

## Footwork and Floor Pattern for Gross Motor Skills in Children with Sensory-Motor Disorders: A Systematic Review

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**Abstract:** Children with sensory-motor impairments, namely Developmental Coordination Disorder (DCD), Attention Deficit Hyperactivity Disorder (ADHD), and Autism Spectrum Disorder (ASD), often experience difficulties in balance, coordination, and agility affecting daily living activities. Structured gross motor interventions have been widely studied, but the combination of badminton footwork and floor patterns as learning in early childhood education has not been comprehensively implemented. This systematic review aims to analyze the effectiveness of badminton footwork and floor patterns in improving gross motor skills in children with sensory-motor impairments. A literature search was conducted in PubMed, Google Scholar, ScienceDirect, and ERIC databases for publications from 2015-2024. Keywords included "footwork training", "agility ladder", "floor patterns", "gross motor skills", "DCD", "ADHD", "autism", and "sensorimotor intervention". Of 847 initial articles, 23 studies met inclusion criteria. A 15-week structured exercise program demonstrated significant improvements on the Gross Motor Development Test-3 ( $p < 0.01$ ). Agility ladder training improved 10m sprint by 2.39% and 20m sprint by 2.10%. In children with DCD, a sensorimotor approach integrating vestibular stimulation resulted in improved postural control ( $d = 0.87$ ). Children with ADHD demonstrated improvements in sustained attention and motor control after 8 weeks ( $p < 0.05$ ). Children with ASD experienced improvements in bilateral coordination and social participation ( $d = 0.72$ ). Strong evidence supports the use of badminton footwork and floor patterns as motor interventions for children with sensorimotor disorders including DCD, ADHD, and ASD, characterized by multisensory integration, clear structure, and repetitive movements appropriate to children's needs with sensory-motor disabilities

**Keywords:** badminton footwork, floor patterns, gross motor skills, DCD, ADHD, autism, sensorimotor intervention, children with special needs

**Abstrak:** Anak-anak dengan gangguan sensorimotor, yaitu Developmental Coordination Disorder (DCD), Attention Deficit Hyperactivity Disorder (ADHD), dan Autism Spectrum Disorder (ASD), sering mengalami kesulitan dalam keseimbangan, koordinasi, dan kelincahan yang berdampak pada aktivitas kehidupan sehari-hari. Intervensi motorik kasar terstruktur telah banyak diteliti, namun kombinasi footwork dan pola lantai hair parry sebagai pembelajaran dalam pendidikan anak usia dini belum diimplementasikan secara komprehensif melalui tinjauan sistematis. Penelitian ini bertujuan untuk menganalisis efektivitas footwork dan pola lantai hair parry dalam meningkatkan keterampilan motorik kasar pada anak dengan gangguan sensorimotor. Penelusuran literatur dilakukan pada basis data PubMed, Google Scholar, ScienceDirect, dan ERIC untuk publikasi tahun 2015–2024. Kata kunci yang digunakan meliputi "practice footwork", "ladder agility", "pattern floor", "gross motor skills", "DCD", "ADHD", "autism", dan "sensorimotor intervention". Dari 847 artikel awal, 23 studi memenuhi kriteria inklusi. Program latihan terstruktur selama 15 minggu menunjukkan peningkatan signifikan pada tes Gross Motor Development-3 ( $p < 0,01$ ). Latihan tangga kelincahan meningkatkan kecepatan lari 10 m sebesar 2,39% dan 20 m sebesar 2,10%. Pada anak dengan DCD, pendekatan sensorimotor yang mengintegrasikan stimulasi vestibular menghasilkan peningkatan kontrol postural ( $d = 0,87$ ). Anak dengan ADHD menunjukkan peningkatan perhatian berkelanjutan dan kontrol motorik setelah 8 minggu ( $p < 0,05$ ). Anak dengan ASD mengalami peningkatan koordinasi bilateral dan partisipasi sosial ( $d = 0,72$ ). Terdapat bukti kuat yang mendukung penggunaan footwork hair parry dan pola lantai sebagai intervensi motorik bagi anak dengan gangguan sensorimotor, termasuk DCD,

ADHD, dan ASD, dengan karakteristik integrasi multisensorik, struktur yang jelas, serta gerakan repetitif yang sesuai dengan kebutuhan anak dengan disabilitas sensorimotor.

**Kata kunci:** footwork hair parry, pola lantai, keterampilan motorik kasar, DCD, ADHD, autisme, intervensi sensorimotor, anak berkebutuhan khusus

## 1. INTRODUCTION

Pyramid learning explain that two levels First , gross motor skills are skills important basics for activity daily child before reach level highest that is skills cognitive . Gross motor skills covering running , jumping , and guarding balance . Unfortunately , every child develop in a way different and not always develop fully in matter This . Data shows that around 5-6% of children age school experience Disturbance Coordination Development (DCD), which is characterized by with difficulty planning and implementing movement coordinated (Blank et al ., 2019). More continue , children with ADHD reported experience motor problems in 30-50% of cases (Kaiser et al ., 2015), while 79% of children with ASD shows significant motor delay (Fournier et al ., 2010).

Impact from this motor disorder No only influence ability physical , but also affects children who experience motor difficulties , tend to avoid activity physical , experiencing decreased sense of trust self , difficulties interact social , and even performance more academic low (Purcell et al ., 2020; Gao et al ., 2024). In children with ADHD, problems motor skills worsen difficulty in control impulse and maintain attention (Fliers et al ., 2010). While that , in children with ASD, motor impairments increase challenge in communication and interaction social (MacDonald et al ., 2013).

Intervention structured and directed motor skills has proven more effective than activity physique traditional in increase children's motor skills (Morgan et al ., 2013; Wang & Zhou, 2024). However , some large existing programs nature common and less specific For children in need special . This is where innovation modification footwork and patterns floor hair parry offer interesting approach .

Feather footwork parry is simultaneous exercise practice coordination ankles , balance dynamic , and agility ( Phomsoupha & Laffaye , 2015). Feather footwork parry involving fast , precise , and directed foot movements . These movements such as lunges, side steps, and cross steps which are characteristics typical hair parry need integration complex from visual, vestibular, and proprioceptive systems (Gabbett et al ., 2008). Therefore that , the exercises This interesting and potential modified without use racket , with focus fully on development footwork patterns .

Temporary that , pattern common floor used in gymnastics and dance involves the movements that follow track or design certain on the floor . This is practice motor planning , awareness spatial , and ability For follow order movement (Lake, 2017; Torrents et al ., 2015). Research show that dance practice that uses pattern complex floor can increase connectivity nerves in the area of the brain that regulates coordination and motor control (Karpati et al ., 2015).

Combination feather footwork modified parry and pattern very interesting floor for children with sensorimotor disabilities . For children with DCD difficulties plan motor movements , visual patterns on the floor give guide concrete that helps they " look " where to go moving . For children with ADHD that is easy distracted , structure and repetition exercise footwork helps develop focus and control impulse . While that , for children with ASD which is frequent difficulty understand instructions abstract , combination visual cues on the floor and movement structured give more learning concrete and can predicted .

Although potential as tool learning for children small with sensorimotor disability , still A little review systematically which special analyze effectiveness combination feather footwork parry and pattern floor For children with sensorimotor disabilities including DCD, ADHD, and ASD. A better understanding Good about approach This can help therapists , teachers, and parents choose appropriate intervention . Therefore that , review systematic This aim For give proof scientific about effectiveness feather footwork parry and pattern floor in increase balance , agility , and coordination in children with sensorimotor disability .

## 2. RESEARCH METHODS

### 2.1. Methodology Study

Review This systematic process is carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, adapted for synthesis narrative (Page et al., 2021). Approach synthesis narrative chosen Because existence heterogeneity anticipated significant between studies, especially in matter population, species interventions, and measures external.

### 2.2. Search Strategy Literature

Search literature conducted in four scientific databases main namely PubMed/MEDLINE for literature biomedical and health, Google Scholar for coverage interdisciplinary, ScienceDirect for science sports and rehabilitation, and ERIC for literature education and education special. Period search limited to published publications between January 2015 and October 2024 to be sure relevance to practice latest. Search strategy designed by combining three keyword groups using Boolean operators (AND/OR) namely interventions (e.g. "footwork", "stairs" agility, "pattern floor"), outcomes (e.g. "gross motor skills", "coordination", "balance", "agility"), and populations (e.g. "children", "DCD", "ADHD", "autism", "motor difficulties").

### 2.3. Criteria Inclusion and Exclusion

Studies included in this review if fulfil criteria following: (1) Study design is studies experimental (RCT or quasi-experimental), study observational, or review systematic; (2) Participants is children aged 4-14 years both with normal development and those diagnosed with DCD, ADHD, ASD, or other sensorimotor disorders; (3) Intervention involving exercise footwork, pattern floor, or combination both; and (4) Measuring at least One gross motor components (balance, agility, or coordination). Studies excluded if: (1) Focus main is on the participants adults (>18 years); (2) Only measure results physiological without measure motor skills; (3) Focus on rehabilitation injury acute; (4) Targeting population very specific clinical; (5) Contains abstract conference or literature gray without review colleagues; or (6) Have methodology that is not clear or No include group control / basic.

### 2.4. Data Selection and Extraction Process

Selection process consists of from four stage. At the stage identification, all article from the database collected and duplicated deleted using Mendeley Reference Manager. At stage screening, two reviewers independent filter title and abstract based on criteria inclusion and exclusion with levels suitability between reviewer  $\kappa=0.87$  which shows very good fit. At stage eligibility, articles that pass the screening beginning read out in a way completed by both reviewers with disagreement completed through discussion or consult with reviewers third. At the stage inclusion, articles that meet all criteria entered in synthesis narrative. Data extraction from article selected done use form standard covering characteristics study, characteristics participants, intervention details, instruments measurement external and characteristics population specific.

### 2.5. Assessment Quality Methodology

Quality methodology from included studies assessed use tools that fit the design study. For RCTs, the Cochrane Risk of Bias Tool 2.0 was used (Sterne et al., 2019). For the study quasi-experimental The Modified Newcastle-Ottawa Scale (Wells et al., 2014) was used for the review. systematic used AMSTAR-2 (Shea et al., 2017). Each studies given ranking low risk of bias, somewhat worrying, or tall

## 3. RESULTS AND DISCUSSION

### 3.1. Study Selection and Characteristics

Search initial analysis across four databases identified a total of 847 articles. After 235 articles duplicate removed, 612 articles filtered based on title and abstract up to 523 articles eliminated Because

No relevant . A total of 89 articles Then assessed its eligibility through review text complete . From the number said , 66 articles excluded Because intervention No specific (n=28), population No appropriate (n=18), output No relevant (n=12), methodology No clear (n=5), or text complete No available (n=3). Ultimately , 23 studies fulfil criteria inclusion and inclusion in synthesis narrative This .

The most common study design is quasi-experimental (n=15, 65.2%), followed by a pilot study controlled randomized (RCT) (n=5, 21.7%) and review systematic (n=3, 13.0%). Size sample range between 24 to 328 participants (median=56) with range age between 4 and 14 years (mean=6.8, SD=2.3). The majority intervention (n=12, 52.2%) using training ladder agility . Duration of the intervention program range between 6 to 15 weeks (mean=10.2 weeks ) with frequency of 2-4 sessions per week (mode=3) and average session length of 42 minutes . Most studies (n=18, 78.3%) focused on children with development typical temporary the rest research DCD (n=4), ADHD (n=2), ASD (n=2), or mixed (n=1). Assessment quality methodology show that 8 studies (34.8%) had low risk of bias , 11 studies (47.8%) had a number of concerns , and 4 studies (17.4%) had high risk of bias .

### **3.2. Findings Based on Motor Outcomes**

#### **3.2.1. Balance**

Footwork and pattern interventions floor in a way consistent show repair balance in all population . Study by Quan et al . (2024) in children age 4-5 years find that 15 weeks footwork and pattern drills floor produce improvement significant on TGMD-3 scores in both the locomotor subtest ( 18.7% increase ,  $p<0.001$ ) and object control ( 15.3% increase ,  $p<0.001$ ) with a large effect size (Cohen's  $d=1.12$ ). This supported by the meta- analysis of Wang & Zhou (2024) which concluded that structured motor training more superior than free play in increase balance dynamic (SMD=0.76).

In the DCD population , Niklasson et al . (2018) in their RCT find that 20 weeks therapy sensorimotoric that integrates footwork significant improved the Sensory Organization Test ( 24.3% improvement ,  $d=0.89$ ) and the Pediatric Balance Scale ( 8.5 point improvement ). Fong et al . (2022) also reported that Tai Chi with pattern floor structured improved the Functional Reach Test (+31.2%) and reduced sway velocity (-42.5%) in children with DCD. A pilot study by Tseng et al . (2018) showed that 8 weeks agility ladder training improves static balance (Stork Balance Test,  $d=0.68$ ) and balance dynamic (SEBT, +14.2%) in the ADHD population . In the ASD population , Bremer et al . (2016) found that 10 weeks dance-based intervention with pattern floor increase BOT-2 Balance subtest score ( 6.8 point increase ,  $d=0.72$ ) and improved Timed Up and Go time .

#### **3.2.2. Agility**

specific footwork drills proven effective increase agility . Fernandez-Fernandez et al . (2020) reported that 6 weeks agility ladder training for players youth football improved the 10m and 20m sprints and the Illinois Agility Test ( 3.12% improvement ). the biggest seen in the reactive agility test ( 4.87% improvement ,  $d=0.91$ ). Review systematic study by Schoemaker & Smits-Engelsman (2015) found that task-oriented training involving footwork produces a larger effect size. large ( $d=0.73$ ) for agility compared to traditional perceptual-motor training ( $d=0.42$ ) in the DCD population .

Pan et al . (2019) found that 12 weeks exercise tennis A footwork-rich table improved the 505 Agility Test ( 6.4% improvement ) and the Hexagon Test ( 8.7% improvement ) in the ADHD population . Srinivasan et al . (2015) reported that 8 week movement program based rhythm ( pattern floor ) increased change-of-direction speed by 12.3% ( $p<0.05$ ) in children with ASD.

#### **3.2.3. Coordination**

The biggest benefit from frequent footwork interventions seen in the increase motor coordination especially in the population clinical . Meta- analysis Zhang et al . (2024) found that structured FMS interventions especially those using footwork/agility ladder ( $d=0.89$ ) are very effective in improve locomotor skills ( $d=0.76$ ) and object control skills ( $d=0.68$ ). A review by Gao et al . (2024) noted that task-oriented intervention with footwork resulted in a mean increase of 12.8 points in the MABC-2 total score with a very large effect size ( $d=1.58$ ) in the DCD population .

Tsai et al . (2020) showed that 10 weeks exercise aquatic with movement similar footwork increases the MABC-2 total score from 8.3rd to 18.7th percentile ( $p < 0.001$ ) with repair significant on manual dexterity ( $d = 0.71$ ) in the ADHD population . Liu et al . (2017) in a pilot study of a footwork- intensive mini-basketball program reported improvement significant on the BOT-2 coordination subtest ( 11.4 points increase ,  $d = 0.87$ ) and scores MABC-2 percentile ( from 12.3 to 25.8) in the ASD population .

### **3.3. Findings Addition to Population Special**

In addition to improving gross motor skills , some included studies show that There is benefit significant secondary (non-motor) especially in the population with ADHD and ASD. In children with ADHD, two studies (Pan et al ., 2019; Tseng et al ., 2018) identified the existence of benefit transfer to the function domain executive and behavioral . A 12- week footwork -rich table tennis intervention besides increase Agility also improved sustained attention ( 32.1 % reduction in CPT-II omission errors ), inhibitory control ( 18.4% improvement in Go/No-Go task), and working memory ( increased 1.8 digits on the digit span backward). 8 weeks of agility ladder training has also been shown to reduce motor hyperactivity ( 18.3% decrease on the ADHD Rating Scale) and improved on-task behavior in the classroom ( 18.3% increase from 52.3% to 68.7%).

In children with ASD, three studies (Bremer et al ., 2016; Liu et al ., 2017; Srinivasan et al ., 2015) show pattern consistent existence improvements in the socio-behavioral domain . Intervention based rhythm and pattern floor increase motor imitation skills ( $d = 0.68$ ) and gesture imitation accuracy (+34.2%) which are precursor important For interaction social . Dance-based intervention ( pattern floor ) increase participation group in a way significant ( from 42% to 78% of the time) session ) and eye contact during activity ( increase from 23% to 51%). A footwork- intensive mini-basketball program was found reduced repetitive behaviors ( 16.8% reduction in RBS-R).

### **3.4. Mechanism Proposed Effectiveness**

Observed effectiveness from footwork and pattern interventions floor can explained through a number of mechanism neurobiological and pedagogical interconnectedness related . Intervention This in a way united nature multisensory Where child must integrate visual input ( seeing patterns on the floor or child ladder ), proprioception ( feeling position joints and feet), vestibular ( managing balance during change direction ), and tactile ( foot contact with surface ). For children with frequent DCD and ASD experience problem integration sensory , exercise structured This provide organized and actionable input predicted believed facilitate track more nerves efficient (Niklasson et al ., 2018).

Period ages 4-12 years is a crucial window of opportunity For complex motor interventions (Wang & Zhou, 2024). Footwork and pattern training repetitive floor However varies stimulate activation in the premotor cortex, cerebellum, and basal ganglia, all of which are vital for motor control . This process strengthen connection nerves and facilitate transition from stage cognitive to stage autonomous in the Fitts & Posner model. In children with ADHD, the demands attention to motor sequences is suspected increase connectivity fronto -striatal (Pan et al ., 2019).

The structured and adaptable nature of the intervention predicted is key its effectiveness in the population special . For DCD, the visual pattern on the floor act as helpful external cues compensate internal deficit in motor planning (Schoemaker & Smits-Engelsman, 2015). For ADHD , clear structure and repetition help train sustained attention and impulse control with predictability reducing cognitive load allows child focus on quality execution (Tseng et al ., 2018). For ASD, movements that can be predicted reduce anxiety Where concrete visual cues more easy understood than abstract verbal instructions (Bremer et al ., 2016).

### **3.5. Implications For Practice**

Findings from review This show that footwork and pattern interventions floor effective However success its implementation depends on the principle flexibility and personalization For accommodate profile unique sensory -motor every child . Protocol intervention must become guide No rigid rules with flexible duration , responsive progression based mastery No based time , and prioritize quality movement compared to speed .

Adaptation strategy special For DCD population includes use clear visual cues and minimal verbal, allowing self-correct children before give signals , as well as use exercise repetitive until movement become autonomous. For ADHD, session must short , varied fast , and game-based with using demanding footwork reaction fast For train inhibitory control and attention switching. For ASD, it is necessary provide heavy work before session to downregulate and introduce footwork variations only after pattern base consolidated in a way consistent For reduce anxiety.

### **3.6. Limitations and Future Research Directions**

Although findings This promising , some limitations need attention . Heterogeneity significant studies Good in protocol intervention and tool measure outcome making comparison direct and meta-analysis quantitative become difficult . Amount studies limited to the population clinical specific limit generalization so that findings For population This must considered as findings promising start . Lack of long-term follow-up long Because majority studies only measure results quick post-intervention so that sustainability benefit Not yet known . Lack of studies mechanism for example using neuroimaging to validate proposed neural pathways .

Future research need focus on quality RCTs tall with sample large , assessor blinding, and concealment in DCD, ADHD, and ASD populations for increase internal validity and strength generalization . Long-term follow-up study minimum length of 6 and 12 months post-intervention required For evaluate retention skills and sustainability benefit Clinical comparison of footwork versus therapy traditional (OT/PT) is required For determine superiority comparative and position intervention in practice clinical . Pre-post fMRI study For identify change activation brain required For validate mechanism proposed neuroplasticity . Feasibility and effectiveness studies cost implementation in the environment school required For evaluate viability implementation real -world interventions .

## **4. CONCLUSION**

Review systematic This conclude that footwork and pattern interventions floor is approach based very effective evidence For increase balance , agility , and coordination in children including they with disturbance sensory -motor (DCD, ADHD, and ASD). Findings key show that intervention This effective and powerful in a way clinical with produces a similar effect size consistent currently to very large with more benefits significant in the population clinical compared to population typical . Intervention This provide a transfer effect where besides motor skills it also improves function executive and attention in children with ADHD as well motor imitation and participation social in children with ASD.

Effectiveness driven by stimulation integration multisensory , neuroplasticity , and provisioning crucial structures for child with obstacle sensory -motor. Intervention This economical costs and can with easy integrated to in the therapy program or school with optimal protocol (2-3 times/ week , 12-15 weeks ) and easy adapted For various level ability . In terms of overall , footwork and pattern floor give potential solutions forward-looking and comprehensive For support motor, cognitive , and social development child .

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