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School Based Motor Skill Interventions for Developmentally Delayed and Non-Delayed Children

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Abstract

Introduction: A mere 33% of all children meet the recommended minimum physical activity guidelines for adequate health maintenance. Available literature however suggests children are more likely to be active when they are competent with their own motor ability. This review aimed to evaluate how several regimented motor skills training courses and interventions improve motor skill competence among children compared with age matched control peers. *Method:* Electronic databases were searched and included Medline Complete and Psych INFO (both hosted by EBSCO Host). The search syntax examined titles and abstracts. The study aimed to create novelty by examining participants with and without developmental delays simultaneously from studies around the globe. Included interventions were aimed at the most crucial developmental years for children (between 3 and 11 years). *Results:* Results were found in favor of the motor skill intervention groups (from pre-to post-test). Included interventions involved weekly motor skills exposure of 60 to 120 minutes for periods of between 2 and 6 months. Over 50% of included interventions involved alterations to current school curriculums. The included studies were of moderate to high quality. *Conclusion:* The findings suggest that for those with and without developmental delays, several interventions can be effectively applied in once weekly 60-minute sessions (over eight or more weeks) to improve children's motor skill abilities. Applying appropriate difficulty to interventions seems equally influential. Implications are discussed.

Keywords

motor skills, motor ability, intervention, physical activity, children, child, systematic review

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Introduction

Physical inactivity is the fourth-leading cause of non-communicable disease, leading to 3 million preventable deaths around the globe each year. A mere 33% of all children meet the recommended minimum physical activity guidelines of 60-minutes/day.[1] Furthermore, the prevalence of physical inactivity is continually on the rise. A systematic review conducted by Janssen and LeBlanc[2] found physical activity is also associated with a number of potential benefits to children's health including increased bone and muscle strength, improved social and emotional well-being, and an increased ability to concentrate for longer periods of time.[2] Numerous studies have also found significant relationships between motor skill proficiency and physical activity participation. For example, a cross-sectional study by Barnett et al[3] found that motor skill proficiency increased a child's likelihood of being regularly physically active by up to 20%.[3] Research has also found that motor proficiency during childhood can have long lasting effects. This was made evident in a longitudinal study by Barnett et al[3] who found motor skill proficient children were more active in their adolescent years. Further, a systematic review by Kriemler et al[4] examined 11 studies related to motor skill proficiency among children. The review suggested that the implementation of basic motor skill interventions have the potential to not only improve children's motor skill acquisition but additionally increase the likelihood of physical activity participation.[4]

Although previous research has found these associations between motor skill interventions and physical activity levels, the knowledge surrounding the specificities, frequencies, and durations of effective interventions

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remains unclear. Additionally, few systematic reviews have combined the examination of global data to gain more representative knowledge on the topic. Therefore, the current review will aim to address these limitations by examining the specifics of motor skill interventions globally.

Objectives. In-order to reduce the prevalence of inactivity amongst children around the globe, their motor skill development and acquisition must become a priority. Therefore, the most effective and cost-efficient methods of motor skill development and acquisition need to be further examined and determined to ensure all children can have the greatest likelihood of proficiency in the area. This systematic review will evaluate how regimented motor skills training courses and interventions improve motor skills in children (compared with aged matched control peers), with or without developmental problems aged 3 to 11 years (the most influential years on such development). The examined studies will compare intervention success through the comparison of experimental and control groups with any type of motor functioning outcome.

Method

Search Strategy

Studies were identified through searching 2 databases: Medline Complete and Psych INFO (both hosted by EBSCO Host). The search strategy followed the PICO (population, intervention, control and outcome) model. The participants were children with or without developmental challenges aged between 3 and 11 years (1), and the intervention was any motor skill training course designed to improve motor skills (2). Specific keywords (child, kid, boy, girl and motor skill) were used for each database combined with Boolean operators (AND, OR). The same combination of search terms and limiters was utilized for each database search. The search syntax only identified key words throughout titles and abstracts. The search syntax is presented in Appendix.

Study Selection Criteria

Types of studies. This systematic review included any random-control trial, quasi-experimental, or longitudinal prospective study designs that implemented any intervention aimed at improving children's motor skills. Included studies examined intervention success with both experimental and control groups. Studies were published in peer-reviewed journals written in English. *Types of participants.* Studies were only included if the sample consisted of children with or without developmental problems who were aged between 3 and 11 years. *Types of intervention.* Studies required any intervention deigned to improve children's motor skills. *Types of outcome measures.* Any aspect of motor functioning.

Exclusion Criteria

Unrepresentative samples of 4 or fewer participants and any systematic reviews or review studies were excluded. Study samples which included participants younger than 3 or older than 11 years were additionally omitted. Due to potential bias susceptibility, pilot studies were also left out of the current review.[5] Studies without a comparison control group as well as studies without an intervention deigned to improve motor skills were also eliminated from the review. Finally, any studies without an aspect of motor functioning as the outcome variable were also excluded.

Quality Assessment

The methodological quality of the selected intervention studies was assessed using a modified version of the "Quality Assessment of Controlled Intervention Studies" developed by the National Institute of Health in the United States (https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools). The scale score evaluates the methodological quality of studies using a yes or no/not stated response. Items with a "yes" response are considered 1 mark and items with a "no/not stated" response are considered 0 marks. The scale has 8 criteria and can therefore receive a mark from 0 to 8. Those studies which met more then half the criteria (5 or more/8) were considered high quality. It should be noted that scores should not be the only means for methodological comparison between studies as criterion are not equal in importance.

Results

PRISMA Flowchart

The summary of the review process is illustrated in the PRISMA flowchart (Figure 1 above). The searches of Medline and Psych INFO returned 695 references with the most recent 600 included in the review. Following the screening of titles and abstracts, 36 met the inclusion criteria and their full text articles were acquired. After examining the full text articles, 8 met the inclusion criteria and were submitted to the synthesis. Table 1 below provides a summary of the features and methodological aspects of the included studies (Table 1). During the full-text examination, 28 articles were excluded: 11

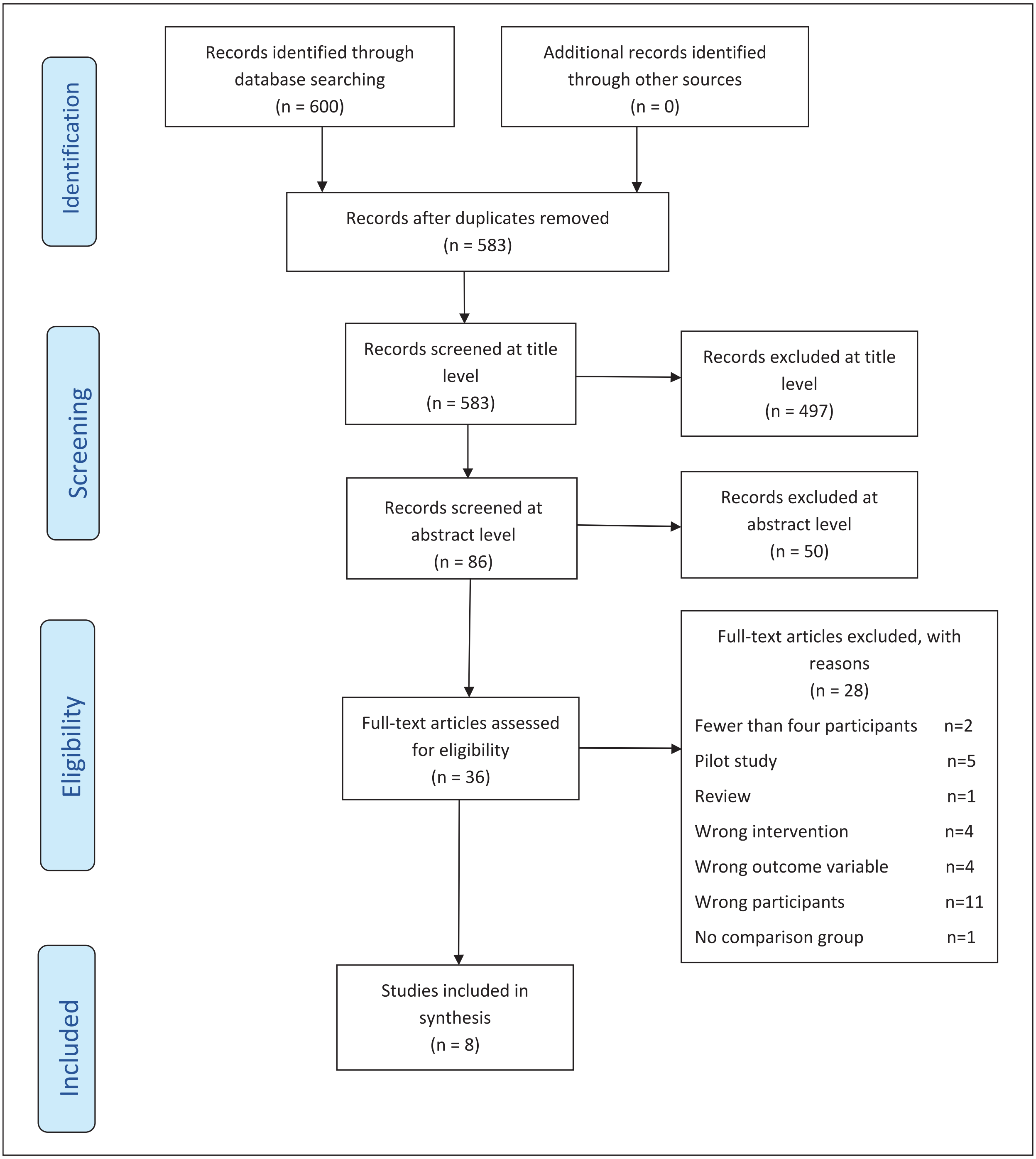

Figure 1. PRISMA flowchart.
Source: Moher D, Liberati A, Tetzlaff J, Altman DG; The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med.* 2009;6(7):e1000097. doi:10.1371/journal.pmed1000097.
For more information, visit www.prisma-statement.org.

articles were omitted as they included participants under the age of 3 or over the age of 11 years. Five pilot studies and 4 studies without a motor skill intervention were also excluded from the review. Four studies without a motor skill measurement and 2 studies which had samples of <4 participants were also left out. A further study without a comparison group and a systematic review article were also omitted from the review.

Table 1. Characteristics and Quality Assessment of Included Studies (N = 8).

Authors, country	Participants	Intervention design	Comparisons	Outcome measures	Results	Summary score
Jarani et al,[6] Albania	First and fourth grade children from 4 randomly selected schools: N = 767, *R* = 7-10 years, *M* = 8.3 years, SD = N/A	Study type: RCT; active control; interventions: 5 months (2 × 45 minutes/week) of professionally taught physical education (PE) lessons aimed at ^ skill-related fitness components: (1) Exercise-based PE group; 8 classes (N = 261) (2) Games-based PE group; 8 classes (N = 251)	5 months (2 × 45 minutes/ week) of PE lessons run by general teacher: (1) General PE group; 8 classes (N = 225)	Testing: pre-and post (5 months apart) Test: the body coordination test for children and a coordinative test battery	Exercise group; gross motor skill summary scores: I > C (*P* < .001); games group; gross motor skill summary scores: I > C (*P* < .001)	5/8
Bardaglio et al,[7] Italy	Third grade children from 3 randomly selected schools: N = 205, *R* = 6-10 years, *M* = 8.74 years, SD = 0.49	Study type: RCT; active control; interventions: 4 months (1 × 60 minutes/week) of professionally taught PE lessons aimed at ^ coordinative motor skills in team games: (1) 1 Instructor-based PE program (N = 64) (2) 2 Instructors-based PE program (N = 64)	4 months (1 × 60 minutes/ week) of PE program taught by generalist teacher: (1) General PE group (N = 77)	Testing: pre-and post (4 months apart) Test: the observational coordinative motor skills scale was used on a game of dodgeball by 3 trained observational PhD students	1-Instructor; motor scale summary scores: I > C (*P* < .001); 2-instructors; motor scale summary scores: I > C (*P* < .001); 2 vs 1 instructor: 2 > 1 (*P* < .001)	4/8
Piek et al,[8] Australia	Low socioeconomic pre-primary classes from 12 West Australian schools: N = 335, *R* = 4-6 years, *M* = 5.5 years, SD = 3.58 months	Study type: RCT; active control; intervention: 10 weeks (4 × 30 minutes/week) of animal farm in class (imitating movements of animals) aimed at ^ general motor ability: (1) Animal-farm group; 6 schools	10 weeks of normal school-based curriculum: (1) Normal curriculum (apart from 3 testing sessions); 6 schools	Testing: pre-and post (6 months apart; with 12-month follow-up) Test: the Bruininks-Oseretsky test of motor proficiency (version 2—short form); 14 items	Motor skill proficiency scores: I > C (*P* < .035); boys were found to improve over girls (*P* < .022)	5/8
Alesi et al,[9] Italy	Boys recruited from gyms and schools: N = 46, *R* = 7-11 years, *M* = 9.1 years, SD = 1.3 years	Study type: longitudinal prospective design; active control; intervention: 6 months (2 × 75 minutes/week) of a football exercise program run by a soccer-certified teacher aimed at ^ general motor ability: (1) Football exercise group; recruited from gyms; (N = 24)	6 months of no sport or physical activity participation: (1) No activity group; recruited from schools (N = 22)	Testing: pre-and post (6 months apart) Test: a battery including 20m sprint test, agility test and times of visual discrimination test	Football exercise group; significant improvements in; sprint, agility, and times of visual discrimination tests: T2 > T1 (*P* < .05); no activity group; significant improvement in sprint test: T2 > T1 (*P* < .05); insignificant improvements in agility (*P* = .370) and times of visual discrimination tests (*P* = .178)	3/8

(continued)

Table 1. (continued)

Authors, country	Participants	Intervention design	Comparisons	Outcome measures	Results	Summary score
Vernadakis et al,[10] Greece	First and second-grade children from 3 public elementary schools: N = 66, *R* = 6-7 years, *M* = 6.35 years, SD = 0.73 years	Study type: RCT; active control; interventions: 8 weeks (2 × 30 minutes/week) of training program or active gaming; run by qualified professional aimed at examining the difference between traditional object control training and active gaming for ^ motor skill: (1) Fundamental motor skills (FMS) training program (N = 22) (2) FMS Xbox Kinect (active gaming) program (N = 22)	8 weeks (2 × 30 minutes/week) of unstructured free-play activity: (1) Free-play group; (N = 22)	Testing: pre-and post (8 weeks apart; with 1 month follow-up) Test: the test of gross motor development (trained assessors taped footage of skill acquisition and ranked it)	FMS training group; test of gross motor development summary ranking: I > C ($P < .001$); FMS > active gaming ($P < .001$); active gaming group; test of gross motor development summary ranking: I > C ($P < .001$)	4/8
Altunsöz and Goodway,[11] Turkey	Children with developmental delays from 2 head start centers: N = 72, *R* = 3-5 years, *M* = 4 years, SD = 0.5 years	Study type: RCT; active control; interventions: 8 weeks (2 × 30 minutes/week) of SKIP (developmentally appropriate instruction and practices) or SKIP-PI (SKIP and parent enhancement—where parents worked with their children at home on motor activities) aimed at assessing the interventions impact on object control competence: (1) SKIP group (N = 22) (2) SKIP-PI group (N = 25)	8 weeks (2 × 20-30 minutes/week) of regular head start curriculum with no skill instruction: (1) Regular curriculum; (N = 25)	Testing: pre-and post (8 weeks apart; with 1-month follow-up) Test: test of gross motor development 2; all data collection procedures were videotaped and analyzed by trained researchers	SKIP group; object control summary scores: I > C ($P < .001$); SKIP-PI group; object control summary scores: I > C ($P < .001$); SKIP-PI > SKIP ($P < .001$); regular head start group; object control summary scores; insignificant improvement ($P = .37$)	4/8
Bhatia et al,[12] USA	Children were recruited from 4 junior private schools and a high performing kindergarten: N = 100, *R* = 5-5 years, *M* = 5 years, SD = N/A	Study type: quasi-experimental; active control; intervention: 8 months of access to shelves set up in the classroom containing items used in daily life (tongs, jugs, etc.); children were shown how to use objects effectively and were progressively challenged to master harder object tasks aiming to ^ fine motor development: (1) Object group; recruited from 4 private schools (N = 50)	8 Months of traditional kindergarten curriculum with no additional materials: (1) Traditional curriculum; recruited from kindergarten's (N = 50)	Testing: pre-and post (8 months apart) Test: the flag posting test (requires children to place tiny flags mounted on pins into preset pinholes)	Object group; flag accuracy test scores: I > C ($P < .001$); no gender and treatment interaction ($P = .321$)	5/8
Pesce et al,[13] Italy	Children from 8 pre-and primary schools: N = 920, *R* = 5-10 years, *M* = N/A, SD = N/A	Study type: cluster RCT; active control; intervention: 6 months (1 × 60 minutes/week) of specialist PE teaching (in an out of school area): (1) Specialist PE group; 18 classes (N = 232)	6 Months (1 × 60 minutes/week) of traditional PE teaching (in school): (1) Traditional PE group; 18 classes (N = 232)	Testing: pre-and post (6 months apart) Test: the test of motor developmental level—movement assessment battery for children (evaluates movement competence providing objective data on skills)	Specialist PE group; motor skill summary scores: I > C manual dexterity ($P < .001$); ball skills ($P < .001$); static/dynamic balance ($P < .001$)	5/8

Children from studies were normally developing (unless mentioned otherwise); mixed gender studies = girls and boys were represented relatively equally.
Abbreviations: N, total number; *R*, range; *M*, mean; SD, standard deviation; RCT, random control trial; ^, increase; I, intervention; C, control; T1, test time one; T2, test time two; N/A, not available.

Methodological Features

The sample sizes of the studies reviewed was diverse ranging from 46 to 900 participants. The average number of participants in all studies was 311 with half of the included studies having at least 200 participants. Seven of the 8 studies consisted of mixed gender samples who were relatively evenly represented in allocated groups with the eighth study consisting of only male participants. Seven studies consisted of normally developing children with the remaining study involving developmentally delayed children. Six studies comprised of random control trials with the remaining 2 study designs including a longitudinal prospective study and a quasi-experimental design. All 8 studies were actively controlled.

Half of the reviewed studies examined interventions that altered current school curriculums by replacing traditional PE with forms of specialized PE for periods of 2, 4, 5, and 6 months. At the same frequency (60-90 minutes/week), the control groups in these studies participated in PE or unstructured play coordinated by generalist teachers. Two further reviewed studies included interventions applied in pre-schools which also involved alterations to current curriculums. This adjustment involved the inclusion of up to 120 minutes/week of basic motor activities which allowed for difficulty progression over periods of 8 and 10 weeks. Control groups in these studies followed normal curriculums. A further study included in the review also involved an intervention that altered curriculum for a period of 8 weeks. This intervention was applied at a head-start center and provided children with developmental delay specialized activity instruction for 60 minutes/week while the control group maintained normal curriculum. The final intervention involved a weekly 60-minute football practice session for a period of 6 months while the control group participated in no physical activity. All studies reviewed involved both pre-and post-testing with 3 including follow-up testing. No 2 outcome test measures were the same in this review.

Methodological Quality

Bases on the quality assessment tool, the studies included in the review were of moderate to high quality. Half the included studies reviewed were of high quality, meeting more than half the criteria (5/8). A further 3 studies were of moderate quality meeting exactly half the criteria (4/8). The final reviewed study was of low-quality meeting less than half the prescribed criteria (3/8).

Findings

All 8 studies included in the review found significant results in support of the motor skill intervention groups, that is, all intervention groups were found to have greater improvements on related areas of motor skill measures compared to the control groups (from pre-to post-test). Additionally, studies which consisted of 2 experimental groups found greater improvements in the experimental group involving more qualified instructors and complex time-consuming motor tasks.

Discussion

Research has suggested that reducing the prevalence of inactivity among children should involve an improvement in motor related skills. The current review has investigated 8 motor skill interventions applied in countries including Albania, Italy, Australia, Greece, Turkey, and the United States. The findings suggest that there are several effective interventions that can be applied to improve children's motor ability. Interestingly, the review found more pronounced associations between interventions and motor skill competence with more complex and challenging interventions. The current review additionally found that PE lessons with specialized instructors was also associated with greater improvements in motor skills. These findings should however be interpreted with caution as all 8 studies failed to state whether sample sizes were sufficiently large enough to be able to detect a difference in the main outcome between groups with at least 80% power.

In addition, 7 of the 8 studies included in the review were limited in that the people assessing the outcomes were not blinded to the participants group assignment which could have resulted in detection bias.[14] In a further limitation, 6 of the reviewed studies also failed to blind participants to treatment group assignment resulting in potential performance bias.[14] A further limitation existed in the Alesi et al[9] study which deliberately recruited participants for the intervention group from gyms (who were already considered active), and the control group from schools (who were considered inactive) resulting in selection bias.[15] Additionally, the Piek et al[8] study was affected by attrition bias with 176 participants failing to complete all 3 phases of testing, however the results of these participants were excluded from their analysis.[16]

Overall, the current systematic review was limited in that it relied only upon published studies resulting in some form of publication bias.[17] Additionally, the quality assessment scale used to compare studies was limited in that each criterion is not of equal methodological importance. Finally, the results of each study were somewhat difficult to compare as different measurement tests were utilized in each individual study.

Physical inactivity is associated 3-million preventable deaths around the world each year.[1] Previous research has found associations with motor skill competence and physical activity participation for children.[2] The current systematic review evaluated several methods for improving children's motor skills. Overall, the implementation of a weekly 60-minute motor-related intervention over a period-of-time as short as 8-weeks can significantly improve the motor ability of children. Future reviews should endeavor to determine the minimum frequency and basic level of motor skill acquisition required for children to participate in adequate levels of physical activity. Finally, to increase the generalizability of findings, research should also endeavor to only include studies which exert 80% power.

Key Points for Clinical Practice

- This paper provided a dissemination of evidence to influence and shape policy relevant to school-based systems.
- The paper demonstrates the potential effectiveness of interventions for those experiencing developmental delays in developmental school-systems.
- The paper implicated the effectiveness of different motor-related interventions, time intervals (weekly 60-minute sessions for eight or more weeks), more qualified instructors and complex time-consuming motor tasks in the sucess of such interventions.

Appendix

Search Syntax

(TI child*) OR (TI kid*) OR (TI boy*) OR (TI girl*) OR (AB child*) OR (AB kid*) OR (AB boy*) OR (AB girl*)
AND
(TI motor skill*) OR (AB motor skill*)

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Author contributions

The author confirms that the manuscript has been read and approved by the author and that there are no other persons who satisfied the criteria for authorship but are not listed.

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