Assessment of Balance Impairment in ADHD Children

Mona Ahmed Fathy
Ehab Mohamed Eid, Professor of Public Health in Medical Studies Department Faculty of Postgraduate Childhood Studies Ain Shams University
Ahmed Mohamed El Kahky, Professor of Physiotherapy in Medical Studies Department Faculty of Postgraduate Childhood Studies Ain Shams University;
Iman Hussein Kamel, Assistant professor Research of Child health Department -National Research Center

Abstract

Background: Attention- deficit hyperactivity disorder (ADHD) is a neurodevelopmental condition characterized by an age- inappropriate level of inattention, hyperactivity- impulsivity. Children with ADHD demonstrate impaired motor performance and balance abnormalities. Balance is important in daily life and any malfunction increases the risk of injury. Causes of balance impairment in ADHD may be related to hypofrontality, delay maturation of cerebellum, and other brain structures, or comorbidity with Developmental coordination disorder (DCD).

Aim of the study: To assess balance impairment among children with ADHD and to study its relations with ADHD determinants.

Methods: The study was conducted on 96 child, of both gender, aged from (5- 10) years diagnosed as children with ADHD, in a period of one year (2013- 2014). Conner's' rating scale- Revised Short form, Wechsler intelligence scale for children, Developmental Coordination Disorders Questionnaire and Movement Assessment Battery for Children were used.

Results: 46 child (47.9%) had (DCD) where: 16 of them were at risk (mild to moderate DCD), and 30 had significant DCD. Subscores of static and dynamic balance revealed that: 38 child (39.6%) had balance impairment where: 11 of them showed mild balance impairment and 27 had significant balance impairment. There was no statistical significant difference between gender or age or degree of ADHD and balance impairment. There was a statistical significant difference between balance impairment and ADHD predominant types, also, significant difference between balance and groups of DCD, positive correlation between balance impairment and total score of DCD questionnaire and total percentile rank of MABC2.

Conclusion: ADHD is highly associated with impairment of balance so motor profile should be clearly assessed for better intervention to improve children quality of life.

Key words: Attention deficit hyperactivity disorder, developmental coordination disorder, Conner's rating scale- Revised, Wechsler intelligence scale for children, Movement assessment battery for children, Developmental coordination questionnaire.

تقييم القصور فى التوازن فى الأطفال المصابين باضطراب فرط الحركة ونقص الانتباه

مقدمة: يعتبر فرط الحركة وتشتت الانتباه من أكثر الاضطرابات شيوعاً فى الأطفال حيث يشكل أكثر من ٦% من الأطفال فى سن المدارس وغالبًا ما يصاحبه العديد من الاضطرابات النمائية من بينها اضطرابات الحركة والتوازن. يقدر مدى انتشار اضطرابات التطور الحركية التآزرية فى الأطفال حوالى ٦% ويزداد وجوده فى الأطفال المصابين بفرط الحركة ونقص الانتباه، تزداد إصابة أطفال فرط الحركة ونقص الانتباه بقصور فى التوازن لعدة أسباب اهمها وجود اسباب تشريحيه فى المخ والمخيخ أو المصاحبة لاضطرابات التازرية النمائية.

الهدف: الهدف من الدراسة تقييم التوازن فى الأطفال المصابين بفرط الحركة ونقص الانتباه وتقييم العلاقة بين التوازن وبين فرط الحركة وتشتت الانتباه والعوامل المحددة له من حيث السن والنوع ودرجة الإصابة.

العينة: اجريت الدراسة على ٩٦ طفل من الجنسين تتراوح اعمارهم بين ٥ إلى ١٠ سنوات فى الفترة من سبتمبر ٢٠١٣ إلى سبتمبر ٢٠١٤، وقد خضعوا جميعًا بعد معايير الاستبعاد إلى اخذ التاريخ المرضى وإلى فحص إكلينيكى شامل مع التركيز على فحص الجهاز العصبى والتوازن، كما اجريت المقاييس النفسية على الأطفال: مقياس كونر الصورة المراجعة القصيرة لتشخيص فرط الحركة وتشتت الانتباه- ومقياس وكسلر للأطفال لتحديد مستوى الذكاء- واستبيان للكشف عن اضطرابات التطور الحركية التازرية وبطارية قياس الحركة للأطفال.

النتائج: وقد اشارت نتائج الدراسة وجود اضطرابات التطور الحركية التآزرية فى الاطفال المصابين بفرط الحركة وتشتت الانتباه: بنسبة ٤٧,٩% كما اثبتت ان ٣٨ طفل (٣٩,٦%) يعانون من قصور التوازن: ١١ منهم بدرجة بسيطة و٢٧ يعانون من اضطراب شديد، وقد اثبتت النتائج عدم وجود فروق دالة بين قصور التوازن والعمر الزمنى بينما يوجد فروق داله بين قصور التوازن وبين انواع فرط الحركة وكان نوع تشتت الانتباه اعلى نسبه وعدم وجود فروق داله بالنسبة للنوع او درجه الاصابة بفرط الحركة وبين التوازن بينما اثبتت فروق دالة بين المجموعات واختبار التوازن الثباتى والديناميكى فى البطارية المستخدمة حيث كانت المجموعة الأشد اصابة مصاحبة لأقل النتائج.

الكلمات الكاشفة: إضطراب فرط الحركة وتشتت الإنتباه- إضطرابات التطور الحركية التآزريه- بطارية قياس الحركة للاطفال.

Introduction:

Attention deficit- hyperactivity disorder (ADHD) is a neurobehavioral disorder characterized by either significant inattention, hyperactivity and impulsiveness or combination of both (Gun- H Kim, 2012). ADHD shows high rates of comorbidity with other neurodevelopmental disorders, particularly with Developmental Coordination Disorder (DCD), which is defined on the basis of a wide range of motor impairments interfering with daily activities and/ or academic achievements (APA, 2013).

Motor problems in ADHD are still a neglected area of clinical attention (Juliana et.al., 2017). Findings of some studies have revealed a wide range of motor problems in ADHD, including excessive overflow movements, poor timing, difficulties in both learning and performing a variety of motor skills, and deficits in fine motor skills (Pitcher et.al., 2003). Other studies revealed problems in controlling movements, deficits in balance performance (Michal etal., 2017), problems in gait and postural control (Papadopoulos et.al., 2014). Balance deficits and difficulties to maintain posture control are also the most reported motor problems in DCD population (Shumway, 2001). Maintenance of balance in static and dynamic conditions represents a crucial motor function and is required for the development and execution of a wide variety of more complex motor skills (Hove et.al., 2015).

Balance abilities were investigated by (Buderath et.al., 2009) in children with ADHD using static and dynamic posturography. Furthermore (Mao et.al., 2014) demonstrated that children with ADHD had less effective balance strategies than a control group when riding a mechanical horse. Using computerized dynamic posturography, (Ren et.al., 2014) found that ADHD boys had poorer postural control ability and impaired visual and vestibular information processing in comparison with typically developing children.

Balance is mediated by the coordinated function of the visual, vestibular, proprioceptive, musculoskeletal, and central nervous systems. The cerebellum plays an integrative role in the management of balance, particularly the vermis and paravermal area. In parallel, volumetric abnormalities of the cerebellar vermis are among the most frequent findings in structural studies of ADHD (Winter et.al., 1990). ADHD show lower performance on tasks of motor control and postural stability which are the main cause of reduction of physical activity, (Harvey et.al., 2003).

Postural and gait balance abnormalities are implicated as important factors of hypo frontality, and may be related to cerebellar inhibitory deficits (O'Halloran, 2012). Early identification and intervention are important as the rate of comorbidity between ADHD and motor impairment has been considered to be close to 50% and it is suggested to be associated with negative long- term outcomes (Dewey et.al., 2002)

Aim Of The Study:

This study aimed to assess balance impairment in children with ADHD and to study its relation with ADHD determinants.

Subjects:

The present study was conducted on 96 child of both gender, aged from (5- 10) years, who attended unit of children with special needs in (El Agoza Rehabilitation And Physiotherapy Centre of Military Force) and diagnosed as having ADHD. The study was done in a period for one year starting from September 2013 to September 2014. This study was performed through 2 phases:

- Phase (1): Descriptive study: for detecting cases with motor skills impairment including balance in children with ADHD.
- Phase (2): analytic study: To assess the relation between static and dynamic balance and ADHD determinants.

1. Inclusion criteria:
   a. Age: from (5- 10) years.
   b. Gender: both gender.
   c. Cases diagnosed as ADHD.
   d. IQ score greater than 70.
2. Exclusion criteria:
   a. Children with neurologic condition affecting movement (e.g., cerebral Palsy, degenerative disorder) or other psychiatric disorders.
   b. Children with Musculoskeletal diseases.
   c. Children with chronic medical diseases, visual impairment, auditory diseases.

Methods:

All children were subjected to:

1. Full history taking focusing on: Symptoms of inattention, hyperactivity, impulsivity, history of developmental milestones, Details history of the child's current gross motor and fine motor difficulties and his performance in daily activities.
2. Thorough clinical examination focusing on neurological assessment:
   a. Psychometric Tests:
      - Conner's' rating scale Revised: Short form (CRS- R) (Conner's., 1997): The short form for parents contains 27 item It consists of four subscales: Oppositional (6 items) Cognitive problems (6 items) Hyperactivity (6 items ADHD index(12 items). Raw scores are converted to standard scores.
      - Wechsler Intelligence Scale for Children (WISC): Weschler (1949) Which includes: Verbal subjects: it consists of 6 subscales: Information, Comprehension Arithmetic, Similarities, Vocabulary, and Digit span. Performal scales: Consists of 6 subscales: Picture completion, Picture arrangement, Block design, Object assembly, Coding, Mazes. Raw scores are collected and compared to scaled scores
      - Developmental Coordination Disorders Questionnaire (DCDQ07): Wilson, et.al. (2009) DCDQ07 is an appropriate clinical screening tool for DCD in children. It provides a standard method to measure a child's coordination in everyday, functional activities. It consists of 15 items, which group into three distinct factors: Control during Movement items; Fine Motor and Handwriting items; General

Coordination items. Parents are asked to compare the degree of similarity of their child with other children, and to rate this on a 5- point scale, ranging from "not at all like this child", to "extremely like this child", the total score ranges from 15 to 75 there are Cut- off scores for each age group.

3. Movement Assessment Battery for Children, Second Edition (MABC-2; (Henderson et.al. 2007): The MABC- 2 is a standardized assessment tool that requires a child to perform a series of motor tasks in a strictly specific way to objectively measure motor impairment. The MABC- 2 can be used for identification, intervention planning, program evaluation, and as a research tool, it is designed for children aged 3 years 0 months to 16 years 11 months; it includes motor tasks related to functioning in daily life. For the present study, the first age band (3-6) years and the second age band ages (7- 10) were administered. Within each age band, eight tasks are grouped under three headings and subtests varied among age bands.
   a. Manual dexterity component (3 tasks): posting coins/ placing pegs, threading beads/ threading lace, drawing trail1/ drawing trail2
   b. Aiming and catching component (2 tasks): catching bean bag/ Catching ball with two hands, Throwing bean bag onto mat
   c. Balance (3 tasks) component: Three balance tasks (one focusing on static and two on dynamic balance: Age band 1 for static balance: One leg balance: the child is asked to stand on one leg on the mat unsupported up to 30 seconds. Both legs are tested and the child is given 1 practice attempt with each leg for up to 15 seconds and 2 formal trials for each leg up to 30 seconds. The score corresponds to the number of seconds that the child maintains balance.
4. Dynamic balance:
   a. Walking heels raised: the child walks along a straight line with heels raised without stepping off the line. Fifteen steps are required. The child is given 1 practice attempt, which consists of 5 steps, and 2 formal trials. up to 15 steps or reach the end of the line the score corresponds to the number of correct consecutive steps that the child accomplished.
   b. Jumping on mats: The child is asked to jump with feet together from mat to mat. The score corresponds to the number of correct consecutive jumps from the start.
   c. Age band 2 for static balance: one board balance: The child is asked to keep balance on one foot on a balance board (for both legs) for up to 30 seconds child is given 1 practice attempt with each leg for up to 15 seconds and 2 formal trials for each leg up to 30 seconds. The score corresponds to the number of seconds that the child maintains balance.
5. Dynamic balance:
   a. Walking Heel- to- toe forward: The child is asked to walk along a straight line, placing heel of one foot against toe of other with each step. The child is given 1 practice attempt, which consists of 5 steps, and 2 formal trials. Up to 15 steps or reach the end of the line the score corresponds to the number of correct consecutive steps that the child accomplished.
   b. Hopping on mats: The child is asked to hop with one leg from mat to mat. Both legs are tested the child is given 1 practice attempt and 2 formal trials for each leg. The score corresponds to the number of correct consecutive hops from the start.

Interpretation of test scores: The child's raw score on each item was recorded then raw scores are converted to standard scores., scores are then summed to produce total scores, Finally, percentile tables are consulted to determine how an individual compares with his/ her age peers and any child who his total test score fall between 6 and the 15th percentile is mildly impaired and any score is at or below the 5th percentile is considered a definite indication of significant coordination problems. This can be done also at the level of individual items sub-scores (manual dexterity, ball skills and balance).

Statistical analysis:

The data were entered, coded and processed on computer using Statistical Packaged for Social Science (IBM SPSS version 22, 2013). The level $P \leq 0.05$ was considered the cut- off value for significance. Description of quantitative variables as mean and SD; And qualitative variables as number and percentage; Chi- Square test $\chi 2$; Fisher exact test; One way ANOVA; Post Hoc Tests;. The correlation coefficient method were done.

Results:

The current study was conducted on 96 child, who attended unit of children with special needs at (ElAgoza Rehabilitation And Physiotherapy Centre of Military Force) during a period of one year (from September 2013- to September 2014), of both gender: 80 males (83.3%), 16 females (16.7%), aged from (5- 10) years and diagnosed of having ADHD: (30) of them were of hyperactive predominant type (31.3%), (34) were inattentive type (35.4%) and (32) were combined type (33.3%).R esults revealed that 46 child (47.9%) had Developmental Coordination Disorders (DCD): where (16) of them were at risk (mild to moderate DCD), and (30) had significant DCD. Results according to scores of balance component of MABC2 were: 38 child (39.6%) showed balance impairment, where 11 cases of them (11.5%) had mild balance impairment while 27 cases(28.1%) had significant balance impairment.

Table (1) Relation between static and dynamic balance impairment and gender..

Gender	Normal Balance Performance	Mild Balance Impairment	Significant Balance Impairment	χ^2	P Value
	N (%)				
Male (80)	46 (57.5)	11(13.7)	23 (28.8)	2.943	0.230
Female (16)	12 (75)	0 (0)	4 (25)		

Table (1) shows that there was no statistical significant difference between balance impairment and gender

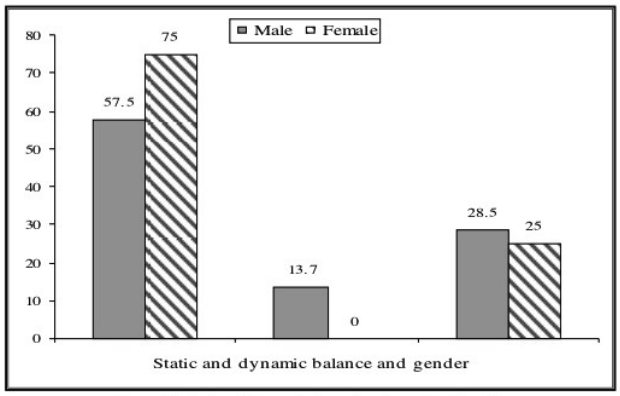

Figure (1) relation between balance impairment and gender

Table (2) Relation Between Static And Dynamic Balance Impairment And ADHD Degree.

ADHD Degree	Normal Balance Performance	Mild Balance impairment	Significant Balance impairment	χ^2	P Value
	N (%)				
Mild (36)	23 (63.9)	5 (13.9)	8 (22.2)		
Moderate (54)	33 (61.1)	6 (11.1)	15 (27.8)	5.301	0.258
Sever (6)	2 (33.3)	0 (0)	4 (66.7)		

Table (2) shows that there was no statistical significant difference between balance performance and degree of ADHD.

Table (3) Relation Between Static And Dynamic Balance Impairment And ADHD Predominant Types.

ADHD Predominant Types	Normal Balance Performance	Mild Balance impairment	Significant Balance impairment	χ^2	P Value
	N (%)				
Hyperactive (30)	25 (83.3)	4 (13.3)	1 (3.3)		
Inattentive (34)	18 (52.9)	2 (5.9)	14 (41.2)	15.008	0.005**
Combined (32)	15 (46.9)	5 (15.6)	12 (37.5)		

Table(3)shows that there was a statistical significant difference (P value< 0.050) between static and dynamic balance and ADHD predominant types

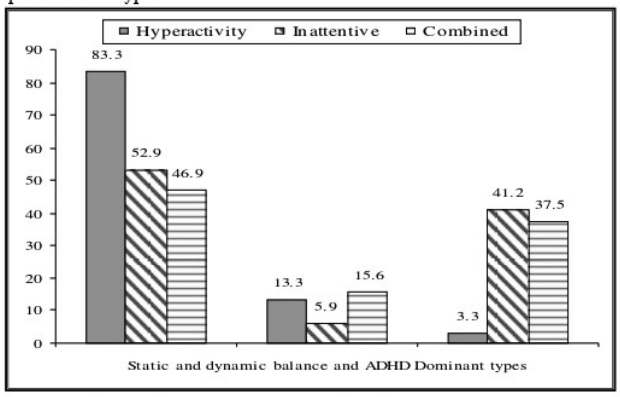

Figure (2) relation between balance and ADHD predominant types

Table (4) relation between balance percentile rank of Movement assessment battery and groups of DCD.

	Not DCD (50)	At risk of DCD (16)	Significant DCD (30)	ANOVA	P Value
	Mean ±S D				
static and dynamic balance percentile rank	31.8±10.3	11.2±6.1	5.6±6.17	95.248	<0.001**

Table (4) shows that there was a statistical significant difference (P value< 0.050) between 3 groups of DCD regarding the balance percentile of Movement assessment battery, the lowest mean was in significant DCD group.

Table (5) Multiple comparison between groups of DCD and the balance percentile rank

	Dcd Groups	Mean Difference	Std. Error	P Value
static and dynamic balance percentile rank	Not Dcd& At Risk	20.59	2.50	<0.001**
	Not Dcd& Significant	26.24	2.01	<0.001**
	At Risk& Significant	5.65	2.69	<0.039*

Table (5) shows that there was a statistical significant difference (P value< 0.050) between each group and the other of DCD regarding the balance percentile rank of movement assessment battery. Post Hoc tests were used.

Table (6) Correlation between questionnaire total score, total percentile rank and balance component of movement assessment battery

Questionnaire Total Score	r	P Value
Total Percentile Rank	0.755	<0.001**
static and dynamic balance percentile rank	0.724	<0.001**

Table (6) shows that there was a statistical significant positive correlation (P value <0.050) between questionnaire total score, total percentile rank and balance component of movement assessment battery

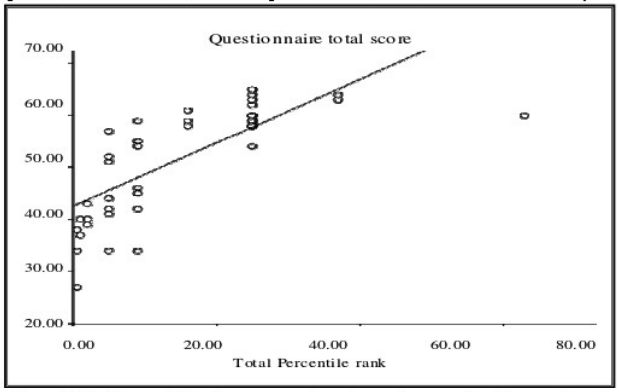

Figure (3) Positive correlation between questionnaire total score and total percentile rank

Discussion:

Attention deficit hyperactivity disorder (ADHD) is a highly comorbid condition and can be detected by the presence of inattention, impulsivity, and hyperactivity (Willcutt., 2012). DSM 5 classification notes an important relationship between ADHD and motor difficulties; however, it states that although mild motor delays often co- occur with ADHD, these are not specific to the disorder. Developmental coordination disorder (DCD) include a marked impairment in the development of coordination. This impairment significantly interferes with academic achievement or activities of daily living, The child may present with mild motor delays, difficulties with cross body coordination, or problems with balance (APA, 2013). Specific motor difficulties in ADHD as well as the relationship between the cardinal symptoms of ADHD and motor performance were included in some studies (Tseng et.al., 2004). Problems in balance performance and postural control are expected in ADHD for two main reasons: First, ADHD shows high rates of comorbidity with Developmental Coordination Disorder (DCD), whose main features are difficulties in the acquisition and execution of coordinated motor skills,

and the two disorders show overlap in genetic studies (Fliers et.al., 2008). In addition, some studies have suggested a cerebellar dysfunction in individuals with DCD (Fong, Tsang& Ng, 2012), or deficits in effectiveness of child sensory system or sensory organization (Sherng et.al., 2007). Second, areas of the brain involved in motor function (e. g. the motor and premotor cortex, basal ganglia and cerebellum are typically of abnormal volume in ADHD, as well as abnormalities in temporal, and parietal regions (Castellanos et.al., 2002; (Krain, 2006).

This study was designed to study balance impairment in children diagnosed with ADHD as well as to assess the relation between balance impairment and ADHD determinants.

The current study was conducted on 96 child with Attention Deficit Hyperactivity Disorder (ADHD), during a period of one year (September 2013 to September 2014); by applying the questionnaire as screening for motor problems and MABC2 as a diagnostic test, results revealed that 46 child 47.9%) had Developmental Coordination Disorders (DCD): where (16) cases of them were at risk (mild to moderate motor impairment), and (30) cases had significant DCD. Subscores of balance performance component of MABC2 were: 38 child (39.6%) showed balance impairment: where 11 child (11.5%) had mild balance impairment and 27 child (28.1%) had significant balance impairment.

Similar to our results, Kadesjo& Gillberg, (1998); Kaplan et.al., (1998) reported that, not all children diagnosed with ADHD displayed impairments in motor functioning and approximately 30 to 50% of children with ADHD meet criteria for coordination problem.S imilarly, in a study done by (Hui- Yi et.al., 2011) for assessment of Motor ability and adaptive function in children with attention deficit hyperactivity disorder, he found that 36% of the participants had significant motor impairment and 28% were borderline cases.

Similarly, among samples of children with ADHD, the prevalence of children who present a probable risk of DCD with a score at or below the 15th percentile on the MABC varies as follows: 51.5% (Pitcher et.al., 2003), 65% (Fliers, et.al., 2010) and 73.5% (Brossard- Racine et.al., 2012).

Recommended cut- points indicating the presence or risk of DCD have varied (Wilson et.al. 2009) children who received scores at or below the 15th percentile were included in this study as it is recommended in the Movement Assessment Battery for children that scoring below the 5th percentile means that children are considered to have a definite and severe motor impairment while children scoring from the 6th to 15th percentile are considered to have a degree of difficulty that is mild to moderate or borderline, these borderline children are still at risk and require careful consideration of their whole clinical picture and the impact the motor difficulties on their development(Henderson and Sugden 1992).

In this study no significant difference was found between gender and balance impairment on applying balance component of M ABC2.

Similarly, on a study done by (Stray, 2009) for assessment of motor function in ADHD, no gender differences were found in motor impairment in all subtests including that of balance assessment.

Similar to our study, (Beyer, 1999) found on assessing balance in children with ADHD that there was no statistical significance difference found between gender as regard balance impairment.

Also, through several studies done by (Fliers et.al., 2008) he reported that the influence of gender on motor performance in ADHD is unclear as it varied among studies, while one study found evidence of increased relative motor deficit in girls with ADHD compared to boys with the disorder, another study suggested that girls with ADHD show nearly normative motor development whereas boys with ADHD do not.

In our results, there was no statistical significant difference (P value< 0.050) between significant balance impairment and age groups while significant difference between age groups in children with mild balance impairment

In a retrospective study of 73 children with ADHD age (5- 17) years (62 boys and 11 girls) assessed by items of Motor Function Neurological Assessment, (Stray, 2001) found that motor problem were present both in the younger ADHD group (age 5- 10) and in the older group (age 11- 17) in all motor domains, also he reported in another study that there were no significant age effects on motor performance on any of the battery subtests involving balance performance (Stray, 2009).

Our findings were in accordance with more recent evidence of the partial persistence of structural brain abnormalities related to developmental motor problems across ages (Castellanos et.al., 2002; Shaw, 2007).

This is un going with a study done by Valentini, (2015) using MABC for detecting motor impairment he found significant differences across age bands in performing balance subtest where children at age band 3 (10- 16 years) had better performance at balance tests than age band 1(3- 6 years), and also with findings reported from a study on motor abilities of ADHD children in South Africa, where a high prevalence of impairment was only found in children from 9 to 12 years old (Prinsloo& Pienaar 2003).

In our study, there was no statistically significant association between ADHD degree and balance affection. Similar to our result, Watemberg et.al., (2007) found that the combination of ADHD and DCD is detected irrespective of ADHD severity.

In the present study, there was statistically significant higher balance impairment in inattentive ADHD subtype and combined type than hyper active type p< 0.005.

Similarly, (Yocheved Bensinger& Brody 2015) found a negative correlation between the scores on the cognitive inattention and ADHD subscales of the Conners' and performance on all MABC- 2 subtests, in that greater deficit in attention was related to decreased performance on balance and other motor tasks.

Similar to the present study, in a study done by (kooistra, 2009)on assessing motor function of ADHD he found that inattentive and combined type perform worse on MABC and on performing balance subtest the combined type was more impaired, however, on performing the test among control he discovered that balance differs less from control

in ADHD inattention type than in combined type This is going with a study done by (Willcutt, 2012) he concluded that the children with ADHD inattentive type as well as children with ADHD- combined type show more often an impairment of all motor skills. This finding concurs with that of (Pitcher et.al., 2003) by using the MABC score, he found that children with primary inattentive and combined ADHD subtypes perform worse on fine and gross motor abilities including dynamic balance. This is going with a study by (Tseng et.al., 2004) which described an impairment of balance among ADHD children. He found that children with ADHD scored significantly lower than others on the balance subscore of Bruininks Oseretsky Test of Motor Proficiency.

The present study also revealed statistically significant differences p value< 0.050 between DCD groups regarding the balance component of Movement assessment battery, the lowest mean of balance deficit was in significant DCD group (ADHD with significant DCD.

Our results correspond with findings of (Langmaid etal., 2013) as he found that children with ADHD/ DCD group have more severe motor problems in all domains than children with only ADHD. Apart from that, children with ADHD who do not meet the criteria for DCD may still have motor skill challenges, to a lesser degree.

Similar to our study, a study done by (William et.al., 2013) where comparison between groups of children those with ADHD and DCD, and DCD alone, and ADHD alone, and controls using MABC: significant difference was found between score of MABC subtests including balance between groups, the worst balance impairment score was in ADHD/ DCD group.

Our results correspond with findings of (Mao et.al., 2014) on his study on balance performance in ADHD children, he found worse ability to maintain dynamic balance in ADHD children than other involved group.

This is similar to findings of (Green et.al., 2002) when using the M-ABC, he found that children with DCD demonstrate greater impairments in balance. Similarly, in a study done by (Francisco Rosa, 2015) for assessment of motor profile in ADHD There was significant difference between motor development in ADHD group and control, it was found also that children with ADHD were at risk for delayed development in all domains, especially for balance, spatial and temporal organizations.

This is in line with a study done to assess balance deficits in ADHD children (Konicarova J, 2014) found a relationship between ADHD symptoms and balance deficits, which cannot be attributed to medication and the presence of any neurological disease. The present study shows that there was a statistical significant positive correlation (P value <0.050) between questionnaire total score and total percentile rank of MABC2 and balance. This coincides with a study done by (Wilson et.al., 2009) he found that children with both ADHD and DCD performed lowest on both the Movement Assessment Battery for Children (MABC2) and on the DCDQ, where positive correlations were found between total performance on the MABC- 2 and parent report on the DCDQ, r= 0.53, p= 0.04.

Conclusion:

This study showed that ADHD was highly associated with poor static and dynamic balance performance, being more related to inattentive and combined type irrespective to the degree of severity of ADHD or age of children, both gender are affected. Early identification, clinical assessment and practical rehabilitation of motor ability for children with ADHD are important.F uture research on this issue should be directed to finding factors that underlie both conditions for better prevention and intervention strategies.

References:

1. American Psychiatric Association (2013): **Developmental coordination disorder. In: Diagnostic and Statistical Manual of Mental Disorders**, Fifth Edition, American Psychiatric Association, Arlington, VA.
2. Beyer, R. (1999): Motor proficiency of boys with attention deficit hyperactivity disorder and boys with learning disabilities. **Adapted Physical Activity Quarterly**, 16(4), 403- 414. .
3. BrossardRacineM., Shevell, M., Snider, L., Belanger, S. A.& Majnemer, A. (2012): Motor skills of children newly diagnosed with attention deficit hyperactivity disorder prior to and following treatment with stimulant medication. **Research in Developmental Disabilities**, 33(6), 2080- 2087.
4. Buderath, P., Gartner, K., Frings, M., Christiansen, H., Schoch, B., Konczak, Timmann, D. (2009): Postural and gait performance in children with attention deficit/ hyperactivity disorder. **Gait& Posture**, 29, 249- 254.
5. Castellanos, F. X., Lee, P. P., Sharp, W., Jeffries, N. O., Greenstein, D. K., Clasen, L. S. (2002): Developmental trajectories of brain volume abnormalities in children and adolescents with attention-deficit/hyperactivity disorder. **JAMA: The Journal of the American Medical Association**, 288(14), 1740- 1748.
6. Cherng R. J. Y. W. H Suc. Y. J, Shend (2007): Standing balance of children with developmental coordination disorder under altered sensory condition, **Hum Mov Sci**: 26:913- 926.
7. Conners, C. K. (1997): **Conners, Rating scales revised**, Toronto: Multi health systems Inc., Seventh Printing: August 2003.
8. Dewey D, Kaplan BJ, Crawford SG, Wilson BN. (2002): Developmental coordination disorder: associated problems in attention, learning, and psychosocial adjustment. **Hum Mov Sci** 21: 905- 918.
9. Fliers, E. A., De Hoog, M. L. A., Franke, B., Faraone, S. V., Rommelse, N. N. J., Buitelaar, J. K., (2010): Actual motor performance and self- perceived motor competence in children with attention- deficit hyperactivity disorder compared with healthy siblings and peers. **Journal of Developmental and Behavioral Pediatrics**, 31(1), 35- 40.
10. Fliers, E. A., Rommelse, N., Vermeulen, S. H., Altink, M., Buschgens, C. J., Faraone, S. V., Buitelaar, J. K. (2008): Motor

coordination problems in children and adolescentswith ADHD rated by parents and teachers: Effects of age and gender. **Journal of Neural Transmission**, 115, 211- 220.

11. Fong, S. S., Tsang, W. W.& Ng, G. Y. (2012): Altered postural control strategies and sensory organization in children with developmental coordination disorder. **Human Movement Science**, 31, 1317- 1327.
12. Fransisco Rosa Neto, Juliana B. Goulardins, Daniela Rigoli, Jan P. Piek, Jorge A. (2015): **Motor development of children with attention deficit hyperactivity disorder Revista Brasileira de Psiquiatria**. 37: 228- 234
13. Green D, Baird G, Barnett AL, Henderson L, Huber J, Henderson SE (2002): The severity and nature of motor impairment in Asperger's syndrome: A comparison with specific developmental disorder of motor function. **Journal of Child Psychology and Psychiatry**; 43(5): 655- 668.
14. Gun- H Kim, JiYeon Kim, Jung HyeByeon, Baik- Lin Eun, Young Jun Rhie, Won HeeSeo, and So- HeeEu; (2012): Attention Deficit Hyperactivity Disorder in Epileptic Children; (2012): **J. Korean Med Sci**. 2012 October; 27(10): 1229- 1232.
15. Harvey, W. J.& Reid, G. (2003): Attention- Deficit/Hyperactivity disorder: A review of research on movement skill performance and physical fitness. **Adapted Physical Activity Quarterly**, 20(1), 1- 25.
16. Henderson and Sugden (1992): **The Movement Assessment Battery for Children**. San Antonio, TX: The Psychological Corporation.
17. Henderson SE, Sugden DA, Barnett AL (2007): **Movement Assessment Battery for Children** Second Edition [Movement ABC-2] London, UK: The Psychological Corporation.
18. Hui- Yi Wanga, Tzu- Hsiu, Huangb, Sing- Kai L (2011): Motor ability and adaptive function in children with attention deficit hyperactivity disorder **The Kaohsiung Journal of Medical Science** Volume 27, Issue 10, : Pp.446- 452.
19. Hove MJ, Zeffiro TA, Biederman J, Li Z, Schmahmann J, Valera EM (2015):. Postural sway and regional cerebellar volume in adults with attention- deficit/ hyperactivity disorder. **Neuro image Clin**. 2015; 8(C): 422- 428.
20. IBM Corp. Released (2013): **IBM SPSS Statistics for Windows**, Version 22.0. Armonk, NY: IBM Corp.
21. Juliana B. Goulardins1, Juliana C. B. Marques1, and Jorge A. De Oliveira (2017): Attention Deficit Hyperactivity Disorder and Motor Impairment: **A Critical Review Perceptual and Motor Skills**, Vol. 124(2) 425- 440.
22. Kadesjo, B.& Gillberg, C. (1998): Attention deficits and clumsiness in Swedish 7- year- old children. **Developmental Medicine& Child Neurology**, 40, 796- 804.
23. Kaplan, B. J., Wilson, B. N., Dewey, D.& Crawford, S. G. (1998): DCD may not be a discrete disorder. **Human Movement Science**, 17, 471- 490.
24. Konicarova J, Bob P, Raboch J (2014): Balance deficits and ADHD symptoms in medication- naïve school- aged boys **Dev Disabil**; 35(6): 1252- 1258
25. Kooistra, L., Ramage, B., Crawford, S., Cantell, M., Wormsbecker, S., Gibbard, B., et.al. (2009): Can attention deficit hyperactivity disorder and fetal alcohol spectrum disorder be differentiated by motor and balance deficits? **Human Movement Science**, 28(4), 529- 542.
26. Krain, A. L.& Castellanos, F. X. (2006): Brain development and ADHD. **Clinical Psychology Review**, 26(4), 433- 444.
27. Langmaid R. A., Papadopoulous, N., Johnson, B. P., Phillips, J.& Rinehart, N. J. (2013): Movement scaling in children with ADHD-combined type. **Journal of Attention Disorders**, 20, 131- 137
28. Mao, H. Y., Kuo, L. C., Yang, A. L.& Su, C. T. (2014): Balance in children with attention deficit hyperactivity disorder- combined type. **Research in Developmental Disabilities**, 35, 1252- 1258.
29. Michal Goetz, Jaroslava Paulasova Schwabova, Zdenek Hlavka, Radek Ptacek, and Craig BH Surman(2017): Dynamic balance in children with attention- deficit hyperactivity disorder and its relationship with cognitive functions and cerebellum **Neuropsychiatr Dis Treat**. 2017; 13: 873- 880.
30. O'Halloran CJ, Kinsella GJ, Storey E (2012): The cerebellum and neuropsychological functioning: a critical review. **J Clin Exp Neuropsychol.** ; 34(1): 35- 56.
31. Papadopoulos, N., McGinley, J. L., Bradshaw, J. L.& Rinehart, N. J. (2014): An investigation of gait in children with attention deficit hyperactivity disorder: A case controlled study. **Psychiatry Research**, 218, 319- 323.
32. Pitcher, T. M., Piek, J. P.& Hay, D. A. (2003): Fine and gross motor ability in males with ADHD. **Developmental Medicine& Child Neurology**, 45, 525- 535.
33. Prinsloo, A.& Pienaar, A. E. (2003): Prevalence of developmental coordination disorder and influences of physical activity levels and body composition on the children of farm workers: FLAGH- study. African **Journal for Physical, Health Education, Recreation and Dance**, 9, 151- 164.
34. Ren Y, Yu L, Yang L, Cheng J, Feng L, Wang Y(2014): Postural control and sensory information integration abilities of boys with two subtypes of attention deficit hyperactivity disorder: a case- control study. **Chin Med. J.** 2014;127(24): 4197- 4203.
35. Shaw P, Gornick M, Lerch J, Addington A, Seal J, Greenstein D et.al. (2007): Polymorphisms of the dopamine D4 receptor, clinical outcome, and cortical structure in attention- deficit= hyperactivity disorder. **Arch Gen Psychiatry** 64: 921- 931.
36. Shumway Cook A, M. H. Wollcut A, (2001): **Motor control theory and practical application**. William and Wilkins. Baltimor.
37. Stray LL (2001): Motor function in children with ADHD: A retrospective study of motor problems in children with ADHD based on (MFNU, Modified function- neurological assessment). **Master**.

2001, University of Bergen, Division for Physiotherapy Science, the Faculty of Medicine.

38. Stray, L. L., Stray, T., Iversen, S., Ruud, A., Ellertsen, B.& Tønnessen, F. E. (2009b): The motor function neurological assessment (MFNU) as an indicator of motor function problems in boys with ADHD. **Behavioral and Brain Functions**, 5
39. Tseng, M. H., Henderson, A., Chow, S. M.& Yao, G. (2004):. Relationship between motor proficiency, attention, impulse, and activity in children with ADHD. **Developmental Medicine& Child Neurology**, 46, 381- 388.
40. Valentini N. C., J. E. Clark J. Whitall (2015): **Developmental co-ordination disorder in socially disadvantaged Brazilian children** https: //www. researchgate. net/publication/268876367.
41. Watemberg N, Waiserberg N, Zuk L, Lerman Sagie (2007): Developmental coordination disorder in children with attention-deficit- hyperactivity disorder and physical therapy intervention. **Developmental Medicine and Child Neurology**: 49(12): 920- 925
42. Wechsler D; (1949): **Wechsler Intelligence Scale for children. Manual**, The psychological Corporation, New York.
43. Willcutt, E. G. (2012): The prevalence of DSM- IV attention- deficit/ hyperactivity disorder: A meta- analytic review. **Neurotherapeutics**, 9, 490- 499.
44. Williams J, Cristina Omizzolo, Mary P. Galea D, Alasdair Vance (2013): Motor imagery skills of children with Attention Deficit Hyperactivity Disorder and Developmental Coordination Disorder. **Hum Mov Sc**i.; 32(1): 121- 35
45. Wilson, B. N., Crawford, S. G., Green, D., Roberts, G., Aylott, A. & Kaplan, B. J. (2009): Psychometric properties of the revised developmental coordination disorder questionnaire. **Physical and Occupational Therapy in Pediatrics**, 29:2, 182- 202.
46. Winter DA, Patla AE, Frank JS. (1990): Assessment of balance control in humans. **Med Prog Technol**. ; 16(1- 2): 31- 51
47. Yocheved Bensinger, Brody (2015): **Developmental Coordination Disorder: The relationship Between Gait And Attention With Possible Implications For Early Identification And Intervention CUNY Academic Works**. http://academicworks.cuny.edu/ gc_etds/859.