



Quantitative analysis on literature of working memory on the athlete in china

Working memory is widely discussed in competitive sports. Researchers have systematically investigated the working memory system in the field of sports which was mainly based on papers publishing in English. Therefore, it is essential, in our opinion, to provide an overview of papers focusing on working memory and its relevance in sport psychology which were published in other languages, like Chinese. The China National Knowledge Infrastructure (CNKI) database was searched in November 2017, with no date restrictions, chose the theme as index item and index words were athlete and working memory (index mode was specific match). Studies were included if they were empirical research which used quantification index to demonstrate their results (investigated the relation of working memory and athlete), contained a population of athlete, involved in working memory task, published on normal domestic journals or the thesis of master or doctor. In total, 41 citations were identified, 13 of which were retrieved for full-text indexed and then conducted a quantitative analysis. There was little amount of studies in this field and most of which used scales and experimental research design methods. The studies contained the effect of working memory on athlete cognition and performance, the detriment of working memory because of combat sports as well as the impact factors on athlete working memory. Research of working memory and athlete in China gets some achievements. Inter-disciplinary research and working memory training will be trends of this field in the future.

Keywords: China, athlete, working memory, quantitative analysis

Introduction

Working memory (WM) refers to the competence of maintaining and manipulating information temporarily when an individual was executing cognitive tasks [1-3]. Currently, WM is one of the active fields in cognitive psychology due to its apparent connection with superior cognitive competences like language, learning, reasoning, thinking, problem solving and decision making [4].

The athletes' cognition is closely related to their superior neuron function, sport intelligence and mental states like emotion which further influences the perception, logic, responses and stress status in the match [5]. Researchers treat the sport itself as backgrounds to observe the athletes' behavior launch, sport memory and decision making. The WM capacity has been identified as influential in sport cognitive results [6]. The athletes with larger WM capacity perform better on sport cognition which helps them to win. However, there is no evidence from the available research to comprehensively

demonstrate the specific connection between working memory and athletes in China so far.

To show the outline and problems in working memory study on the athletes in China, the present research conducted a quantitative analysis on research (open published on professional journals, college newspapers and thesis of master & doctor) of working memory for athletes in China.

Method

The documents were retrieved from the China National Knowledge Infrastructure (CNKI) in November 2017. Firstly, under the index condition, we chose the theme as index item. Secondly, the index words should include both athlete and working memory. Thirdly, the index mode was specific match. Last but the least, the index range was entire.

Then, we got 41 documents. The 41 selected documents were artificially arranged by professionals (doctors of psychology). The arrangement criteria were as follows: (1)

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empirical research which used quantification index to demonstrate the result; (2) athletes were included in the participant part; (3) the working memory task was involved in the research; (4) documents should be full-text indexed and published on normal domestic journals and the thesis of master or doctor. Finally, 13 documents were chosen for the quantitative analysis which included 6 journal papers, 6 thesis of master and one thesis of doctor.

Results

■ Publish time and article number

Among the 13 relevant research, one was published in the year of 2009 (occupied 7.7%), one was published in 2010 (occupied 7.7%), one was published in 2012 (occupied 7.7%), three were published in 2013 (occupied 23.1%), two were published in 2014 (occupied 15.4%) and four were published in 2016 (occupied 30.7%). The specific information is list in **TABLE 1**.

■ Document type

Among the 13 relevant research, five were came from college newspapers (occupied 38.5%), three were belong to thesis of sport domain (occupied 23.1%), four were belong to thesis of psychology domain (occupied 30.7%) and one was published on the core journal in China (occupied 7.7%). The specific information is in **FIGURE 1**.

■ Research agency

Among the 13 relevant research, the author organizations included college psychology

school (6, occupied 46.2%) and college sport school (7, occupied 53.8%). The research tools involved behavioral experiment (10, occupied 76.9%) and eye movement equipment (3, occupied 23.1%).

■ Research subject

The relevant research included subjects from different sport items which were four of badminton specialty (occupied 30.7%), four of basketball specialty (occupied 30.7%), two of boxing specialty (occupied 15.4%), one in orientation (occupied 7.7%), one in football specialty (occupied 7.7%) and one in volleyball specialty (occupied 7.7%). The age range of subjects was 15 to 25 and one research included the adolescent athlete (subjects of the other 12 research were 20 years old average). The length of training was between 3 to 15 years.

■ Research content

Among the 13 relevant research, there were six research focused on the effects of working memory on athlete cognitive competence like decision making and attention (occupied 46.2%), four research explored the effects of working memory on athlete performance like motor skills, prediction and change detection (occupied 30.7%), two research investigated the athlete working memory impairment (occupied 15.4%) and one research showed the impact factor of athlete working memory (occupied 7.7%).

Discussion

■ Effects of working memory on athlete cognition

Practices of sport training showed that the athletes not only should contribute their attention on the match, they should also have good perception, memory and decision making in the match [7]. Therefore, research focused on the athlete cognition and its mechanism was given more attention and turned to be a popular issue in sport psychology. Studies of the effects of working memory on athlete cognition in China mainly include the effects of working memory capacity on athlete decision making and attention.

The studies of Ye and Tian used the self-made working memory program, sport decision making program to investigate the effects of

Table 1. Publish time and article number of documents focused on athlete working memory in China.

Year	2009	2010	2011	2012	2013	2014	2016
Number	1	1	1	1	3	2	4

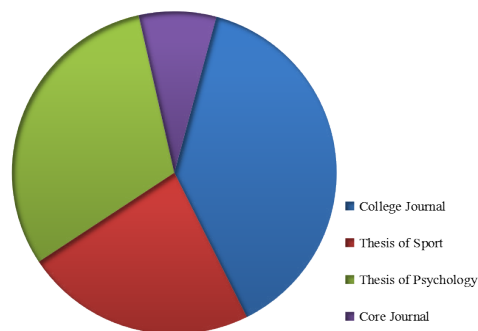


FIGURE 1. Publish time and article number of documents focused on athlete working memory in China.

emotion, working memory capacity and problem representation on athlete decision making. Their results demonstrated that working memory capacity affect the quality of athlete decision making. In addition, the visual-spatial working memory capacity modulated the effects of emotion and problem representation on athlete decision making [8,9]. Similar results came from the study of Fu and her colleague. They also used the self-made decision making program and working memory program to explore the effects of emotion regulation and working memory capacity on sport decision making [10,11]. They found that, emotion, emotion regulation and working memory capacity were important factors for sport decision making. Moreover, the effect of emotion regulation on decision making was different because of working memory capacity and the effect of verbal working memory capacity on decision making was influenced by different emotion regulation strategies.

The study of Wang and her colleague used the attention blink and working memory programs to investigate the effects of working memory capacity on athlete attention blink. The results demonstrated that the effects of masking on attention blink depending on the lag. When the masking is absent, the low duration of attention blink is longer [12]. While the study of Zhu and her colleague used the orient match map as materials together with the eye movement equipment to explore the effects of cognitive load on visual attention tactics. Their results showed that the long-term exercise training on orient may change athlete visual attention strategy. Their study indicated that the visual attention tactics of orient expertise included two kind of visual attention processes which were the goal-directed and stimulus driven attention tactics [13].

Basic conclusion can be drawn from the above studies, the larger visual spatial working memory capacity of the athletes lead to better decision making outcomes and more effective visual attention tactics. These findings provide an interesting future direction for sport professionals to consider. Superior cognitive competence like working memory should be taken into consideration for professional sport expertise training.

Effects of working memory on athlete performance

The working memory of athlete is an important issue in both sport psychology and cognitive psychology. Research of working memory has both theoretical and practical value for athlete performance. The antagonistic sport items like basketball, football and volleyball require excellent force and skill as well as distinctive mental competence like cognitive judgment [14]. Research of the effects of working memory on athlete performance in China mainly included several aspects as follows:

Firstly, the study of Wang used video simulation training and eye movement equipment to investigate the cognitive processing characteristics of perceptual-motor skills about badminton performers' selective attention and working memory [15]. In the visual search and access to training expertise, the study of Wang pointed out that the video simulation training on the perceptual-skills to enhance the role, so that broaden the channels of perceptual training.

Secondly, Zhang used self-made anticipation test system of volleyball, the simulated competitive situations together with the eye movement equipment to explore the relation among emotion, executive function and anticipation. The results showed that, the effect of emotion on the anticipation of volleyball expertise was moderated by executive function [16].

Thirdly, the study of Nian and Chai adopted a dual-task paradigm of object working memory and scene search to investigate the effects of working memory on basketball players' scene search performance. They found that it had significant differences within a group with object working memory. The reaction of basketball players at all levels was obviously different after comparison between intra-group and inter-group [17].

Last but not the least, the study of Fan adopted the flick paradigm, spatial cue paradigm and dual task paradigm to explore the effects of stimulus property, attention type and working memory on change detection. The results demonstrated that football players performed better than control groups under the central executive function task which indicated that

football players had stronger executive function competence [18].

Conclusions can be drawn from the above studies which focused on the effects of working memory on athlete performance. It turned out that not only in the theoretical aspect, but also in the practical aspect, these studies gave constructive training suggestions. Moreover, other than questionnaire and behavioral tests, the eye movement equipment was also applied to investigate the inter mechanism of athlete working memory which researchers should seek to explore novel experimental paradigms like this.

The working memory impairment for athletes

Competitive sports events like free combat and boxing often lead athlete injured especially the head and face were main areas in the training and match. The head injury was tested by equipment which only detected the organic lesions and injuries other than the functional impairments. We still don't know whether these sports events induced superior cognition damage or not.

The study of Yu and his colleague used the N-back test and Chinese auditory learning test (CALT) to investigate the effects of Sanda on working memory impairment [19]. They found that Sanda may damage the athletes' working memory, short-term memory and long-term memory. Similar results came from Li and his colleague [20]. They used the basic perception test to explore the effects of rapid weight loss on cognitive function in adolescent athletes. Their results demonstrated that mental efficiency decreased significantly in adolescent male free combat and boxing, when body weight (BW) reduced 2% BW, while when body weight reduced 5% BW, digital identification, mental arithmetic efficiency, Chinese characters rotation and digit working memory decreased significantly.

The studies above indicated that as a professional group like athletes of free combat and boxing events who were easily to get hurt in the match. The damage may not perform as organic lesions but may lead to functional brain injury which demonstrated as detriment in superior cognitive function like working memory. Clearly, more research is required to understand the specific detriment on working memory for athletes of free combat and boxing events.

Impact factors on athlete working memory

The function of working memory was not only limited by the individual working memory capacity, but also closely related to the structure of retrieval contents. The contextual interference effect is a learning phenomenon where interference during practice is beneficial to skill learning [21].

Wang and her colleague used the video working memory task in the video simulation to investigate the effects of contextual information and cognitive load on the structured capacity of badminton athletes' working memory [22]. The results showed that working memory competence was influenced by the cognitive load and contextual information. The accuracy of expertise was obviously higher than the novices. For the extraction time of memory, subjects with contextual information was faster than the subjects without contextual information.

The above study was the only one which focused on the impact factors of athlete working memory in China. Therefore, there is a long way to go on this topic. A systematic approach is required to understand the impact factors of working memory in sport domain.

Disclosure Statement

The authors have declared that no competing interests exist.

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