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Review Article

Nursing Section

Non computerised Circadian Interventions for Improving Working Memory Performance among Children

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ABSTRACT

Working memory provides a mental workspace for tasks requiring both processing and storage. Working memory is a cognitive system whose essential function is to facilitate and beautify the potential of encoding, storage, and retrieval functions that are imperative for gaining knowledge and processing of facts. It has been prompted that various mediations applied within day-to-day contexts of children have the potential to improve working memory and generate transfer to real-world skills, anyway little is known about the effectiveness of these interventions among children. This review focuses to detect deliberately the adequacy of intervention or interventional package on working memory performance of children to identify their effects on Working memory, advantages extended to near-and far-transfer capability of interventions, and gains sustained overtime and dosage of it. Literature searches were conducted across 10 electronic data bases using consistent keywords. Papers were screened by title and abstract (n=964) and judged against predefined eligibility criteria (n=63). Eighteen papers were included in the appraisal. Different working memory interventional approaches were included such as adapting the surroundings to decrease working memory loads; direct working memory training with and without tactics mandate and coaching competencies which circuitously effect on working memory (athletics, lexical apprehension, astonishing man-made play, and self-possession). Both direct training on working memory undertakings and rehearsing certain abilities that may likewise affect randomly on working memory which delivered refinement on working memory errands. Hardly, any research articulated dosage impact, estimated outlying shift of outcomes (n=4), or tried the solidness of valid statements after added time (n=4). The absence of an unmistakable hypothetical structure brought about uncertain forecasts about instructing and switch impacts. Methodological difficulties likewise compel the intensity of the proof, including: small-scale sample sizes; oversight of blinding of members and result assessors; and shortfall of active control group.

Keywords: Child, Executive function, Physical activity, Short-term, Training

INTRODUCTION

Different cerebrum forms are associated with learning to such an extent that disturbances in any one procedure may bring about a learning difficulty. Learning difficulties are characterised as a noteworthy inconsistency in any case clarified by physical or tactile hindrances between the children's scholarly working and scholastic exhibition. There is no single known reason for learning difficulties, however a few examinations have recognised hereditary components, sensorimotor framework mix impedances, and prematurity as hazard factors [1].

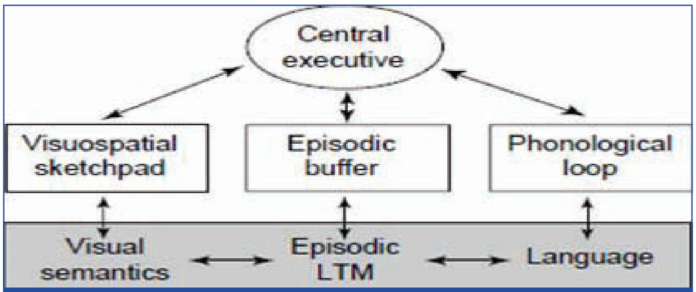
According to National Center of Learning Disability survey conducted in 2012, 12% adults have learning disability [2]. In India, reported prevalence of learning disability ranges from 1.6-15%, fluctuating dependent on age-orbit, study strategy, apparatus utilised and region of the country [3-6]. The general predominance of dyslexia in various pieces of the world is variable, (3.6-8.5% in Italy versus 4.5-12.0% in the United States) [7]. Dyslexia is the most widely recognised learning disability, affecting 80% of all those identified as learning-disabled [8]. The incidence of dyslexia in Indian primary school children has been reported to be 2-18%, dysgraphia 14%, and dyscalculia 5.5% [9].

Continuous examinations have focused on the part of working memory in learning difficulties. These investigations have discovered that working memory is a significant indicator of learning capacity [10]. Working memory appraisal can be useful in deciding learning capabilities in the child [11]. There is a speculation that diverse intervention applied within young children's everyday contexts has the potential to improve their working memory skills such as attention, language, and academic attainment [12].

Working memory is the ability to hold in mind and manipulate information over short periods in the face of distraction. It develops more in the first 10 years of life and reaches adult capacity levels around the age of 14 years [13]. Working memory is a significant component of directorial functioning and is accepted to be indispensable for critical thinking. Accordingly, working memory is quintessential to the procurement of new understanding and abilities. Anatomically, working memory is directed by means of the frontal flap [3].

Working memory supports many everyday activities and is strongly linked with attention, language learning, mental math, understanding advancement, and receptive skills and dexterity. Subsequently, poor working memory is connected with a huge scope of learning challenges, alongside unique vocabulary weakness, dyslexia (translation troubles), dyscalculia (impairment to represent and process numerical magnitude of mathematics) [14]. Children with poor working memory aptitudes experience issues adapting to practically all study related exercises including, recollecting and completing guidelines, critical thinking, and arranging, sorting out and keeping track of tasks. Instructors often portray such children as careless and distracted [13]. Youngsters with poor working memory wrestle to adapt to the substantial working memory heap of the study hall. They are at risk for dropping out of school prematurely and failing to achieve their potential in life [12].

There are various theoretical models of the structure and functions of working memory. The multicomponent model of working memory is driven by the central executive, which is capable of retrieving information from the store in the form of conscious awareness [Table/Fig-1]. The episodic buffer is assumed to be a limited capacity storage system and controlled by central executive that is capable of integrating information from a variety of sources. It can store any kind of data-acoustic, visual and spatial. Visual-spatial sketchpad stores non verbal visual and spatial data like items and numbers. Phonological circle stores set number of discourse sounds for a brief period [15,16].



[Table/Fig-1]: Baddeley's (2000) working memory model [16].
LTM: Long-term memory

Research into the effectiveness of working memory training has stemmed from two perspectives, theoretical and applied perspectives [17]. The goal of a theoretical perspective is to understand underlying cognitive processes and also to identify variables that mediate the effects of training and transfer to other cognitive functions. The focus of an applied perspective is to investigate the impact of working memory training on outcomes relating to real-world skills such as attention, language and academic attainment. The most rigorous studies, meta-analyses and systematic reviews suggest that computerised training advances profit from the instructed tasks and untrained activities but far-transfer effects are small and not sustained over time [18-23]. The lack of consistent evidence for far-transfer effects of computerised working memory training has marked the need for alternative intervention approaches. The composed tasks need to be set as typical activities in children's day-to-day schedule [24]. It has been reflected that a diverse range of activities may impact on working memory but little is known about their effectiveness.

Hence, the present review aimed to examine systematically the effectiveness of intervention or interventional package on working memory performance of children to identify; their effects on working memory, advantages extended to near-and-far transfer capacity of interventional package and gains sustained overtime and dosage of it.

LITERATURE SEARCH STRATEGIES

A literature search was performed in the following electronic database: PubMed, CINHAL plus, Google Scholar, Research gate, Science direct, EBSCOhost, PsycINFO, SCOPUS, Web of Science, Shodhganga were used to search the literature for all publications from 1994 to 2019. Final searches were conducted using the terms "working memory" OR "short term memory" OR "executive function*" AND "child*" AND "(training OR intervention* OR treatment OR therapy OR program*)".

Inclusion criteria

"PICO" framework

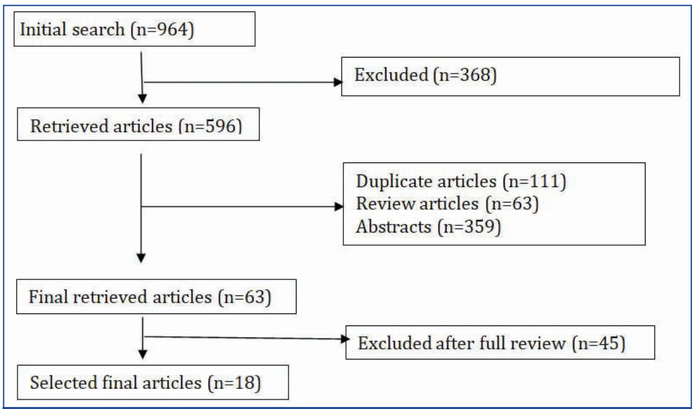
- Population- Research ought to have been carried out within children aged 4-11 years.
- Intervention- Research must have done any mediation, that objectives working memory and is used inside youngsters' day by day settings.
- Comparisons- Research must have a randomised controlled, quasi-experimental, or single case experimental design.
- Outcomes- Research must have at any rate one pre and postmediation proportions of working memory.

- Primary outcome: Effect on working memory
- Secondary outcome: Near-and-far-relay effects and the endurance of consequences added time on working memory.

Exclusion criteria : Computerised working memory training studies were excluded.

Study Selection

[Table/Fig-2] portrays that from above listed search engines, total 964 articles were received; from that 368 articles were excluded based on exclusion criteria. So total retrieved articles were 596, among which 111 duplicate articles, 63 review articles and 359 abstracts were excluded on the basis of outcome measures. Final retrieved articles were 63; among them 45 full text articles were excluded; reasons were age of participants not included 4-11 years of children (n=1), did not implement non computerised working memory intervention approach (n=14), did not have randomised-controlled, quasi-experimental, or single-case experimental design (n=5), and did not include atleast one pre and post intervention measure of the trained task (n=25). Finally, 18 full text articles were included in the review.



[Table/Fig-2]: Flow diagram of search strategy with reasons of exclusion.

RESULTS

All included studies have been categorised into four different patterns of intervention [Table/Fig-3]:

Adapting the surroundings (n=1): Just one research study [25] looked into the adequacy of the methodology which does never again require direct intercession with children. Rather, educators are prepared about how to contemplate children with functioning memory challenges and talented in how to adjust picking up information on activities limit working memory loads for these children. By diminishing working memory stacks in the study hall, children with poor working memory may strongly increase additional information on undertakings.

Direct working memory training without tactics mandate (n=3) [26-28]: Three intercessions included rehashed practice on verbal or visuospatial errands requiring transient memory (stockpiling just assignments) or executive stacked working memory (stockpiling in addition to an extra consideration or preparing load).

Direct working memory training with tactics mandate (n=5) [29-33]: Five research contemplates examined the viability of unequivocally teaching children to utilise intellectual strategies. The utilisation of systems to help the usefulness of working memory rises during adolescence. For example verbal practice (rehashing the to-be-recollected information boisterous or in your mind) creates at around seven years. Different techniques, for example, affiliation and gathering and piecing data develop subsequently. It has been recommended that youngsters can furthermore advantage higher from this system.

Coaching competencies which circuitously effect on working memory (n=9): A wide scope of exercises including judo, athletics, yoga, circumspection, music, sports and customary youth games can effect on executive function abilities including working memory. Nine research studies actualised assortment of intercessions: athletics (n=5) [34-38], lexical apprehension (n=2) [39,40], astonishing man-made play (n=1) [41] and self-possession (n=1) [42].

Author and Year of publication	Country/ University	Samples	Research type	Methodological aspects	Main findings of study
Elliott JG et al., 2010 [25]	Durham, North-East England, UK.	5-6 years and 9-10 years 256 typically developing children	A quasi-experimental study with nested design	Baseline screening among total 3189 students were done. Three cohorts were prepared among instructors isolated into 2 gatherings and gave coaching on working memory intercession, conduct educating, and no mediation for 8-11 months. No subtleties gave to evaluate measure of instructor coaching assigned.	Only Visuospatial short-term memory improved in working memory cohort.
Banales E et al., 2015 [26]	North Ryde, Sydney, Australia	9-10 years four children with reading and poor working memory complexity	Case series study	Automated working memory assessment and additional assessments to check cognitive skills of participants. Verbal working memory coaching (verbal animal N-Back and complex span task), reading training (word attack, sight word, reinforced reading) 30-minutes, 3-times a week for 8 weeks.	Working memory preparing revealed most noteworthy enhancements for verbal working memory and perusing exactness as result.
Henry AL et al., 2014 [27]	London, UK	5-8 years 36 children (18 experimental and 18 control group)	Randomised Controlled Trial (RCT)	Multiple times appraisal were done pretest before intercession, post test after mediation, at a half year interim and at a year interim. BAS-II metrics, verbal similarities, number abilities, word perusing; working memory TB-C digit review, word review, square tuned in, review, forgetting about review odd one range. Short, face-to-face training on both listening review (11 path) and the odd one out tasks (11 path) were conducted 3 times each week around 10 minutes for about a month and a half (complete 18 meetings) with experimental group. All members got acclaim and brilliantly shaded stickers.	Experimental group manifested significantly substantial clinches in executive loaded working memory tasks such as listening recall, odd one out span than in control group at post test (after 6 months) and follow-up (after 12 months).
Passolunghi MC and Costa HM, 2016 [28]	Triestle, Italy	5 years, 48 typically developing children	Randomised Controlled Trial (RCT)- 3 groups	Working memory and numeracy skill assessment done among all participants. Direct working memory training without tactics mandate specified for groups; working memory coaching group and numeracy instruction group, paper and pencil tasks in form of games for 2 times a week about 60 minutes for 5 weeks.	Working memory intervention group elevated both working memory capabilities and early numeracy abilities whereas early numeracy intervention group particularly multiplied solely early numeracy skills.
Caviola S et al., 2009 [29]	Padova, Italy	8-9 years, 4th grade; 46 children	A quasi-experimental study	SVS-questionnaire (4-point scale) used to rate children. Total 22 children were in experimental training group and 24 in control group 4 weeks (1 months) about 40 minutes session total 7 sessions of working memory training (memory recognition, memory recall and everyday memory sessions) were provided to experimental group.	Only sequential-spatial working memory (visuospatial working memory) increased in experimental group.
Comblain A 2007 [30]	Belgium	24 teenager young adults with Down's syndrome	A quasi-experimental study	Total 12 individuals with Down Syndrome in experimental group (4-children, 4-teenagers, 4-young adults) and 12 individuals with down syndrome in control group Experimental group received rehearsal training 30 minutes a week during 8 weeks.	Experimental group participants significantly improved their memory span.
Cornoldi C et al., 2015 [31]	Padova, Italy	8-10 years (3rd, 4th and 5th grade of school), 135 children	A quasi-experimental with cross-over design	Classes were relegated to 2 batches, tutoring batch I receive instruction in the initial 3 months and the other batch act as a control batch. In the subsequent stage, job of the 2 batches were turned around.	Tutoring batch exhibited enhancements in metacognitive and working memory errands with positive-related impacts on the capacity to tackle issues and furthermore kept up at the subsequent post-test (following 3 months).
Peng P and Fuchs D, 2017 [32]	USA	58 (1st grade of school) children, at risk of learning difficulties	Randomised Controlled Trial (RCT)- 3 groups	Children were assigned to 3 groups, Working memory training with and without tactics mandate or no working memory training (controls). 2 interventional group received 35 minutes 10 sessions for 10 consecutive school days	Working memory with strategy instruction group children made significant improvements on verbal working memory and comprehension performance.
Witt M, 2011 [33]	England, UK	38 (9-10 years) children	A quasi-experimental study	Youngsters were isolated into 2 gatherings with "coordinated sets" premise. Every youngster in the mediation bunch was coordinated with a kid in the benchmark group. A month and a half working memory tutoring was given to mediation bunch youngsters.	The interventional bunch had altogether better postmediation visual-design scores than their coordinated controls. Working memory mediation had a critical "thump on" impact into different territories of working memory.
Alesi M et al., 2016 [34]	Palermo, Italy	8-10 years, 44 boys	A quasi-experimental study	Forty four boys subdivided into 2 groups; group I composed of 24 boys in football exercise program and group II composed of 20 sedentary boys with no developmental disabilities. Football practice program of 75 minutes meetings, two times every week, for a half year. Every meeting joined activities to improve kids' coordination aptitudes like strolling, running, bouncing, bowing, tossing, getting a handle on.	The football bunch at post-test demonstrated essentially bigger increases than the inactive gathering on proportions of spryness, visual-spatial working memory, consideration, arranging and restraint. Arranged organised game exercises are critical to improve intellectual abilities.
Davis CL et al., 2007 [35]	Augusta, Georgia	7-11 years 94 overweight elementary school children	Randomised Controlled Trial (RCT)- 3 cohorts	Three cohorts of 30-40 youngsters were haphazardly doled out to low-portion practice treatment (20 min of oxygen consuming activity per meeting), high-portion practice treatment (40 min of activity) or a no activity control condition. Exercise meetings led five days/week for 15 weeks.	Post test score of high-dose exercise group children were significantly greater than those of control group. Physical exercise is a simple method of enhancing aspects of children's mental functioning that are central to cognitive and social development.
Kamijo K et al., 2011 [36]	Illinois, USA	7-9 years 43 preadol-escent	Randomised Control Trial (RCT)- 2 groups	Total 43 kids were haphazardly allocated to take part in either an afterschool physical movement program (interventional bunch n=22) or a shortlist control gathering (control bunch n=21). None of the youngsters got specialised curriculum administrations identified with psychological or attentional clutters. One hundred and twenty minutes physical activity intervention program following each school day for 9 months (150 days) was offered to interventional group.	Afterschool physical movement program bunch youngsters displayed increments in their cardio-respiratory wellness which is related with upgrades in the psychological control of working memory contrasted with shortlist bunch preadolescent.

Koutsandréou F et al., 2016 [37]	Westphalia, Germany	9-10 years of age, 71 elementary school children	Randomised Controlled Trial (RCT)	Total 71 youngsters haphazardly allocated to one of two trial gatherings or a benchmark group. Cardiovascular exercise bunch n=27, engine practice bunch n=23 and control bunch n=21. Exploratory gatherings got 45 minutes 3 times each week practice for 10 weeks. Control bunch got schoolwork meetings to forestall consideration predisposition.	Working memory execution of the 9-10-year-old children profited by both the cardiovascular and the readiness afterschool practice programs. The discoveries delineated that working memory execution improved to a bigger degree because of the readiness practice intercession when contrasted and the cardiovascular mediation.
Van Der Niet AG et al., 2016 [38]	Netherland	8-12 years, 105 primary school children	A quasi-experimental study	Fifty three children were allotted in Interventional group and 52 children in the control group. Interventional group receives cognitively demanding drill mediation for 30 minutes during break time 2-times a week for 22 weeks. Cognitively demanding drill mediation includes sit-ups, push-ups, robe skipping, running, and circuit training.	Interventional bunch youngsters demonstrated a fundamentally more noteworthy enhancement for the Stroop test, estimating restraint, and on the DS test, which estimates verbal working memory, in examination with the benchmark group. No huge impacts were found on the other executive functioning measures and any of the physical wellness factors.
Melby-Lervåg M and Hulme C, 2010 [39]	Oslo, Norway	7-8 years, 160 children	A quasi-experimental study	Total 160 children were evenly allocated to one of four groups: the phoneme-awareness training, rhyme-training, vocabulary training, and untrained control groups. Children in the three training conditions were trained individually for approximately 7 minutes per day for 10 days on the 10 trained words.	Phoneme-awareness training improved serial recall substantially and improved free recall to a lesser extent. In contrast, vocabulary training produced a substantial boost in free recall and a lesser increase in serial recall. These consequences for review were explicit and didn't sum up to undeveloped words. Rhyme preparing created increments in rhyming abilities yet no expansion in either sequential or free review.
van Kleeck A et al., 2006 [40]	Dallas, Texas	4-5 years, 24 specific language impairment children	A quasi-experimental study	Twenty four children divided into experimental and control group. Intervention group children received 15 minutes of small-group sessions 2 times a week each week for 2 semester	Weekly phonological awareness instruction among children with language impairments resulted in improved phonological awareness and improved phonological working memory.
Thibodeau RB et al., 2016 [41]	Southern U S	3-5 years 110 typically developing children	Randomised Controlled Trail (RCT)-3 groups	Total 110 children randomly assigned to 1 of 3 conditions: fantastic pretend-play, non imaginative play intervention or business-as-usual control. Fifteen minutes 5 times a week sessions of fantastical pretend-play and non imaginative play intervention was given to children for total five weeks	Fantastical pretend-play group children showed improvements in executive functions whereas children in the other two conditions did not. Engaging children in fantastical play is one way to directly enhance executive functions development.
Volckaert AMS and Noël MP, 2015 [42]	Belgium	5 years 47 typically developing pre-schoolers	Randomised Controlled Trail (RCT)	Forty seven pre-schoolers after pre-test haphazardly distributed to either a control (n=23) or an exploratory gathering (n=24). The two gatherings took an interest in two 45 minutes meetings, 2 times each week for about two months. Control bunch participated in handcraft meetings and exploratory gathering got hindrance instructional courses.	Experimental group children showed significant higher score in post-test on inhibition, attention and working memory measures. Executive functions have an impact on externalising behaviour.

[Table/Fig-3]: Overview of peculiarity of entire included studies in appraisal (n=18) [25-42].

DISCUSSION

The aim of this review was to look methodically at the viability of intercessions concentrated on working memory performance of children in their everyday contexts. The first research objective was to identify the effects of interventions targeting working memory in children's everyday contexts on each aspect of working memory. A systematic search of the literature resulted in 18 studies being reviewed, encompassing a range of intervention approaches including: adapting the surroundings to reduce working memory loads; direct working memory training without tactics mandate; direct working memory training with tactics mandate; and coaching competencies which circuitously effect on working memory (athletics, lexical apprehension, astonishing man-made play and self-possession). In majority of the studies, the aspect of working memory being trained or measured was not elucidated. Nonetheless, a significant outcome of this review is that working memory skills can be altered through diverse interventions, particularly in relation to verbal working memory skills which were more frequently measured than the visuospatial domain.

The second research objective was to identify near-and-far-transfer effects of working memory intervention package. The evidence here was limited because few studies measured these outcomes. However, there is preliminary evidence suggesting that certain direct and indirect working memory interventions applied within children's everyday contexts have the potential to produce: near-transfer effects on similar working memory tasks [27,33]; and far-transfer effects on areas such as reading comprehension [27], numeracy skills [33], attention and behaviour [42].

The final research objective was regarding the durability and optimum dosage requirements for working memory interventions applied in children's everyday circumstances. Reflection on the potential of these varied interventions to produce training and transfer effects leads to questions about which children may benefit most and the impact of individual differences. The age of participants varied within each intervention type, making it difficult to draw strong conclusions about age effects. A number of the interventions reviewed showed significant benefits for younger children (4-5-year-old) [28,40-42], reinforcing the idea that non computerised approaches might be more suitable for younger children.

The majority of studies were with typically developing children, meaning it was not possible to evaluate the effectiveness of the interventions for children with identified working memory difficulties, neurodevelopmental difficulties or at-risk groups such as those from low socio-economic backgrounds persist. Nonetheless, it would be beneficial in future reviews to evaluate the effect of differences in baseline abilities and other individual differences. The optimum dosage required to produce training effects remains uncertain because dosage variables were often unreported or showed significant variation across studies. However, relatively short interventions of five to six weeks in total duration were shown to be effective [27,41,42]. There is still a great deal to learn about optimal levels of dosage for interventions in the area of child language and development [43].

From both theoretical and applied perspectives, many questions about the utility of working memory training approaches remain unanswered. This review provides suggestive evidence for the effectiveness of diverse working memory interventions applied within children's everyday context, when the trained tasks are executive loaded. Evidence has emerged of what might be possible and there are several advantages to the types of interventions reviewed here in comparison to computerised working memory training. These include: greater flexibility in how the tasks are presented; less of a requirement for young children to sit still for long periods of time; and opportunities to promote social and emotional development in activities embedded within the child's own environment [44]. The considerable challenges of conducting further research in applied settings must also be acknowledged. It may eventually be possible to develop a hybrid intervention approach that integrates the benefits of computerised training and face-to-face training in everyday contexts. For example, education professionals could deliver practice trials on executive loaded working memory tasks in schools and record responses on a portable device (laptop or tablet) with software informing the facilitator about levels of difficulty.

Future studies need to present a clear theoretical account of how and why the intervention should impact working memory in hypothesis driven research. It will be important to apply greater rigour in study methodology, including the use of active control groups and randomised controlled designs. In order to develop a greater understanding of the relationship between intervention ingredients, working memory outcomes and real world skills, outcome measurement must be comprehensive. Greater attention must also be paid to intervention dosage. There is a need to look more closely within interventions, to distil them and identify exactly which ingredients and dosages act as optimal mechanisms of change.

Clarifying for whom non computerised working memory interventions may be most effective, and in what circumstances should be a goal of further research, future studies should target children from understudied sub-groups such as those with identified working memory difficulties, neurodevelopmental difficulties or at-risk groups such as those from low socio-economic backgrounds. Greater consideration should be given to the role of individual differences that could influence the effectiveness of interventions e.g., cognitive level motivation [45].

Limitation(s)

Only the non computerised interventions for improving working memory bases studies were included. Studies in which children aged 4-11 years whose working memory improved by non computerised interventions were included, so these are the main limitations for the study.

CONCLUSION(S)

Varied interventions applied within young children's everyday contexts, have produced improvements on their working memory skills and have the potential to produce near and far-transfer effects. Both direct training on working memory tasks and practicing certain skills that may indirectly impact on working memory (athletics, astonishing man-made play and self-possession) were beneficial. The strength of the evidence is tempered by rigorous methodology and consideration of dosage of working memory interventions. Further well-designed and controlled studies with comprehensive outcome measurement, comparing carefully-considered dosages, are required to expand and enhance the evidence base.

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