be hypothesized that IC is stimulated in different ways depending on the type of sport and the spatio-temporal requirements. As confirmed by Meng et al. (2019), open-skill sports require a greater involvement of inhibition processes because of the rapidity of the stimuli (temporal constraints) and the unpredictability of opponent behaviours (spatial constraints), which change dynamically and continuously. For example, J. Chen et al. (2019) showed that badminton players often have to inhibit a swing as soon as it becomes inappropriate and adapt their movements to deal with a constantly unpredictable environment. Similarly, according to Russo et al. (2006), fencing involves a rapid adaptation of behaviour, and therefore inhibition capacity, given the diversity of actions taken by the opponent. Overall, the results showed that athletes practicing an open-skill sport presented decreased RT and/or fewer error rate compared to sedentary participants (such as in Bianco et al., 2017; Brevers et al., 2018; C. Chavan et al., 2017; Heppe et al., 2019; Russo et al., 2006). Nevertheless, when comparing athletes practicing an open-skill sport with athletes practicing a closed-skill sports, the results are not consistent. Wang et al. (2013a) and Yamashiro et al. (2021) found that practicing an open-skill sport led to better IC performance than practicing a closed-sport (tennis versus swimming in Wang et al., 2013a; baseball versus track and field athletes in Yamashiro et al., 2021). In contrast, no difference between tennis players and swimmers were found in Wang et al. (2013b) and no difference between taekwondo and swimmers were shown in Chia-Chuan et al. (2021). Despite the small number of studies investigating the relationship between IC expertise and the practice of a closed-skill sport, the results seem to indicate the mere effect of practicing a sport, whether it is an open- or a closed-skill sport, could improve IC to a similar extent.

Studies comparing one sport with non-athletes. Table 1 shows that 11 studies compared athletes of one sport with non-athletes: fencing (Chan John et al., 2011; C. Chavan et al., 2017; Russo et al., 2006; Zhang et al., 2015), badminton (J. Chen et al., 2019; Liao et al., 2017), baseball (Muraskin et al., 2015), Nakamoto et al. (2008b), tai chi (C.-Y. Chen et al., 2020), handball (Heppe et al., 2019), table tennis (You et al., 2018).

Among these studies, nine showed that the RTs of the athletes were significantly faster that the RTs of non-athletes, which would indicate the superior functioning of the athletes' inhibition processes. On the other hand, two studies found no significant difference between the groups in terms of RT (Chan John et al., 2011, fencing; Liao et al., 2017, badminton). The interpretation provided by Liao and his collaborators was that the number of years of education in the group of non-athletes might have had an influence on the cognitive functions and therefore on IC. In fact, the level of education has been associated with cognitive performance, namely a lower level of education has been linked with poor performance on cognitive tests (de Passos et al., 2015). These same authors underlined the importance of better controlling participants' demographic characteristics in future research, which would eliminate certain confounding variables in the analyses.

Regarding the participants' error rates during the IC tasks, three articles (C.-Y. Chen et al., 2020; Muraskin et al., 2015; Zhang et al., 2015) showed that the athletes were faster and made fewer mistakes than the non-athletes, whereas two studies (Heppe et al., 2019; Nakamoto et al., 2008b) did not give specific information on this. In contrast, the remaining six of the 11 articles found no significant difference between the groups in terms of errors made. The better IC performance showed by athletes could represent an important asset in sports requiring high controlled attention in stressful decision-making situations. Furley and Et Greg Wood (2016) for example suggested that as some sports (i.e., tennis, basketball, soccer) require high controlled attention in specific moments such as time-constrained decision-making situations, having superior executive functions abilities may represent an asset for time-constrained complex situations. This controlled attention has been theorized as the Attentional Control Theory (Eysenck et al., 2007), which relies on two attentional systems: a goal-directed (top-down) system, in charge of supporting task goals, and a stimulus-driven (bottom-up) system, reactive to salient stimuli (Maurizio et al., 2002). When threat conditions appear, the increased anxiety causes an imbalance and impair the whole attentional control system leading to a decrease in processing efficiency (e.g., visual search strategies and cognitive processes). Interestingly, Ducrocq et al. (2016) demonstrated that tennis-specific attentional control training improved IC under high-pressure conditions suggesting a decreased distractibility during competitive situations. Hence, while anxiety seems to impact control attentional processes (Ducrocq et al., 2016), high proficiency in IC can represent a « protective effect against a potential decrease of attentional focus due to pressure. Inversely, we could assume that evolving in stressful environment, such as in time-constrained sport situations, could improve IC performance. This could be one explanation why athletes exhibit faster inhibition processes than non-athletes in most of the studies collected for this scoping review.

Studies comparing athletes within the same sport (intra-sport). As seen in Table 1, five studies compared different groups of athletes within the same sport: basketball (Chiu et al., 2020), table tennis (Elferink-Gemser et al., 2018), cycling (Martin et al., 2016), badminton (van de Water et al., 2017), soccer (Vestberg et al., 2012).

Chiu et al. (2020) constituted two groups of basketball players with different positions on the court (guards vs forwards), whereas the four other studies compared two groups of athletes with different levels of expertise: elite vs sub-elite table tennis players (Elferink-Gemser et al., 2018), professional vs amateur cyclists (Martin et al., 2016), elite vs. non-elite badminton players (van de Water et al., 2017), and male and female soccer players in high vs low divisions (Vestberg et al., 2012). However, Elferink-Gemser et al. (2018) and Vestberg et al. (2012), in addition to comparing the two groups of athletes, also included a representative sample (1′750 children, adolescents and adults from 8 to 89 years in Elferink-Gemser et al. (2018)) and a standardized group norm in Vestberg et al. (2012) (the authors did not provide additional information).

In Chiu et al. (2020), the researchers examined the effect of basketball players' positions (guards vs forwards) on IC. The authors chose to focus on guards and forwards on the assumption that IC would differ between these two positions as they require different physical skills during the game (movements, direction of travel, speed, etc.) that are subject to IC. The hypothesis was that the guards would present better IC performance compared to the forwards, as their position requires higher level of cognitive load and additional changes in direction during the game. The findings did not support the hypothesis since no significant difference between guards and forwards was demonstrated. The authors argue that all basketball players participate in offensive and defensive tactics, regardless of their offensive or defensive positions, which would diminish the effects of the playing positions. Cognitive differences between offensive and defensive positions have been demonstrated in football (Wylie et al., 2018) and in volleyball (Montuori et al., 2019), but the unique playing position in basketball would explain this lack of effect.

Regarding the other four studies, although van de Water et al. (2017) did not find a significant difference between elite and non-elite badminton players in terms of inhibition, the behavioural results in Elferink-Gemser et al. (2018), Martin et al. (2016) and Vestberg et al. (2012) showed significant difference between the groups investigated. In the study of Elferink-Gemser et al. (2018), the athletes (elite and sub-elite table tennis players) had better performances on all tests compared to the representative sample, and the elite players made fewer errors during the colour-word interference test than the sub-elite players. Along the same lines, Martin et al. (2016) showed via a Stroop task that the professional cyclists decreased their RTs more and made more correct responses than the amateur cyclists. In addition, Vestberg et al. (2012) demonstrated that soccer players in the high-division group had better results in terms of behavioural inhibition than players in the low-division group. These studies show that differences can appear within the same sport depending on the athletes' level of expertise. This theme is explored further in chapter 4.2.2: Is the level of expertise a key factor of IC performance?

Studies comparing several sports. Table 1 shows that nine studies compared athletes from two different sports with non-athletes (Bianco et al. (2017), boxing and fencing; Brevers et al. (2018), taekwondo and fencing; Jack et al. (2021), externally-paced and self-paced sports; Kida et al. (2005), baseball and tennis; Meng et al. (2019), badminton and volleyball; Nakamoto et al. (2008a), baseball and basketball; Wang et al. (2013a), tennis and swimming; Wang et al. (2013b), tennis and swimming; and Chia-Chuan et al. (2021), taekwondo and swimming), whereas a single article (Yamashiro et al., 2021) compared athletes from two different sports (baseball and athletics) without including a group of non-athletes. Also, regarding the type of sport, Yamashiro et al. (2021), Wang et al. (2013a), Wang et al. (2013b), Chia-Chuan et al. (2021), and Jack et al. (2021) compared an open-skill sport to a closed-skill sport, whereas the other five studies compared two open-skill sports.

In the study of Yamashiro et al. (2021), the Go/NoGo task results showed that baseball players exhibited better somatosensory discrimination compared to the athletics group (reflected by decreased RTs in the baseball players). The somatosensory Go/NoGo task was implemented by current pulses delivered to the second digit (NoGo condition) and the fifth digit (Go condition) of the dominant hand. Since baseball is an open-skill sport that takes place in a fast-paced and unpredictable environment, player actions often need to be adapted or suppressed. In contrast, in a closed-skill sport like athletics, characterized by a stable and predictable environment, the inhibition processes are likely to be less stimulated.

Along the same lines, Wang et al. (2013a) showed that the tennis (open-skill sport) players had a shorter SSRT compared to the both the sedentary subjects and the swimmers (closed-skill sport). On the other hand, although Wang et al. (2013b) found that tennis players had shorter RTs and a shorter normalized foreperiod[1] effect than the sedentary subjects, no significant difference was found between the tennis players and swimmers for RT, normalized foreperiod effect, or commission errors. Similarly, Chia-Chuan et al. (2021) did not detect a significant difference between sports groups (taekwondo practitioners vs swimmers vs non-athletes) in SSRT and post-error accuracy, whereas non-athletes had longer RTs than the taekwondo practitioners and exhibited post-error slowing. These results seem to indicate that a closed-skill sport can be just as conducive to stimulating IC as an open-skill sport. We can presume that athletes practicing closed-skill sports would not specifically train motor IC, which is usually measured, but they might rather train other types inhibition, such as the ability to inhibit unwanted thoughts or negative emotions.

Regarding the five studies that compared the athletes of two open-skill sports with non-athletes, it can generally be seen (with the exception of the study of Meng et al., 2019) that the athletes had better performances than the non-athletes in terms of IC. Indeed, Bianco et al. (2017) showed that the athletes had shorter average RTs (fencers: 402 ms ±55; boxers: 418 ms ±55) than the non-athletes (480 ms ±48). Similarly, Brevers et al. (2018) found that athletes (taekwondo practitioners and fencers) had shorter SSRT and better inhibition of proactive motor response than the non-athletes. In addition, Kida et al. (2005) used a Go/NoGo task and showed that baseball players were faster in terms of IC than non-athletes. Nakamoto et al. (2008a) also showed that athletes (baseball and basketball players) had shorter RTs compared to non-athletes.

On the other hand, Meng et al. (2019) found no significant difference between groups (badminton players vs volleyball players vs non-athletes) in SSRT. However, this study found that the volleyball players had a higher successful stopping rate (SSR) than the badminton players. This result suggests

[1]the foreperiod corresponds to the time interval between a warning signal and an imperative signal. In this specific study, the foreperiod was either 500 or 1500 ms. The normalized foreperiod indicates the time cost induced by temporal uncertainty.

that even when two open-skill sports are compared, differences in IC are sometimes observed. This finding was also reported in two other articles of this scoping review. Bianco et al. (2017) showed via a Go/NoGo task that boxers made more errors than fencers, and Kida et al. (2005) showed that baseball players had shorter RTs than tennis players. Thus, this finding underlines the importance of studying the specific characteristics of each sport and identifying the inhibition processes involved, as even between open-skill sports, the expertise level leads to different performances of IC.

4.2.2 Is the level of expertise a key factor of IC performance?

The quantity of practice. Among the 26 articles selected for this scoping review, 20 had quantified the expertise of the athletes in different ways (number of years of practice, number of training sessions per week, accumulated training hours, training hours per week, training hours per session): Bianco et al. (2017), Brevers et al. (2018), Chan John et al. (2011), C. Chavan et al. (2017), J. Chen et al. (2019), Chiu et al. (2020), Russo et al. (2006), Elferink-Gemser et al. (2018), Jack et al. (2021), Liao et al. (2017), Martin et al. (2016), Meng et al. (2019), Nakamoto et al. (2008b), van de Water et al. (2017), Wang et al. (2013a), Wang et al. (2013b), Yamashiro et al. (2021), You et al. (2018), Chia-Chuan et al. (2021), and Zhang et al. (2015).

The number of years of sports practice reported in these articles varied between 2 and 17.2 years, a rather large difference. Indeed, in the article by Chia-Chuan et al. (2021), the swimmers and taekwondo practitioners were required to have completed at least 2 years of training, whereas for C. Chavan et al. (2017), the fencers had to have achieved world-class ranking, which indicates an average of 24’000 hours of training accumulated over 17.2 years of practice. This large difference in terms of years of practice might be due to the type of sport, as each sport has its own technical requirements and a variable learning time. However, it might also be explained by the difficulty of recruiting very high-level athletes who have been practicing their sport for many years.

Fourteen of the 20 studies cited above showed that IC was better in athletes who had a significant amount of training behind them compared to subjects with no sports experience or with less practice: Bianco et al. (2017), Brevers et al. (2018), C. Chavan et al. (2017), J. Chen et al. (2019), Russo et al. (2006), Elferink-Gemser et al. (2018), Jack et al. (2021), Martin et al. (2016), Nakamoto et al. (2008b), Wang et al. (2013a), Wang et al. (2013b), Yamashiro et al. (2021), You et al. (2018), and Zhang et al. (2015). As noted, better IC in these athletes was generally reflected at the behavioural level by shorter RTs (i.e., acceleration of inhibition processes) and a lower number of errors, which, according to Christ et al. (2001), are the two main indicators for evaluating performance in behavioural inhibition. For example, Zhang et al. (2015) showed through a Go/NoGo task that fencers with at least 6 years of practice had shorter RTs and made fewer errors than non-athletes with no fencing experience. In the same vein, the study by Martin et al. (2016) showed that professional cyclists with more than 5 years of cycling experience and more than five training sessions per week had a greater decrease in RT over time and achieved more correct responses compared to amateur cyclists with an average of 2 years of cycling experience and approximately three training sessions per week. However, in two articles (Wang et al., 2013a; Wang et al., 2013b), although tennis players showed better IC than sedentary subjects, no significant difference was found between swimmers and sedentary subjects, despite the 2.5 to 9 years of training in the group of swimmers. This finding suggests, as mentioned above, that in addition to the amount of sport practiced, it is also important to consider the type of sport being practiced. Indeed, given that swimming is a closed-skill sport, the inhibition processes would be less involved than in tennis, which is an open-skill sport. Thus, even though swimmers train in their sport and sedentary people do not train at all, the type of sport can explain why these two groups did not differ in terms of IC performance.

In contrast, in five of the 20 studies (Chan John et al., 2011; Liao et al., 2017; Meng et al., 2019; van de; Water et al., 2017; Chia-Chuan et al., 2021), the results differed from those obtained by the 14 articles cited in the previous paragraph. According to van de Water et al. (2017), a possible reason why no significant difference was detected between elite and non-elite badminton players is that the test used, the BRIT, was not able to detect differences between the two groups (i.e., elite and non-elite badminton players). Another explanation given by the same authors is that the participants of the two groups were too homogeneous in terms of sports expertise. As for the study of Chan John et al. (2011), the researchers speculated that the results did not show better IC in the fencers compared to the non-fencers because the Go/NoGo task was not challenging enough to be able to pick up a difference in inhibition between the two groups.

Chia-Chuan et al. (2021) noted that the low number of years of practice might explain why no difference in SSRT was shown between the groups (taekwondo practitioners vs swimmers vs non-athletes) compared to the practice years reported in other articles (at least 2 years). However, this explanation did not pertain to the findings of Liao et al. (2017) and Meng et al. (2019), whose participants had a rather high number of practice years (11.2 in Liao et al. (2017), 11.31 and 11.57 in Meng et al. (2019), but the results did not show significant difference between athletes and non-athletes. Therefore, in addition to the number of years of practice, it appears that other factors might also influence performance in IC. Indeed, according to the interpretation advanced by Liao et al. (2017), years of education in the non-athlete group may also have influenced IC.

Thus, these findings suggest that a number of years of practice are needed before differences in IC performance can be detected. However, the discrepancies between the results indicate that the number of practice years cannot be the only factor influencing IC performance.

Other classifications of sports expertise. Among the 26 studies in this scoping review, six articles did not quantify the expertise of the athletes. Specifically, one study (C.-Y. Chen et al., 2020) gave no information about the athletes’ expertise (tai chi), whereas another article (Nakamoto et al., 2008a) described the skill levels of the athletes (basketball and baseball players) by placing them into one of three groups: high-skill, medium-skill and low-skill. The other four studies indicated the team level of the athletes: in the article by Heppe et al. (2019), the handball players played in the second league in Germany; in the study of Kida et al. (2005), the tennis players belonged to the Japanese Kansai Student Tennis League (university students) and the baseball players played at the AAA level (professional players) or the Japanese Kansai Big 6 Baseball League (university students) or the Japanese High School Baseball Federation team (high school students); in the study of Muraskin et al. (2015), the athletes were Division I college baseball players; and in the study of Vestberg et al. (2012), the high-division male and female soccer players played in the highest Swedish national leagues, whereas the low-division male players were in Swedish Division I and the female players were in Division II.

This finding suggests that the amount of sports practice in numerical values is not the only factor that determines an athlete's expertise, which was also shown by Swann et al. (2015) in a review including 91 athletic expertise studies. These authors argued that when comparing athletes within the same sport, the notion of expertise should be based not only on the amount of experience at that specific level, but also on the athletes' highest performance level and their degree of success at this level. On the other hand, when comparing athletes from different sports, the overall competitiveness of the sport and its competitiveness in the athlete's home country of the must be considered. Interestingly, the recent article of Jack et al. (2021) followed the recommendation of Swann et al. (2015) and categorized their athletes population into non-athletes, novice, amateur, elite and super-elite. When no information about the athletes' expertise is given, such as in C.-Y. Chen et al. (2020), the results are difficult to interpret in context. Therefore, we recommend that all articles should report athletes' expertise in details, in order to provide a more comprehensive picture of the population.

While the definition of sporting expertise remains an unresolved issue in the field, we believe that the classification proposed by Swann et al. (2015) provides useful avenues to differentiate the different levels of expertise in athletes. We encourage researchers to move away from the simplistic classification of expertise based on the athletes' years of practice or the level of practice, and to opt for a more precise athletes' classification when investigating the effect of sporting expertise.

Starting age of practice and previous sports experience. In addition to the amount of practice, expertise in sport may also depend on other factors that are difficult to control, such as the age at the start of training or the individual's history with sport. Table 1 shows that three studies indicated the average age at the start of training for the athletes: 10.1 years for badminton players (Liao et al., 2017), 10.06 years for badminton players and 10.83 years for volleyball players (Meng et al., 2019), and 8 years for elite badminton players and 11 years for non-elite badminton players (van de Water et al., 2017). These values varied between 8 and 11 years, which is standard for certain sports but considerably late for early-maturity sports characterized by predominant technical features and the athlete's lean and flexible body. Indeed, according to Baker (2003), in sports where the highest performance level is achieved at an early age, such as rhythmic gymnastics and figure skating, early specialization is considered fundamental. However, with regard to IC, the study of Büning et al. (2021) showed that it is more likely the divergent learning experiences in sport that improve executive functions, including motor inhibition and creativity. According to these authors, it is important to favour multi-sport activities rather than early specialization in order to promote better cognitive adaptation. In addition, the study of Bedard et al. (2002), who were interested in the development of IC over the life course, used an SST task and showed a progressive acceleration of SSRT with age throughout childhood (between 6 and 17 years old) and in young adults (between 18 and 29 years old). Interestingly, a thorough picture of the development of IC throughout life has been proposed by Diamond (2013), which suggests that good IC early in life appears to be predictive of IC outcomes in adulthood. In the same vein, Christ et al. (2001) showed that childhood is a fundamental period for cognitive and frontal lobe development. Notably, this study examined IC during childhood and found that younger children (<11 years) had slower inhibition response times than older children (≥11 years old), suggesting that there is a period of life more conducive to the development of IC, which is put into place over time.

Therefore, it can be assumed that early specialization in sport does not necessarily have an effective impact on IC. Indeed, IC instead seems to improve through contact with various motor experiences (e.g., the practice of multiple sports), and IC mechanisms develop gradually throughout childhood and the initial phase of adulthood. For this reason, it is important to consider sports expertise related to IC from a broader perspective that encompasses several factors, such as the level reached by the athletes and the sports practiced during childhood.

Our analysis thus suggests that the relationship between sports practice and expertise in IC depends on a minimum amount of practice to become expert. However, this quantity is not fixed but varies depending on the type of sport and can be influenced by other factors that are difficult to control.

4.3 What are the knowledge gaps pointing to future research directions?

This scoping review has enriched our thinking about the relationship between sports practice and performance in IC and suggests avenues for future research. Regarding the type of task, the relevance of laboratory inhibition tasks in the sports field should be assessed to ensure solid links between sports practice and IC expertise, and experiments that reflect the sports context more authentically should be devised so that the athletes' motor responses actually mimic those used on the playing field. In addition, more longitudinal studies could be conducted to follow the evolution of athletes' IC over the long term and to confirm the effect of sport practice on IC performance over time. Out of the 26 studies included in this scoping review, only three articles (Jack et al., 2021; Kida et al., 2005; Vestberg et al., 2012) proposed a longitudinal experimental design to better understand whether IC ability is rather innate or acquired and whether it can be developed. Kida et al. (2005) for example showed that 2 years of baseball hitting practice led to decreased RTs measured with a Go/NoGo task. Jack et al. (2021) showed that IC can be developed longitudinally over a 16-week period and Vestberg et al. (2012) used prospective data of goal and assists in football to compare them with the results of a design fluency test assessed the year before. Regarding the type of sport, it would be interesting to assess IC in other categories of sport, such as artistic or target sports, in order to test the relevance of classifications into open- versus closed-skill sports. As for the amount of practice, a more precise definition of expertise in sport would help better classify athletes according to their performance level and more clearly explain the link between sports practice and expertise in IC. In addition, it would be worthwhile to assess whether the relationship between sports practice and expertise in motor inhibition depends on the number of years of practice based on the technical evolution in each sport or only up to the acquisition of a certain performance level, after which additional years of practice would no longer be a determining factor.

5. Conclusion

In this scoping review, we identified 26 studies in the field of IC in sports to better understand the relationship between sports practice and IC expertise. In general, the main results showed that athletes exhibit shorter RTs than non-athletes, which would reflect better IC performance.

Regarding the type of task, this scoping review showed that Go/NoGo and SST tasks predominate in studies of the relationship between sports practice and expertise in IC. We found, however, that not all Go/NoGo tasks or SSTs show significant differences between groups of athletes. In addition, we found a lack of studies that propose tasks closer to the sports context.

Regarding the type of sport, this scoping review showed that open-skill sports are favoured in studies investigating the relationship between sports practice and expertise in IC as these sports require a greater involvement of inhibition processes because of the changing environment, the rapidity of the stimuli (temporal constraints) and the unpredictability of opponent behaviours (spatial constraints), which change dynamically and continuously. Yet, our research supports the idea that focusing only on open-skill sports is insufficient and even questions the pertinence of the open- vs closed-sport distinction in trying to explain the sports practice–IC expertise relationship.

As for the amount of sports practice, this review revealed that the relationship between sports practice and expertise in IC depends on a minimum amount of practice to become expert. However, this quantity is not fixed but varies with the type of sport and can be influenced by other factors that are difficult to control, such as the age at the start of training or the educational background.

Authors' Contributions

All authors conceived the review, developed the methodology and discussed the results. D.B. and M.S. explored the literature. M.S. wrote the main manuscript. All authors reviewed the manuscript.

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Appendix

Appendix 1. Search strategy for PubMed

Database	Search string
PubMed	(“motor inhibition”[All Fields] OR “inhibitory control”[All Fields]) AND (“sport”[All Fields] OR “sports”[All Fields]) AND (“athletes”[All Fields] OR “experts”[All Fields] OR “expertise”[All Fields] OR “elite”[All Fields])