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Research Article

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Cognitive Mechanisms Underlying Sports Performance of Athletes Engaged in Strategic Team Sports

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ABSTRACT
We examined the cognitive performance of athletes engaged in strategic team sports such as football and basketball with sixty participants including athletes with at least five years of experience at National/State level in football and basketball and non-athletes. Measures of vigilance (continuous performance task), selective attention (spatial cuing task), visual search (feature and conjunction search task), attention network task, working memory (n-back task) and motion perception (apparent motion task) were employed. Athletes outperformed non- athletes on measures of vigilance, visual search, selective attention, and motion perception as they need to process multiple stimuli and engage in coordinated actions. Compared to football players, basketball players performed better with respect to vigilance, attentional facilitation and shifting; and faster target detection in conjunction search task with higher set-size. This is explained in terms of the need to assess the diverse environment and dynamically respond to the requirements related to movement sequences. Basketball and football players were comparable to non-athletes on the working memory task. Football players showed better performance on motion perception task compared to basketball players by effectively varying the temporal distance between stimuli for a strong motion percept, which may account for their ability to judge the speed of motion helping them to accurately perceive other's actions to prepare for their own action. Thus, different strategic team sports may involve different cognitive skills mediating sports performance. Future work needs to explore more about sport- specific cognitive-perceptual expertise in athletes engaged in team sports as a function of training and experience using a longitudinal design.

Keywords: Sports Cognition, Strategic Team Sports, Selective Attention, Visual Search, Engagement and Disengagement of Attention, Spatial Cuing, Motion Perception, Working Memory

Introduction

There has been a recent upsurge in research in the area of sports investigating the characteristic skills and cognitive abilities underlying expertise in sports [1]. Studies have primarily focused on motor imagery, perceptual abilities, and flow states to define the cognitive mechanisms of expertise in sports which distinguish skilled performers from low skilled ones. It is argued that although perceptual abilities are inherent in all levels of sport performance, cognitive abilities are essential for expertise in sports. Although, research on sports expertise is relevant for theoretical as well as practical reasons, yet very few studies have examined cognitive processes other than action capabilities to define expertise in sports [2]. The component processes underlying expertise in sports need to also examine the role of different aspects of attention (sustained, selective and executive attention) and working memory in addition to motion perception. Sports Psychology researchers have focused on expert-novice differences rather than focusing on the processes that explain such differences. Such research is considered difficult because the cognitive mechanisms underlying sports performance may evolve over time and may interact in a nonlinear manner [3]. Few studies have examined cognitive processes such as attentional shift, focused attention and perceptual decision making in athletes [4]. It is argued that although visual-perceptual abilities are inherent in all levels of sport performance, general cognitive processes such as attention and working memory are essential for developing specific skill and expertise in a given sport [5]. Voss et al. also categorize three kinds of sports: static, interceptive and strategic [4]. Static sports are self-paced and independent (swimming); interceptive sports are externally paced and require involve good coordination between body and object of play (tennis or badminton); strategic sports require information processing and effective as well as efficient attentional processes. This is why researchers have reported differences in performance on various cognitive tasks. For instance, athletes engaged in strategic sports perform better on visual attention and inhibition compared to those in interceptive sports [6,7]. The present study aimed to

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compare cognitive performance of athletes engaged in different strategic sports (basketball vs football players) to understand the association between participation in strategic sports and different aspects of attention (sustained, selective and executive control of attention) and working memory (reaction times and accuracy as measures of performance). Vigilance as a measure of sustained attention, orienting and visual search, as a measure of selective attention and ANT as a measure of executive control of attention were examined in the present study. In addition, working memory maintenance and manipulation as a function of working memory load was also examined.

Role of attention in skilled sports performance has been highlighted by many [8]. Sports performance requires alertness, attentional selectivity, and ability to perform two or more skills concurrently. Visual attention plays an important role in sport [9,10]. For referees in team sport, for example, it is important to perceive as many game situations as possible. Recognizing and extracting relevant features allows the referee to make good decisions [11,12]. Numerous studies in the past have reported the predominant attentional capacities of sports experts [13,14]. For example, Nougier and colleagues used behavioral measurements to study attention orienting [15]. They showed that experts practicing open- skills sport, such as basketball, exhibit higher attentional flexibility (i.e. quickly shifting attention in the visual space). In addition, experts can modulate their attention resources according to the task demands [16]. They are also capable of extracting important information more quickly and use this ability to perceive more relevant features [13]. This process is described as selective attention, which Posner and Boies defined as "the ability to select information from one source of one kind rather than the other" [17]. Experts selective attention and visual search strategies have been studied using eye-tracking systems [18,19].

The research program initiated by Bard and colleagues at Laval University in Canada was the first to investigate systematically differences in visual search strategy in sport [20]. This study typically investigated the differences in search strategies which occurred when subjects were presented with schematic slides of sport situations. For example. Bard and Fleury examined the search patterns of five expert and five novice basketball players while viewing typical offensive game situations [21]. Whilst viewing the slides, subjects visual search patterns were recorded using eye movement registration system. Results showed fewer fixations prior to response by expert basket ballers than novices. Expert performers show systematic differences in the location of ocular fixations across the available features of the display, suggesting enhanced selective attention processes [19,22,23].

Research on sports cognition in the recent years has examined cognitive profiles of athletes and has shown better performance on cognitive functions related to their training and sport-specific demands. To the best of our knowledge none of the previous studies have compared cognitive performance across strategic or open skill sports. Most of the work has either compared open vs closed skill sports or strategic vs static sports or expert vs novices [24,25]. However, it is equally important to understand if different strategic sports also vary in terms of the cognitive demands related to different aspects of attention, working memory and motion perception. Such knowledge also allows to explore if training and experience in a certain strategic sport could be associated with benefits in certain cognitive functions. In addition to the development of sport expertise, stability in performance is an important concern among athletes which may largely be determined by basic cognitive abilities [26]. Strategic team sports like basketball and football require rapid visual search, orienting, and rapid shifts in attention as well as sustained attention. Working memory (visuospatial working memory in particular) underlies performance across different sports. The present study examined performance on measures of selective, sustained and executive attention; maintenance and manipulation in working memory and motion perception among experienced athletes of open skill strategic team sports.

It was hypothesized that sports persons would show an advantage with attentional processes with faster reaction times on tasks of sustained attention, spatial cueing, attention network task and better accuracy on the working memory task, compared to the non-player controls. It was also hypothesized that there would be differences in these cognitive processes (reaction times and accuracy as the measures of cognitive performance) critical for performance in football and basketball. However, specific hypothesis related to the nature of differences in the cognitive processes that are critical for football players versus basketball players was explored in this research, given the paucity of research comparing different strategic sports.

Method

Participants

A total of sixty participants (Mean age: 22.5 years, all males) were taken for the study. Participants were either pursuing their graduation or had completed their graduation. Forty athletes with at least two years of consistent experience of playing professional Basketball and Football at National level with twenty athletes in each of the two sports were recruited for the study. Criterion for selection was at least two years of professional experience with a particular sport at National level in this case football/basketball from the time of assessment. Age and education matched twenty non-athletes with no professional experience with any sport were taken as the control group. Football and basketball players were recruited for the study from a local football club and a sports complex. Random assignment of participants to the respective groups was followed in the present study. Coaches were approached first for the selection of the participants. The participants were screened for visual acuity using the visual acuity test, and neurological/psychiatric disorder with the help of a proforma. None of the participants were recovering from concussion at the time of data collection.

Measures

Continuous Performance Task

The continuous performance task was used as a measure of vigilance. Vigilance is a measure of sustained attention. Subject's basic level of alertness is a fundamental component of all cognitive tasks. This task requires low intensity of stimulus presentation and low frequency of critical incidents.

Stimuli and Procedure

Stimulus for this task was designed using the software visual basic. The stimulus consists of dots arranged in an imaginary square path. The dots are shown on the monitor as small circles. A brightly flashing dot travels along the square path in small jumps. Sometimes the dot takes a double jump to which the subject has to respond by pressing the enter key. A practice session is run first in a 1-minute cycle followed by the main session with a 5-minute cycle, with 30 double jump detections within five cycles to be made in a five-minute session. Number of double and single jumps is randomized.

Visual Search Task

This paradigm allows researchers to examine how visual stimuli are differentiated, what stimulus properties attract attention, how attention is deployed from one object to the next how one keeps track of what was attended. In a typical visual search task, participants have to identify a target among distractors and the number of distracters is randomly varied across trials. In a conjunction search task, a target is defined in terms of two features (eg green circle among blue squares) as used in the current study.

Stimuli and Procedure

Stimuli for this experiment consisted of blue squares with a green square as the target. Size of each square is 1cm. The test begins with the fixation cross which appears at the centre of the screen and stays for 200 ms. The search display is then presented with or without the target. The number of distracters varies across trials ranging between 4-24 stimulus items. The subjects are required to press a key if the target is present and press another key if the target is absent. 25-30% trials are target present trials. Total number of trials is 210. A practice session with 20 trials is run before starting the main trials.

Spatial Cuing Task

Spatial cuing task was used to measure covert orienting of attention.

Stimuli and Procedure

Stimuli for this experiment consisted of an arrow pointing towards night or left which was used as a cue that predicted the location of the target. The experiment started with a fixation dot presented for 400 ms followed by an arrow pointing towards right or left. Cue was presented for 100 ms followed by a colored red square as the target which appeared to the night or left of the fixation dot. The target was either in the same location as predicted by the cue on valid train or on the location which opposite to the location predicted by the cue on invalid trials. 80% of the trials were valid trials when cue correctly predicted the target and 20% of the trials were invalid trials when cue did not predict the target correctly. There were some neutral trials also in which a neutral cue appeared with a straight line without any arrow Neutral cue did not predict the location of the target. The participants were asked to focus on the central fixation dot throughout the experiment. They were required to press the key "N" on the keyboard as soon as the target appeared. They were required to detect the target and press the key as quickly as possible.

N- Back Task of Visuospatial Working Memory

The n-back task was used to examine visuospatial working memory in the present study. This task requires on-line monitoring, updating, and manipulation of remembered information.

Stimuli and Procedure

Stimulus was designed using visual basic running on a PC computer with a 14 monitor with a refresh rate of 100 Hz. The responses were obtained through the keyboard. Participants were seated in a dark room 60 cm away from the monitor. Each stimulus was a point on the perimeter of the circle that subtended 0.95" x 0.95 from the participant's eye. 9 such points were used. Alphabet 'A' was the stimulus, which could appear in one of the nine locations.

The participant was required to match the currently shown position of a white colored capital letter "A" to the immediate previous position and say, "YES" if they match and "NO" if they did not for the one back task. The trial began with an initial position of the stimulus for which the subjects did not have to make any response but they had to remember its location on the screen. This was followed by the next stimulus position. The participants were required to press the key Y on the keyboard for a yes response, or the key N for a no response. The trial did not move forward until response. There were 140 trials in total with 25-30% trials being the target trials and remaining were non-target trials.

Attentional Network Task (ANT)

Attentional Network Test (ANT), a combination of flanker task and spatial cuing, was employed to examine the efficiency of alerting, orienting and executive attention networks.

Stimuli and Procedure

In this task the target array is a black colored single arrow or a horizontal row of five arrows. presented above or below fixation, over a grey background. The participant was required to respond whether the central target arrow was painting to the left or right by pressing the corresponding left or right key on the keyboard. The ANT consisted of a total of 24 practice trials and three experimental blocks of 48 trials in each. Each trial represented one of 12 conditions in equal proportions, three target types (congruent, incongruent and neutral) and four cues (no cue, central cue, double cue and spatial cue) are employed. The trial began with a fixation at the Centre of the screen for 400ms followed by the cue (*) for 100 ms after which a blank screen was presented for 400ms followed by the arrow flankers above or below the fixation cross. Participants were required to respond to the direction of the central target arrow (left or right) by pressing the z key for the leftward target and / key for the rightward target.

Motion Perception Task

Experiment on motion perception was conducted to examine the perception of appearance of motion with respect to speed of motion among sports persons:

Stimuli and Procedure

Distance from center is a proportion of the number of horizontal pixels on the drawing screen. The center-to-center distance between the dots would be twice this number Computer has 96 pixels per inch and the drawing screen contains 1272 horizontal pixels. Task on each trial is to set the interstimulus interval (IST) so that one gets the strongest appearance of motion between the dots. The ISI is the time between the offset of one dot and the onset of the other dot. The participants were required to press the

<i> key to increase the ISI and the <k> key to decrease the ISI After one has set the timing so that the appearance of motion is as strong as possible. the participant is asked to press the space bar to start the next trial. On different trials the spacing between the dots will change. There were five levels at which distance between the two dots was varied Task is the same on each trial to set the ISI so that one has the strongest appearance of motion between the dots

Results

Accuracy and reaction times were the measures of performance for all the tasks. Data obtained with 60 participants was subjected to statistical analysis in order to compare the performance of the two experimental groups and to compare the performance of the experimental groups (athletes) against that of the control group (non-athletes) for each experiment. Anticipatory and slow trials were treated as outliers following the mean +/- 3SD criteria. About 1-2% of such trials were removed in each group and each experiment. Only correct trials were analyzed for each task. Accuracy ranged between 92-98% across all the tasks and all the three groups of participants. Statistical analysis was conducted using the software Stats and SPSS. Mixed ANOVA and post hoc comparisons using the Tukey's post hoc tests were computed for each experiment to find out the independent and interactive effects of various conditions within each experiment and differences across the three groups. Accuracy scores were used to analyze the performance on vigilance task and working memory task. Reaction times were used to analyze the performance on visual search task, spatial cuing, motion perception, and attention network task.

Vigilance Task

Results based on one way ANOVA showed a significant effect of group, $F(2, 57) = 6.55$, $p < .01$. Sports persons performed better on the vigilance task compared to the control group (see Table 1 in Appendix). Basketball players were significantly better compared to football players with respect to vigilance/sustained attention, $t(57) = 5.50$, $p <. 01$.

Table 1: Mean performance of the three groups in terms of accuracy on the vigilance task

Group	N	Mean	SD
FP	20	17.95	6.71
BP	20	23.45	4.81
CG	20	18.15	5.02

Visual Search Task

Reaction times for feature search and conjunction search conditions across the three set sizes and three groups were compared. Mixed ANOVA with 3 (groups) x 2 (search type) x 3 (set size) was performed with groups as a between subject factor and search type and set size as within subject factors. Main effect of group, $F(2, 57) = 0.671$, $p > .05$, was not significant. Main effect of search type was significant with slower RTs for conjunction search compared to feature search, F(1, 58)= 88 87, p < 001. However, the interaction between group and search type was not significant, F(2, 171) 2.16, $p > .05$. Main effect of set size, $F(2, 57) = 29.07$, p < 001 was significant with increase in RTs as a function of set size. There was a significant interaction between search type and set size, $F(2, 57) = 17.82$, $p < .001$. Post hoc comparisons shows significantly slower reaction times for set size 16 and 64 for conjunction search compared to feature search (All ps < .001). The interaction between group and set size, was significant, $F(4, 114) = 2.76$, $p < .05$. However, the post hoc comparisons for this interaction did not yield any significant effects. The three way interaction between group, search type and set size, $F(4, 114)= 2.42$, $p < .05$ was significant (see Figure 1). Results based on posthoc comparisons suggest that the difference in visual search performance between the football players and basketball players did not reach statistical significance (All ps > .05). Table 2 in the appendix presents the mean and SDs on the visual search task across the three groups.

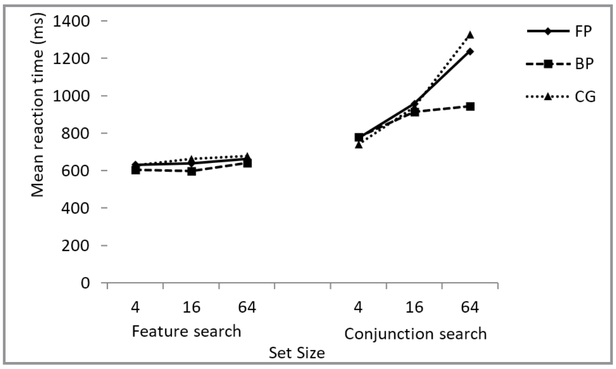

Figure 1: Presents the mean reaction times of the three groups across the three set sizes with respect to feature and conjunction search on visual search task. FP: Football players; BP: Basketball players; CG: Control group

Table 2: Mean performance of football players, basketball players, and control group for feature search and conjunction search conditions for set size 64 on the Visual search task

Group	N	**FP		FA		CP		CA	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
*FP	20	656.69	144.32	854.78	274.27	1286.43	344.53	1826.25	374.33
BP	20	650.6	82.88	728.46	126.86	1343.14	180.39	1919.19	260.62
CG	20	679.88	126.07	787.16	271.74	1316.31	179.11	1876.47	262.97

Note. *FP: Football Players; BP: Basketball Players; CG: Control Group; **FP: Feature Present; FA: Feature Absent; CP: Conjunction Present; CA: Conjunction Absent.

Spatial Cuing Task

Reaction times for invalid trials were greater than valid trials for all the three groups. However, the magnitude of difference in reaction times between the invalid and valid trials varied across the three groups. Main effect of group was significant, F(2. 57) = 3.02, p< .05, with overall faster reaction times of basketball players compared to the football players and control group. The effect of cue type was also significant, F(2, 57) = 40.78, p < .001, with faster reaction times for valid than invalid trials. The interaction between group and cue type F(4, 114)= 3.24, p <.05 was significant (see Figure 2). Football players were found comparable to the control group. Basketball players showed better attentional facilitation as they were significantly faster than football players (t(57) = 8.54, p< .001) and control group (t(57) = 5.44, p < .01) on valid trials. Basketball players were also significantly faster on invalid trials compared to football players (t(57) = 10.40, p < .001) suggesting better attentional disengagement as compared to the football players.

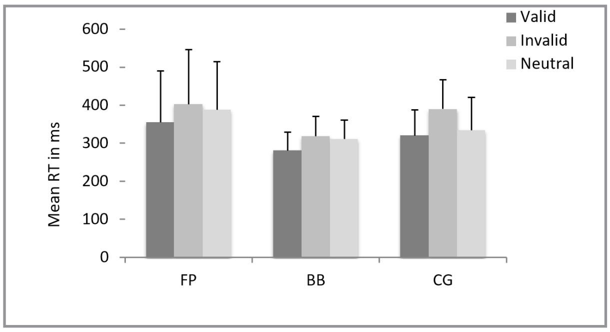

Figure 2: Presents the mean reaction times of the three groups on the spatial cuing task. FP: Football players; BB: Basketball players; CG: control group

Working Memory Task

One-way ANOVA was performed to compare the performance (accuracy) of the three groups of participants on working memory task. Main effect of group was not significant, F(1, 57) = 1.32, p > .05, suggesting comparable performance on working memory task across the three groups. However, mean performance suggests that sports persons performed better on the working memory task as compared to the control group. These results may be due to the lesser working memory load involved in the task.

Attention Network Task

The ANT task was employed to examine the three most important facets of attentional processing viz alerting orienting and executive attention networks [27]. The Alerting Network's functioning is studied by presenting a cue before target stimulus responses are faster when the target is preceded by an alerting cue. The orienting network is explored by presenting a cue that signals the position of the target stimulus will appear responses are faster when cue signals the position of the target than when it does not convey information about the target's spatial location. The Executive attention network has responses that tend to be slower for incongruent than for congruent trials, revealing the time needed to resolve the conflict between the target stimulus and to be ignored flanker information. The experiment has two within factors 'Cue Type" (no cue, centre cue, double que spatial cue), and "Flanker type" (neutral, congruent, incongruent). As apparent the 1st factor depicts where a cue shall appear so that the participant can make use of it and the 2nd factor depicts the nature of the cue information. Overall, mean accuracy for non-athletes was 94.83%, for football players it was 97.57%, and for basketball players it was 98.64%. Data obtained with the ANT task was also analyzed with respect to alerting effect, orienting effect and conflict effect scores of the attention networks Data was also analyzed with respect to the reaction times for each of the four cue conditions and congruency to compare the performance of the three groups. The grand mean with respect to target detection RTs was found to be 580.65 ms for the control group, 572.83 ms for football players and 559.15 ms for basketball players. Main effect of group was not significant, F(2, 57)= 959, p > .05. The three groups were comparable with respect to the overall accuracy and overall detection RTs.

Mixed ANOVA with group x network type was performed to compare the scores on alerting, orienting and executive control network scores across the three groups. Main effect of group was not significant, F(2, 57) = 0.13, p> .05. Main effect of network scores, F(2, 57) = 9.34, p < .001, was significant. The interaction between group and network scores was also significant, F(4, 114)= 4.04, p < .01. Post hoc comparisons for the network scores indicated that the alerting, orienting and executive control were comparable across the three groups (All ps > .05) (see Figure 3). Descriptive analysis (mean scores) suggest relatively better executive control among sports persons compared to the control group and relatively better orienting effect among basketball players compared to football players (see Table 3 in Appendix).

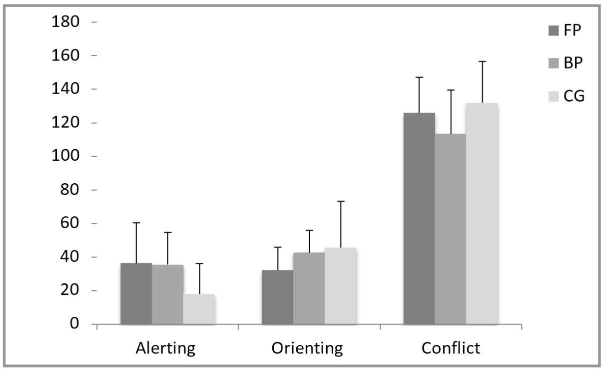

Figure 3: Presents the alerting, orienting, and executive control effect scores across the three groups

Table 3: Means and standard deviations of alerting, orienting and executive control effect as network scores across football players, basketball players and control group on the Attention Network Task

Group	N	AE		OE		EC	
		Mean	SD	Mean	SD	Mean	SD
FP	20	36.29	24.12	32.2	19.16	125.87	18.32
BP	20	35.45	13.8	42.6	13.4	113.55	27.6
CG	20	17.75	21.25	45.5	26.05	131.91	24.84

Note. FP: football players; BP: basketball players; CG: control group; AE: Alerting effect; OE: Orienting effect; EA: Executive control

Motion Perception Task

Performance on motion perception task was measured with respect to the best ISI (inter- stimulus interval) achieved with increasing distance of the moving dots from the centre to provide the participant's strongest sense of motion. Football players performed better on the motion perception task compared to basketball players and control group participants (see Table 4 in Appendix). One-way ANOVA was computed to compare the performance of the three groups of participants on the motion perception task. The three groups were significantly different with respect to the mean best ISI, $F(2, 57) = 3.96$, $p < .05$ on the motion perception task. Football players were found to be significantly better with motion perception as the best ISI increased with increase in distance between the dots giving them the strongest appearance of motion as compared to basketball players ($p < .05$).

Table 4: Mean and SD values of mean best ISI of football players, basketball players, and control group on Motion Perception Task

Group	N	Mean	SD
FP	20	43.80	18.45
BP	20	30.13	15.44
CG	20	34.50	12.56

Note. FP: Football Players; BP: Basketball Players; and CG: Control Group

To sum up, sports persons showed benefits with vigilance, visual search, selective attention (voluntary orienting), and motion perception. Basketball players were found to be better with vigilance, attentional facilitation and disengagement of attention, and self-guided search by controlling for distractor interference. However, football players showed an advantage with the speed for motion perception. Football players and basketball players were comparable with respect to visual search in case of less distractor interference, and working memory.

Discussion

The present study aimed to examine attentional processes like selective attention via spatial cuing and visual search task, sustained attention using a vigilance task, attentional networks using ANT, and working memory using the n-back task among sports persons engaged in strategic open skill sports (football and basketball players). Data obtained was analyzed to compare the performance (RTs and/or accuracy) of sports persons against the control group as well as to compare the performance of football players against that of basketball players. Results indicate a) Sports persons performed better on measures of vigilance, visual search, selective attention (voluntary orienting), and motion perception; b) Basketball players were found to be better with respect to vigilance or sustained alertness compared to football players; c) Basketball players were found to be better with respect to attentional facilitation and disengagement of attention on the spatial cuing task compared to football players; d) Basketball players were faster to detect the target in case of conjunction search condition with larger number of distractors compared to football players; e) basketball and football players were comparable on working memory task; f) football players showed better performance on motion perception task compared to basketball players.

Consistent with previous studies, sports persons in strategic sports such as football and basketball displayed better performance on tasks of motion perception and visual attention compared to non-athletes [6,28]. In one of the recent studies by Rahimi et al. overall faster reaction times were observed among strategic sport athletes [25]. Sports persons may be at an advantage as they are required to process multiple stimuli, engage in coordinated actions and execute complex actions [29]. Most of the previous work comparing strategic team sports (basketball, volleyball for instance) with self-paced sports (eg swimming) has demonstrated that the cognitive demands of playing such sport may train athletes to perform better on tasks of attention and executive functions. Playing a strategic sport may require the athletes to filter out irrelevant distracting information and selectively attend to cues that inform about player's position [30]. This is consistent with the findings of the current study showing benefits related to selective attention among football and basketball players compared to non-athletes. It is possible that strategic sport athletes have efficient information processing which may facilitate top-down processes in anticipation of the tact and move of their opponent team [4].

Basketball players performed better on the vigilance or continuous performance task suggesting greater demand for sustained and focused attention while playing a sport like basketball. The demands on vigilance are determined by many factors. For instance, during a long testing time the participant has to show continuous attention; the relevant signals appear randomly and do not attract automatic attention. The vigilance task in the current study also tapped this ability to sustain attention over a prolonged period of time which could be a greater demand in basketball. These findings are in line with a previous study by Gallotta et al. which showed better concentration performance among children engaged in open skill sports [31]. In addition, previous work on another similar strategic team sport like volleyball, showed superior performance of athletes related to stimulus driven visual attention [6] in terms of the alerting effect on the attention network task. However, the continuous performance task as used in the current study requires a more enduring involvement of attention as opposed to the alerting cue-based spatial attention task in case of the attention network task. Involvement of the prefrontal cortex during complex movement could be the potential mechanism underlying open skill sports and attentional functions in general.

Basketball players also showed better attentional facilitation and faster attentional disengagement compared to the football players and non-athletes in a spatial cuing task. Previous research has shown superior covert orienting among sports persons however, some studies have suggested that basic aspects of attention such as orienting are not affected by sport expertise [32]. In the current study, orienting was manipulated by presenting a cue indicating where in space a target is likely to occur, thereby directing attention to the cued location [33]. These effects have been attributed to covert attention which influences the efficiency of information processing. Basketball players showed more efficient control over such covert attention, which suggests that they could direct their attention much faster and could make use of the cue/warning signal for preparation to respond to the subsequent target. Basketball players were also found to be able to disengage attention from an uncued location much faster compared to football players. Disengagement of attention suggests one's ability to shift attention which is one of the important components of attentional control. In team sports like basketball, athletes are unable to predict the diverse environment and thus need to respond fast and dynamically to varying requirements related to movement sequences [34]. However, this effect was not observed in case of football players.

Football and basketball players were significantly different from the control group on the visual search task for both feature search and conjunction search across the three set sizes. Control group participants were slower as compared to the sports persons and also showed a greater cost with a marked increase in reaction times from feature search to conjunction search. However, the difference in visual search performance between the football players and basketball players did not reach statistical significance. However, sports persons showed a significant advantage with the search function as compared to the control group. Search is guided by environmental information as well as internal cognitive process such as attention, memory, and deterministic process like self-organized criticality. The advantage with visual search among sports persons could be due to trained attentional processes that enable effective filtering mechanisms to detect the target and adequate perceptual speed. In general, expert athletes engaged in open skill sports such as basketball and football can resist competing stimuli and focus on the task better than non-athletes [35].

We also find that the football players, basketball players and non-athletes were comparable with respect overall target detection reaction times on the attention network task which examines alerting, orienting and executive control networks of attention. These results suggest that though the overall target detection times did not vary across the three groups, the specific effects with respect to the attention networks are not due to general slowing with target detection itself. However, the interaction between group and network scores did not reach statistical significance. Planned comparisons showed that the alerting network was most efficient for athletes as compared to non-athletes ($p < .05$). However, basketball players showed better efficiency for the orienting network compared to football players ($p < .05$) of attention as also observed in the spatial cuing task.

In addition to the attentional functions, working memory capacity is important to process large amount of information to enable the athletes to enable fast and accurate decisions. Contrary to the existing evidence, athletes engaged in open skill sports like basketball and football were comparable with non-athletes on the visuospatial working memory task. These results may be due to the less working memory load involved in the task. Previous studies have shown significantly better performance of athletes on the demanding n-back task of working memory and was also found to predict success in team sports [36].

Most of the attentional functions showed an advantage for basketball players in the current study whereas football players were significantly better with perception of apparent motion compared to basketball players. Performance on the motion perception task was measured in terms of the best ISI achieved with increasing distance of the moving dots from the centre that provides the strongest sense of motion to the participant. The farther apart the stimuli, the longer the ISI required for a good motion percept. For football players, the best ISI increased with increase in distance between the dots giving them the strongest appearance of motion, which could be due to greater and faster visual tracking involved in a game like football. These results are consistent with another study which has reported that good motion perception ability plays an important role in enhancing football skills [37]. Human perceptual system is flexible, adapting its processing mode to the environment to develop efficient information processing for tasks and stimuli specific to their sports, by extensive training [38]. Football players have an advantage with motion perception which may account for their better ability to accurately recognize and judge the speed of motion which may help them to accurately perceive other's actions in order to prepare for their own course of action.

The current study shows cognitive advantage among athletes engaged in strategic open- skill team sports like football and basketball. More specifically, basketball players show advantage with respect to sustained and selective attention, engagement of attention and shift of attention, control for distractor interference in a demanding search task, whereas football players were found better with speed of motion perception which has implications for action planning and execution in team sports like football. Following the cognitive component skills approach, athletes are expected to perform better than nonathletes on tasks of general cognitive functions which may not be sport-specific. Recent work has attempted to validate sport-specific cognitive tasks to establish the relevance of cognitive skills in sports performance [39]. The reason why we did not find significant effects specific to football players on most of the cognitive tasks employed in the current study, could be due to the fact that the tasks assessing anticipation, pattern recognition, spatial processing would have been more specific to football as a team sport [40]. Although the current study also used expert performance approach expecting to find differences related to sport expertise, yet a more comprehensive set of cognitive tasks could be used to validate the findings more effectively. Some other limitations of the current study should also be addressed in future work. The study was conducted with 60 participants yet the sample size could be larger for better statistical power. Secondly, the study had a biased sample of male athletes due to the limited availability of female athletes in the respective groups. Further, the nature of training may differ for the two groups of athletes which could be addressed by taking different sport types and diverse levels of expertise. Moreover, a longitudinal design would help in understanding the trajectory of the cognitive mechanisms underlying performance in strategic team sports as they may dynamically change overtime with practice and experience. Another limitation is that we did not control for the differences in general physical fitness of the participants. Future work should record physiological parameters like heart rate variability as well as anthropometric measures like body mass index as measures of fitness [41-51].

Conclusion

There is ample evidence to suggest that physical activity enhances cognitive performance, however very few studies have been conducted to demonstrate the beneficial effect of long-term physical training in individuals skilled with certain sport types. Most of the previous work has compared strategic sports with static sports and provide evidence for superior cognitive performance of athletes engaged in strategic team sports. However, for the first time, the current study demonstrates that cognitive performance may vary even across strategic team sports like basketball and football. In general, the findings related to superior cognitive performance of sports persons with respect to vigilance/sustained attention/alertness, selective attention and motion perception compared to non-athletes, are consistent with previous research [6]. Basketball players showed superior performance on complex attentional processes such as selective attention, engagement and shift of spatial attention, and distractor interference control in self-guided search whereas football players were better with motion perception. Findings of the current study suggest that cognitive plasticity may be driven by expertise in sports type with different cognitive demands. Moreover, research also needs to find out if cognitive performance is a consequence of experience and training in sports or apriori cognitive phenotype. Future work needs to explore more about sport-specific cognitive-perceptual expertise in athletes engaged in team sports as a function of training and experience using a longitudinal design. Studies like this have the potential to inform about the effect of sports experience on brain and cognitive function as well as inform the trainers to cultivate expert athletes.

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