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Erwin Borremans

Asperger Syndrome and Physical Exercise

A Study about Senso-motor Profiles, Physical Fitness, and the Effectiveness of an Exercise Training Program in a Group of Adolescents with Asperger Syndrome

JYVÄSKYLÄN YLIOPISTO

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"Move your body. Stretch your mind!"

(Slogan of the 2004 European year of education through sport)

ABSTRACT

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The present study was designed to compare the motor competence, physical fitness, physical activity levels, and sensory processing of young adults with Asperger syndrome (AS) with age and gender matched controls, and to compare the motor skills between younger and older participants within both groups. Additionally, this study examined the efficacy of an exercise program as part of an ongoing vocational training program on motor competence and physical fitness for adolescents with AS.

Young adults with AS performed motor competence and physical fitness tasks at a remarkably lower level than their peers, as they scored lower on all subtests, including manual dexterity, balance, ball skills, coordination, flexibility, muscular strength, running speed and cardio-respiratory endurance. Adolescents with AS were also less physically active and they continued to demonstrate motor delays over age, even though motor competencies of individuals with AS seemed to improve after the adolescent years.

Differences between groups with and without AS were also found on overall sensory processing as well as on three of the four sensory quadrants (low registration, sensation seeking, and sensation avoidance). Further analysis revealed that 47% of the group with AS reported extreme levels of sensory processing. Moreover differences in sensory profile over varied levels of motor competence were observed.

The 12-week exercise training program was successful and indicated improved motor competence and physical fitness that was sustained over time. Implementation of similar programs is therefore recommended.

Key words: Asperger syndrome, autism, motor competence, physical fitness, physical activity, sensory processing, social interaction, follow-up, adolescents.

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Hyvinkäänkylä, April 2011
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LIST OF PUBLICATIONS

The present thesis is based on the following original papers, which are referred to in the text by their Roman numerals:

I Borremans, E., Rintala, P., & McCubbin, J. A. (2009). Motor skills of young adults with Asperger syndrome: A comparative study. European Journal of Adapted Physical Activity, 2(1), 21-33.

II Borremans, E., Rintala, P., & McCubbin, J. A. (2010). Physical fitness and physical activity in adolescents with Asperger syndrome: A comparative study. Adapted Physical Activity Quarterly, 27, 308-320.

III Borremans, E., Rintala, P., & Kielinen, M. Sensory processing in adolescents and adults with Asperger Syndrome: A Comparative Study. Manuscript submitted for publication.

IV Borremans, E., Rintala, P., & Kielinen, M. (2009). Effectiveness of an exercise training program on youth with Asperger syndrome. European Journal of Adapted Physical Activity, 2(2), 15-25.

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ABBREVIATIONS

AASP	Adolescent/Adult Sensory Profile
ADHD	Attention-deficit-hyperactivity disorder
ANOVA	Analysis of variance
APA	American Psychiatric Association
AS	Asperger syndrome
ASD	Autism spectrum disorder
BMI	Body mass index
BOTMP	Bruininks-Oseretsky Test of Motor Proficiency
DCD	Developmental coordination disorder
DSM-IV	Diagnostic and Statistical Manual of Mental disorders (4^{th} edition)
Eurofit	European physical fitness test
HFA	High functioning autism
HGR	Handgrip strength
hr	heart rate
ICD	International classification of diseases
IEP	Individual education plan
IQ	Intelligence quotient
M	Mean
MANOVA	Multivariate analysis of variance
M-ABC-II	Movement Assessment Battery for Children, second edition
PA	Physical activity
PE	Physical education
PARQ	Physical activity research questionnaire
PEL	Physical activity in leisure time
PDD	Pervasive developmental disorder
RM	Repeated measures
SAR	Sit-and-reach
SBJ	Standing broad jump
SD	Standard deviation
SHR5	10 by 5 meter shuttle run
SLB	Single leg balance
SSS	Simple sport score
SP	Sensory profile
SSQ	Sensory sensitivity questionnaire
SUP	Sit-ups
USDHHS	U.S. Department of Health & Human Services
UWT2	UKK 2 km walking test

CONTENTS

1 INTRODUCTION

Asperger syndrome (AS) is a condition considered to fall at the higher end of the continuum of Autistic Spectrum Disorders (ASD), and people with it, therefore, show significant difficulties in social interaction, along with restricted and repetitive patterns of behavior and interests. Although not required for diagnosis, physical clumsiness is frequently reported. Youth with AS display this variety of complex behaviors across academic, behavioral, social/ emotional, leisure/recreational, and also vocational areas. Within physical education settings, there is a need to better understand possible causes of the specific senso-motor challenges concerning movement, coordination, and sensory sensitivities of students with AS and, in order to determine practical solutions to these challenges.

While there is considerable research and knowledge regarding the social, emotional, cognitive and linguistic abilities of people with AS (Smith, 2000), research regarding the senso-motor domain, including movement, coordination and sensitivities, is unfortunately scarce. However, there is a crucial need for studies in this area. Tony Attwood (2007), one of the world's most known AS clinicians, even stipulated that an increase in research of this particular aspect of AS is a must in the next decade, as is the development and evaluation of more remedial strategies to improve senso-motor functioning.

Specific challenges in the senso-motor domain, such as problems with handwriting, poorly planned movements, being physically unfit, and, unusual reactions to sensory stimuli are discussed little in the literature and limited research exists on the precise nature of these difficulties. Literature on physical fitness and AS is almost non-existant in spite of the important need to gain insight into physical activity levels and fitness profiles of individuals with AS. This knowledge is crucial as we believe that increasing physical fitness and activity levels through exercise training could be a key element in the habilitation process of individuals with AS.

Therefore, the following review of literature and the summary, based on the four original articles (I-IV), focus on comparing motor skills, physical fitness and physical activity, and sensory processing of youth with AS and with age and gender matched peers, as well on the effectiveness of a physical exercise training program.

2 REVIEW OF LITERATURE

In order to fully understand the senso-motor profiles presented in this study in chapter 5 and 6, and also in order to correctly assess the impact of the exercise training program with our specific population, it is necessary to describe the features of Asperger syndrome in detail. Not only will this help us enhance the interpretation of results, it will also ensure that the reader of this study is aware of the author's understanding of AS. This chapter therefore provides an overview on Asperger syndrome and its characteristics. In addition, more detailed discussions of the characteristics related to this project, in the areas of motor competence, physical activity and physical fitness, sensory processing, and exercise training programs, are presented.

2.1 Asperger syndrome: an introduction

Numerous good and comprehensive introductions on the subject of Asperger syndrome exist. However this chapter provides the opportunity to add and highlight specific information relevant for this inquiry.

Asperger syndrome is a condition considered to fall at the higher end of the continuum of Autistic Spectrum Disorders, with up to date, still enough distinct features to warrant its own label. Overall, AS can be defined as a neurodevelopmental disability that is characterized by subtle and sustained impairment in three areas of development: social communication, social interaction, and social imagination. It was first described by the Austrian Hans Asperger in 1944 (Asperger, 1944), whose work remained widely undiscovered until it was first published in English many decades later.

It was Lorna Wing who first used the term Asperger syndrome (AS) in the English-speaking world in 1981 (Wing, 1981). She described a group of individuals with characteristics that resembled those of a group of boys originally described by Asperger. Although these children had the classic autistic features when very young, they did develop normal speech and a desire to socialize with others. Individuals with AS have some of the behavioral and social difficulties associated with other degrees of autism, but they tend to have language and cognitive skills within or above normal range. AS involves a 'more subtle' presentation of difficulties.

2.2 Specific characteristics of AS

2.2.1 Four sets of diagnostic criteria

On one hand, the most widely used diagnostic criteria for psychological assessment, the DSM-IV (American Psychiatric Association, 1994) and the ICD-10 (World Health Organization, 1993), base their diagnostic criteria for AS largely on the three fundamental impairments as outlined in the triad of impairments in autism by Wing and Gould (1979), including impairments of social interaction, impairment of social communication, and impairment of social imagination, flexible thinking and imaginative play. Following Asperger, both rule out early language delay, and neither include motor coordination difficulties as a diagnostic feature.

On the other hand, other sets of criteria have been proposed by clinicians such as Gillberg and Szatmari (Gillberg & Gillberg, 1989; Szatmari, Brenner, & Naggy, 1989). Even though similarities with the ICD and DSM are there, these more clinical oriented criteria are often less stringent and do differ to some extent. Detailed information concerning the different sets of diagnostic criteria is given below (Tables 1 & 2).

In the present project, individuals were enrolled and included to the study based on their AS diagnosis made according to the ICD-10 criteria. This diagnosis was made in the school setting prior to, and independent from, this research; so there was no opportunity left to make a choice between the different sets of criteria. First, the ICD-10 classification system is the most commonly used in our school system in Finland, and therefore it is most likely that if the freedom of choice would have been present, this set of criteria would have been chosen as well. Second, according to our clinical observations, we are confident that the use of the DSM-IV criteria, for example, would not have resulted in neither false positives nor false negatives as compared to the used set of criteria. The criteria for AS from the ICD-10 are listed in Table 1. A copy of the other 3 sets of criteria is provided in Appendixes 1-3.

Since clinicians have a choice of four sets of similar but slightly different diagnostic criteria for AS, the precise status of impairments, especially the ones in the senso-motor domain, seem to be unclear and controversial. For example, where the DSM-IV does not even define motor clumsiness, the ICD-10 and Gillberg and Gillberg (1989) refer to clumsiness of movement; although, motor

TABLE 1 Diagnostic criteria of Asperger's syndrome from ICD-10 (WHO, 1993)

A. There is no clinically significant general delay in spoken or receptive language or cognitive development. Diagnosis requires that single words should have developed by two years of age or earlier and that communicative phrases be used by three years of age or earlier. Self-help skills, adaptive behaviour and curiosity about the environment during the first three years should be at a level consistent with normal intellectual development. However, motor milestones may be somewhat delayed and motor clumsiness is usual (although not a necessary diagnostic feature). Isolated special skills, often related to abnormal preoccupations, are common, but are not required for diagnosis.

B. Qualitative abnormalities in reciprocal social interaction, manifest in at least one of the following areas:
   a. Failure adequately to use eye-to-eye gaze, facial expression, body posture and gesture to regulate social interaction;
   b. Failure to develop (in a manner appropriate to mental age, and despite ample opportunities) peer relationships that involve a mutual sharing of interests, activities and emotions;
   c. Lack of socio-emotional reciprocity as shown by an impaired or deviant response to other people's emotions; or lack of modulation of behaviour according to social context, or a weak integration of social, emotional and communicative behaviours;
   d. Lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g., a lack of showing, bringing, or pointing out to other people objects of interest to the individual).

C. The individual exhibits an unusually intense, circumscribed interest or restricted, repetitive, and stereotyped patterns of behaviour, interests and activities manifest in at least one of the following areas:
   a. An encompassing preoccupation with stereotyped and restricted patterns of interest that are abnormal in content or focus: or one or more interests that are abnormal in their intensity and circumscribed nature though not in the content or focus;
   b. Apparently compulsive adherence to specific, non-functional routines or rituals;
   c. Stereotyped and repetitive motor mannerisms that involve either hand/finger flapping or twisting, or complex whole body movements;
   d. Preoccupations with part-objects or non-functional elements of play materials (such as their colour, the feel of their surface, or the noise/vibration that they generate);

D. The disorder is not attributable to the other varieties of pervasive developmental disorder; schizotypal disorder; simple schizophrenia; reactive and disinhibited attachment disorder of childhood; obsessional personality disorder; obsessive-compulsive disorder.

clumsiness (observed as poor performance on neuro-developmental examination) is only included as one of the six diagnostic characteristics in Gillberg's criteria. A partial summary of the diagnostic criteria for Asperger syndrome is given in Table 2. To facilitate understanding and allow for quick reference, only the (in our view) most substantial differences are listed, without including all the criteria's subsections.

Eventhough sensory characteristics have been described extensively in autobiographies of people with AS as having great impact on the daily life of individuals with AS (e.g., Sainsbury, 2000; Willey, 1999; Williams, 1998) clinicians and researchers have unfortunately not been 'sensitive' to this important aspect of Asperger syndrome. Major questions regarding the nature of their (a)typical sensory profiles, the reasons for atypical sensory processing patterns of individuals, the existence of gender differences in sensory processing, the ways in which these sensitivities interfere with simple acts in every day life, or the ways to modify sensory sensitivities effectively, are not yet satisfactorily answered.

TABLE 2 Partial summary of Diagnostic Criteria for Asperger (Adapted from Mattila et al., 2007)

	DSM-IV	ICD-10	Gillberg	Szatmari
Language delay	No	No	Possibly	
Cognitive development delay	No	No		
Self-help skill delay	No	No		
Social interaction impairment -Impaired nonverbal communication -Inadequate friendships	Yes Possibly Possibly	Yes Possibly Possibly	Yes Yes Possibly	Yes Yes Yes
Repetitive, stereotyped behavior -All-absorbing interest -Routines or rituals	Yes Possibly Possibly	Yes Possibly Possibly	Yes Yes Yes	
Odd speech			Yes	Yes
Motor clumsiness		Possibly	Yes	
Isolated special skills		Frequent		
Clinically significant impairment in areas of functioning	Yes			
Exclusion of other disorder	Yes	Yes	No	Yes
Sensory issues				

Note: Blank = not defined by the criteria

2.2.2 Review of specific characteristics of AS important for this study

The following review further describes and explains the characteristics of AS especially important to this investigation, particularly difficulties in motor domain and sensory sensitivities.

2.2.2.1 Difficulties in motor domain

Individuals with AS often have motor clumsiness, having difficulties with both gross and fine motor skills. The difficulty is often not just the task itself, considering their cognitive skills are often high, but the motor planning involved in completing the task. Typical difficulties are related to handwriting, riding a bike, balance and ball skills. Because these and other difficulties in the motor domain are of particular interest in our study, we opted to focus not only on the motor competence aspect, but also to include the much less reported (but very much related) topics of physical activity and physical fitness.

Motor clumsiness and motor competences

In his classic paper on the syndrome, Hans Asperger (1944, translated in Frith, 1989) presented four case histories. They describe children with AS as motorically clumsy or poorly coordinated. In describing a boy named Fritz, he noted: “Motor milestones were rather delayed. He learned to walk at fourteen months, and for a long time was extremely clumsy and unable to do things for himself” (Asperger, p. 39). In relation to another boy named Harro, he described: “The motor clumsiness was particularly well demonstrated in physical education lessons. Even when he was following the group leader’s instructions and trying for once to do a particular physical exercise, his movements would be ugly and angular. He was never able to swing with the rhythm of the group. His movements never unfolded naturally and spontaneously.” (Asperger, p. 57).

Such challenges with motor competence, or in other words motor clumsiness, are mentioned as common. Yet they are not defining features of Asperger syndrome in both the ICD-10 and the DSM-IV. Eventhough the specific characteristics of motor impairment remain poorly described, estimates of the prevalence of these problems range from 50% to 85%, (Attwood, 1998; Gillberg & Gillberg, 1989; Klin, Volkmar, Sparrow, Cicchetti, & Rourke, 1995; Manjiviona & Prior, 1995; Noterdaeme, Wriedt, & Hoehne, 2010; Sahlander, Mattsson, & Bejerot, 2008; Smith, 2000). These motor problems can involve different domains, including fine motor and gross motor skills, gait, balance, and ball skills. Individuals with AS may have a history of delayed acquisition of specific motor skills such as walking, pedaling a bike, catching a ball, standing on one leg, hopping, climbing parallel-bars, and so on. They are often visibly awkward, exhibiting stiff gait patterns, odd posture, poor manipulative skills, and deficits in visual-motor coordination. The pervasive nature of these motor problems, as well as the fact that more children are being diagnosed every year due to a greater awareness of AS, makes it increasingly likely that physical education teachers and coaches will have children with AS in their programs and on their teams. To increase active participation of adolescents with AS in physical education, some useful suggestions and teaching strategies have been added into the discussion section.

Often the presence of clumsiness in AS has been defined on the basis of the clinician's subjective impressions such as having difficulties tossing a ball or following physical movement directions (e.g., 'reach forward with left arm'). Only a limited number of studies have used standardized tests of motor skill, such as the Bruininks-Oseretsky test of Motor Proficiency (BOTMP; Bruininks, 1976), the Movement Assessment battery for Children (M-ABC; Henderson & Sudgen, 1992), and the Zuricher Neuromotor assessment (Largo, Fischer, & Caflisch, 2002). Despite of the wide variety of tests used, there seems to be agreement that motor impairment is very common among children and adolescents with AS and autism, with 50-100% of the children with AS meeting the diagnosis for motor impairment (Green et al., 2002; Manjiviona & Prior, 1995; Miyahara et al., 1997). Manjiviona and Prior (1995) compared children and adolescents with AS and high functioning autism (HFA) and did not find differences between the groups regarding motor abilities. Similar results were recently reported by Noterdaeme and collegues (2010) with motor problems being identified in 53% of children with AS and 47% of children with HFA. These 'motor' results add to the evidence that HFA and AS can be considered as one group on a continuum of autism spectrum disorders. It should also be noted that while motor impairment has been well documented in children, specific information regarding young adults remains scarce due to the absence of normative standardized motor tests in the age group of 15 to 25.

Physical (in)activity and physical fitness

Physical activity is vital for a healthy lifestyle for individuals with and without disabilities (Huettig & O'Connor, 1999). While there are conflicting reports on the physical activity levels of children with autism spectrum disorders, it has been established that participation in physical activity for children with autism is a challenge due to motor clumsiness, lower motivation and less interests in group games (O'Connor, French & Henderson, 2000; Pan & Frey, 2006; Todd & Reid, 2006). Their play behaviors tend to be rather solitary in nature, rarely involving other peers (Holmes & Willoughby, 2005). Subsequently, basic movement skills are an important part of physical and motor development and can be a critical factor in the ability of an individual to gain access to play groups and be physically active among others (Berkeley et al, 2001; O'Connor et al, 2000). These activities especially provide opportunities to learn other important skills (Baranek, 2002), such as teamwork, fair play and spontaneous communication. Earlier research suggests that individuals with poor motor coordination or with motor learning difficulties tend to be less physically active than their coordinated peers (Hands & Larkin, 2006; Bouffard et al., 1996) and one likely consequence seems to be a reduced level of physical fitness. It is common for children with AS to take anti-anxiety medications, which can cause them to gain weight resulting in further deficits in physical fitness (Groft & Block, 2003).

Recent research looking at youth with ASD, including AS, indicated that they were less active than their normal developing peers, were at similar risk for health problems associated with inactivity, and showed a similar decline in physical activity with increasing age (Pan & Frey, 2006). Where it is recommended that typically developing children and adolescents should do 60 minutes (1 hour) or more of physical activity each day, few meet this standard (USDHHS, 2009). It is, therefore, important to gain insight into their physical activity levels and fitness profiles, as we believe that increasing physical fitness and activity levels could be a key element in individuals' with AS habilitation process.

2.2.2.2 Sensory sensitivities

Complementary to the motor problems, many individuals with AS have sensory issues related to dysfunctional sensory systems. They may have difficulty with sensory integration, affecting their ability to process, regulate and integrate information received by their tactile, visual, auditory, vestibular, proprioceptive, olfactory, and gustatory systems (e.g., Ben-Sasson et al., 2008; Ben-Sasson et al., 2009; Dunn, Myles, & Orr, 2002; Myles, Cook, Miller, Rinner, & Robbins, 2000). Sometimes one or more of these systems or senses are either over- or under-reactive to certain stimuli. The most common sensitivities involve touch and sound, but in some cases it relates also to taste, smell and visual sensations. The vestibular and proprioceptive systems may also be affected. Furthermore, it is obvious that information gathered through the sensory systems plays a role in execution of movement and motor action.

Myles et al. (2000) summarized that accurate processing of sensory information impacts an individual's ability to effectively plan motor activities in a coordinated manner. Input from the tactile, vestibular, and proprioceptive systems in particular play a contributing part in motor planning. This process of motor planning involves not only the execution of motor actions, but other important components, such as having ideas about possible action in certain situation, having an accurate sense of where the body is, making adjustments when needed, and starting and stopping certain actions in time. The degree of difficulty varies from one individual to another. Most frequently, the individual with AS will perceive ordinary sensations as quite intense or may even be under reactive to a sensation. In other words, people with AS are often hypo- or hypersensitive to specific sensory experiences, yet these characteristics are often not part of the diagnostic criteria.

While the nature and severity of atypical sensory processing is still poorly understood in AS, a growing body of knowledge suggests that these individuals do have atypical sensory processing (Ben-Sasson et al., 2009; Crane, Goddard, & Pring, 2009; Dunn, Myles, & Orr, 2002). Hypo- and hypersensitivity can occur across the full range of sensations and is commonly associated with challenging behavior (Dunn et al., 2002). People with AS are often sensitive to: tactile input, including light touch, texture, sudden changes in temperature; auditory input such as noise and unexpected sounds; and visual stimuli, being easily distracted in chaotic environments. The continued integration and processing of these stimuli interferes with targeted behavior. Besides being hyper- or hyposensitive to a certain range of stimuli, they may also show deficits in their ability to place their bodies in the space around them and guide speed and direction of movement. For example, it might happen that a student bumps in into a peer during a game, even though he saw the other coming, but was not able to process the obtained information fast enough into a motor action to avoid collision. It is obvious that such challenges with sensory integration are also closely related with difficulties in the motor domain. To emphasize this relationship of various levels of sensory processing to motor skills even more, we opted to use the term senso-motor characteristics as the combination of characteristics in the motor and sensory domain in parts of the discussion. This is the basis for the sensory profile having its own fundamental role in this body of research.

The prevalence of such abnormalities is relatively high with estimates ranging from 30-100% (e.g., Baranek, Boyd, Poe, David, & Watson, 2007; Crane, Goddard, Pring et al., 2009; Dawson & Watling, 2000; Dickie, Baranek, Schultz, Watson, & McComish, 2009; Kern, Garver et al., 2007; Kern et al., 2006; Sahlander et al., 2008). In a Finnish study by Nieminen-von Wendt and co-workers (2005), the corresponding figures for subjectively reported presence of atypical sensibilities was 91.4%. Recent evidence also suggests that sensory processing is also related to other important characteristics of AS, such as intelligence and social competence. Crane et al. (2009) hypothesized in their pilot study that high non-verbal IQ scores in adults with ASD may serve as a protective factor against sensory processing abnormalities. They reasoned these adults (with a higher IQ) might be more adept in implementing strategies to reduce the effects of deviant sensory processing. Evidence about the relationship between social competence and sensory processing is given by Hilton, Graver, & LaVesser (2007). They concluded that sensory processing is a function of severity within autism spectrum disorders and may be an important factor to consider when addressing the performance of these children.

How does this atypical sensory processing reveal itself in a school setting? In a school setting, sensory issues can prove overwhelming to an individual and make it difficult to perform daily activities such as cueing in line, using a fork and knife, tying shoelaces, handwriting, regular physical education classes and recreation settings. Myles and colleagues (2004) found differences in sensory characteristics of children with autism and children with AS, with youth with AS presenting more behavioral and attentional challenges. This might be because of differences in functioning levels since children with AS showed more ability to notice differences between themselves and others, even though they sometimes have an inability to adjust a response in spite of feedback. Another recent study by Kern and colleagues (2007) examined sensory processing over a wide age range including adults. Results indicated that the older persons in their index group scored closer to the controls than the younger persons, suggesting some type of neurological normalization with increasing age.

Though sensory as well as motor development, are a natural process for most individuals, sometimes complications can occur. Where difficulties in the motor domain are often referred to as motor clumsiness in the larger sense of the word, difficulties with sensory development are known as sensory integration dysfunction. For some people, sensory integration does not develop properly. Sounds, sights and movement may seem more chaotic, more distracting and stronger than they do to others. Balance and coordination may also be a problem. Because of these sensory problems, a child may avoid the playful, sensory-rich experiences that are natural building blocks to learning and developing skills and relationships (Attwood, 2007). When the process of sensory integration is disordered, a number of challenges in learning, motor development, or behavior may be observed. Physical and occupational therapy can be used to help improve this condition. Sensory integration therapy and exercise can help to normalize and accommodate certain atypical sensory responses when built into a tailor made sensory diet. This is the reason why sensory issues are an important part from this project; through better understanding of the whole senso-motor domain, more progress can be made and drop-outs from school can be avoided.

2.3 Prevalence and etiology of AS

After having presented a clear image of AS, the prevalence is discussed here in order to not only complete the clinical picture, but also to give an indication of the number of youngsters a national system of education and welfare might be facing. The number of individuals with AS has increased dramatically over the last decade, although its exact prevalence has yet to be determined. Given the lack of consensus over what does and does not constitute AS, it is not surprising to find that the prevalence rates reported by researchers tend to be quite varied. Recent research in Finland suggests that it may be as common as one in 250 people (0.4%) (Mattila et al., 2007). This number is in line with international statistics, which have shown prevalence rates between one in 150 (0.6%) and one in 1500 people (0.2%) (Baird et al., 2006; Fombonne, 2003, 2009; Posserud, Lundervold, & Gillberg, 2006).

In terms of gender, AS seems to be more common in males than in females. Epidemiological evidence indicates that the male/female ratio is around 4:1 (Ehlers, Gillberg, & Wing, 1999), but recent research suggests that this female prevalence may be underestimated and that the male/female ratio could be up to 2:1 (Mattila et al., 2007).

It is widely accepted that the autistic traits associated with AS can be associated with other psychiatric conditions, including obsessive-compulsive disorder, Tourette syndrome, anxiety, depression, and attention deficit/hyperactivity disorder (Mattila et al., 2010; Tantam, 1991). Recent research by Mattila et al. (2010) supports the fact of multiple comorbid psychiatric disorders in AS/HFA with a prevalence of comorbidity of up to 74%. For example, behavioral disorders were shown in 44% of individuals with AS/HFA, anxiety disorders in 42% of these individuals and tic disorders in 26% of them.

The etiology of Asperger syndrome is unknown. Only in exceptional cases can a single cause for AS be clearly identified. In general, it is a set of causal factors that underlie the manifestation of AS. Reviews report that many risk factors, predominantly genetic but also environmental, are associated with ASD, but the effects of each are poorly established (Newschaffer et al., 2007). Those factors can be divided into different groups or components. First, the neurobiological component is both a necessary and sufficient factor. Recently, some of the genetics that lead to this neuro-biological disposition have been revealed, although the results are far from definitive (Weiss, et al., 2009).

Second, various environmental causes for a rise in incidence have been suggested, including vaccines (Taylor et al., 2002; Wing & Potter, 2002) and even social deprivation. For example, in abandoned children in Romanian orphanages autistic-like patterns of behavior have been noted in a small percentage of orphans (Hoksbergen et al., 2005; Rutter et al., 1999).

While the exact cause of AS is still unknown, a set of neurobiological and environmental triggers, any one of which may occur at a certain time within a chain of circumstances, seems to lead to AS. It is in this relation between the neurobiological predisposition and the consolidated effects of experience that education, both by parents but also by professionals, has an intermediating (causal) role. The precise balance and causal relations between all these sets of factors remain to be fully uncovered.

2.4 Habilitation and education for students with AS

Given the neurobiological basis and the wide ranging impact on psychic functioning, no "cure" has been found up to date and thus children with AS grow up to be adults with AS. Tantam (1991) and Newson, Dawson, & Everaard (1994) reported on outcomes in young adults with AS and noted that despite relatively good intellect, a majority of those individuals were still living at home, although several had married and some had jobs.

With appropriate education and support, however, a great deal can be done to make their lives easier and to stimulate active participation in society. For example, in a daily fitness program the release of physical energy not only improves movement and coordination abilities, it can also be an emotional restorative for individuals with AS, who have challenges with emotion expression and management (Attwood, 2007). With the right methods and strategies, people with AS can learn to master basic skills needed in everyday life – everything from how to communicate with other people to good personal hygiene. Because children with AS will grow up to be adults with AS, tailor-made vocational training is important to ease life on the 'speedway' to adulthood.

Since the behavior of people with Asperger syndrome is not as obviously different, it may take time before they are diagnosed. Often this happens only when they attend secondary school. Early diagnosis is, therefore, important as it helps to open our eyes to understand the child's different and confusing behavior. It is not only important to start intervention as early as possible, but to keep providing additional support as long as required.

The fact that only limited special facilities for children with AS are available, increases the need to create a greater awareness of AS and its surrounding challenges. As their disabilities is not visible, people with Asperger syndrome are an easy target for teasing and bullying in school (Attwood, 2007). While most individuals go to a normal school, with or without the help of a support assistant, some do attend special classes for children with autism and AS or other small teaching groups. The number of students with AS that attend regular/special needs education depends on a nation's organization of education and health care. In Finland, even after obligatory education (after the age of 16) there are specially designed vocational and preparatory programs for students with AS, which are essentially free of charge. These places are unfortunately limited and only a small selection of candidates are given this unique opportunity. But the good results achieved urge for a wider implementation!

2.5 Finnish preparatory education for adolescents with AS

The students enrolled in this study were all involved in upper secondary education specially designed for students with AS. This unique program has pooled AS resources and knowledge with the goal of facilitating lifelong learning. Learning activities such as independent living programs, college experiences facilitated by individual tutorial systems, and job training and placement, are offered in addition to the basic vocational training.

This preparatory education is intended specifically for students with AS who need practice in basic skills before starting vocational or advanced education, or who find it too challenging to complete a qualification on their own. The scope and content of the education and guidance are tailor-made to the student's current situation—his/her individual needs, capabilities and developmental possibilities. It is, for example, not uncommon to have half a day of core academic subjects in combination with half a day of specific vocational training, such as computer skills, career planning, social skills training on how to apply for an advanced educational degree or a job.

The aim is to plan suitable further studies or job placement that will enable the student to participate in independent life, employment, and studies to the best extent possible. The core concept of Finnish vocational training is to be located close to our students and start from their strengths (rather than weaknesses).

This preparatory education is provided in small groups and in very close cooperation with our students' guardians and home communities and its 'keywords' can be described as routine, clarity, and consistency. Each student is therefore provided with an Individual Education Plan (IEP), a flexible curriculum, a low teacher-to-student ratio in the classroom, and small study groups to facilitate learning. All the courses, physical education included, are designed to meet our students' individual needs, but still follow the National Curriculum. Our ultimate goal is to equip graduates with individually tailored vocational skills, the desire for life-long learning, and the ability to integrate into society as empowered, active members.

2.6 Physical exercise training programs for students with AS

The promotion of physical exercise and activity through physical education is very important for all, but especially for individuals with special needs, like youth with Asperger syndrome. Since the earliest descriptions of AS, individuals with this neurological disorder have been observed to exhibit, besides difficulties in social interaction and communication, poor motor skills and clumsiness (Frith, 1991). Experts therefore strongly advocate for implementation of exercise to habilitate some of these challenges.

2.6.1 Benefits of physical exercise for individuals with AS

Exercise offers a variety of potential physical, social, psychological, and behavioral benefits that can certainly help people with AS to maintain normal function. Nonetheless, the base of existing literature and practice in physical exercise and AS is rather limited. In a recent review about physical exercise and individuals with ASD, Lang et al. (2010) suggested that increasing physical exercise is likely to be beneficial, not only in terms of physical health, but also in terms of reduced maladaptive behavior and increased adapted behavior (e.g., class-room on-task behavior). Several of the reviewed research studies have shown that physical exercise is often associated with decreases in negative stereotypic behaviors (self-stimulatory), hyperactivity, aggression, self-injury, and destructiveness (e.g., Elliott, Dobbin, Rose, & Soper, 1994; Rosenthal-Malek & Mitchell, 1997). Reasons for these positive results might, for example, be the fact that not only movement competence and coordination improves when exercising, but also because of the lowered anxiety level that indirectly results from the exercise. This anxiety often fuels specific negative behaviors and exercise might be able to 'burn-off' or even better "burn-out" these unconstructive behaviors.

Elliot et al. (1994) used different techniques of exercise with a group of adults with ASD and reported that mild exercise seemed to have little effect on behavior and only more intensive aerobic exercise (heart rate above 130) resulted in more significant reductions in stereotyped behaviors or improvements in other areas of functioning. Rosenthal-Malek and Mitchell (1997) also report that following moderate aerobic activity (20 minute jogging sessions), children with ASD may experience increases in attention span and on-task behavior.

Attwood (2007) recently suggested that while a daily fitness program can improve movement and coordination abilities, the release of physical energy could also be an emotional restorative for individuals with AS, who have problems with emotion expression and management. Exercise as a way 'to burn off energy' can therefore also be of great advantage in Cognitive Behavior Therapy programs, especially in terms of emotion management. Although many these positive effects are known, physical exercise has been widely neglected as a mean for increasing not only physical but also mental health in individuals with AS.

2.6.2 Lack of research in the area of exercise and AS

There has been an increase in the number of descriptive investigations on AS in the areas of identification, assessment, characteristics and associated symptoms. However, intervention studies have been scarce, especially those to improve motor skills, physical fitness, and the ability to function in everyday life. In a very recently published review of studies involving physical exercise and individuals with autism spectrum disorders (ASD) Lang et al. (2010) identified 18 studies meeting predetermined inclusion criteria. These studies were evaluated in terms of participant characteristics, type of exercise, procedures used to increase exercise, outcomes, and research methodology. A variety of exercise activities were employed (e.g., jogging, weight training, bike riding) and, following the exercise interventions, decreases in stereotypical behavior, aggression, and off-task behavior were reported. These results suggest that programs for individuals with ASD could benefit from including components designed to incorporate regular and specific types of physical activity. Across the corpus of the included studies, exercise was implemented with only 64 participants diagnosed mainly with autism aged 3-41 years, clearly indicating the need for further inquiry. None of the participants, however, were reported to have Asperger syndrome.

While little is reported about exercise intervention and AS, some recent intervention studies with individuals with other (motor) impairments, such as developmental coordination disorder (DCD), have shown positive learning results (Peters & Wright, 1999; Schoemaker, Hijlkema, & Kalverboer, 1994; Sugden & Chambers, 2003; Taylor & Kuo, 2009; Watemberg, Waiserberg, Zuk, & Lerman-Sagie, 2007). In these studies, various methods, such as process and task oriented approaches, specific group exercise programs or other approaches used by physiotherapist, were proven effective. Research by Peters and Wright

(1999) reported improved motor competence using the M-ABC in a group of fourteen children with DCD after participating in a 10-week (for 1 hour a week) specific group exercise program designed by a physiotherapist. Moreover, Sudgen et al. (2003) found significant improvement in motor skills after conducting a 40-week (3 times around 20 minutes) exercise program with 31 children with DCD using parents and teachers as co-therapists. Watemberg et al. (2007) reported improvements in motor competence after their intervention with children with combined attention-deficit-hyperactivity disorder (ADHD) and DCD. The intensive physical therapy intervention that was provided had a marked impact on the motor performance of these children. It is not particularly surprising that such an expert input from skilled professionals and well-informed parents would work. Other recent evidence, for example, suggests that children with ADHD can concentrate better after an inexpensive 20 minute walk in the park (Taylor, 2009). These findings indicate that exercise can also enhance attention, in addition to fitness and skills, and might serve as a safe, inexpensive, widely accessible new tool for managing behavioral symptoms.

2.6.3 Physical exercise: a cost effective mean to student support

The widespread problem of physical inactivity, along with lower levels of motor competence and physical fitness, underscores the need to promote healthy lifestyles in adolescents with AS through regular exercise. Furthermore, due to the relatively high prevalence of AS, exploring means of support other than through specialized service providers has become a priority. In this light, we consider adequate physical exercise as an important tool to fill this need.

Within our vocational training setting there was a need to create more exercise opportunities, as physical well being is also a key to academic success (Sallis et al., 1999) and provides unique opportunities to be social. Individuals with AS specifically have challenges in areas of social interaction such as keeping focused on a given task, inability to read social cues, inability to take the perspective of another, shift attention, remain on topic in conversation.

It is also difficult for someone with AS to interpret and use body language appropriately in the course of conversation. These challenges are more obvious in less structured settings, where it is more difficult to recognize relevant from irrelevant information. The interaction of structured physical activities provides unique opportunities for socializing, social interaction and social skill training (e.g., Smith, 2000) and is another reason to emphasize the value of structured physical activities for individuals with Asperger syndrome.

On the basis of the above-mentioned results, it could be suggested that regular aerobic exercise may be an easy and useful component of the curriculum for students with AS. One should not assume that the student receives an adequate amount of exercise during free time. An exercise training program should be included in the student's education program. On top of the positive effects on behavior, physical activity programs for students with AS may also lead to an increase in appropriate social behaviors, significant increases in physical fitness, as well as greater enjoyment of being physically active. Exercise training programs for youth with AS have not been well documented and there is certainly a need to evaluate their effectiveness.

3 AIMS OF THE STUDY

The present study was primarily oriented to increase understanding of the sensory and motor functioning of individuals with AS through an examination of their motor-, sensory-, and physical fitness -profiles. Given the senso-motor challenges experienced by individuals within this group, it was expected that information about these topics and about the exercise training program would reveal clinically and educationally relevant information to assist intervention planning and implementation. Despite increased interest and research in both AS and the senso-motor domain, no known research has been conducted that thoroughly examines the effects of an exercise training program in individuals with AS.

This study, therefore, attempts to answer the following main questions:

I. MOTOR PROFILE (Study I)

1. What is the motor profile of adolescents with Asperger syndrome as compared to matched peers?
2. Are there differences in motor profiles between males and females?
3. Are there differences in motor profiles between younger and older participants?
4. Is the use of the M-ABC-II feasible for young adults with AS?

II. PHYSICAL FITNESS & ACTIVITY PROFILE (Study II)

1. What is the physical fitness profile of adolescents with Asperger syndrome as compared to matched peers?
2. Are there differences in physical fitness and physical activity between males and females?
3. Are there differences in physical activity levels between adolescents with AS and neurotypical peers?

4. Are there differences in physical fitness and levels of physical activity between younger and older participants within both groups?

III. SENSORY PROFILE (Study III)

1. Can the Sensory Profile questionnaire provide reliable inferences about an individual's sensory processing patterns?
2. What is the sensory profile of adolescents with Asperger syndrome as compared to matched peers?
3. Are there differences in sensory profiles between males and females?
4. Do older adolescents with AS have less atypical sensory profiles than the younger ones?
5. Do Sensory Profile scores from people with AS differ from those of controls on the individual level?
6. Are there differences in sensory profiles between groups of adolescents with AS over varied levels of motor competence?

IV. EXERCISE TRAINING PROGRAM (Study IV)

1. What is the effect of a 12-week exercise training program on motor competence in adolescents with Asperger syndrome?
2. What is the effect of a 12-week exercise training program on physical fitness in adolescents with Asperger syndrome?

4 MATERIALS AND METHODS

This chapter provides a guide through all the relevant aspects of the conducted studies (I through IV). At the end, special attention is given in a separate paragraph to the validity of the scores used for measuring motor competence. This addition was considered meaningful because the use of the test for motor competence was self-evident neither for this age and nor for this specific population. By accounting for its validity within this study, the use of the test and its scores meets the highest scientific standards.

4.1 Participants

A total of 90 participants, 45 individuals with AS and 45 age and gender matched peers, agreed to participate in this project consisting of four studies (I-IV). To be included in the group with AS, all participants were required to meet the diagnostic criteria as presented in the ICD-10R (F84.5; WHO, 1993). A child neurologist and/or psychologist with extensive experience diagnosing people on the autism spectrum had made the diagnosis based on informal and formal assessments of their behavior and abilities. Intellectual disability and psychosis were used as exclusion criteria. Even though no specific IQ tests were conducted for this study, from the student's diagnostic assessment summaries the knowledge that all participants fell within normal range (with a verbal IQ of at least 80) was obtained.

The control group consisted of age and gender matched peers from the same geographic region. They had no physical or cognitive impairments according to their own reports. All participants were Caucasian.

The participants were fully informed about the project and their written consent was obtained. In addition written assent was obtained from the parents of adolescent participants. The school's ethical committee approved the project and the treatment of participants was in accordance with the ethical standards of the American Psychological Association.

STUDY I and II.
In study I and II thirty adolescents aged 15-21 years (M = 17.2 yrs; SD = 1.2 yrs) with AS were recruited from an upper secondary vocational education program, especially designed for young adults with AS. The group of participants with AS consisted of 9 females (M = 18.0 yrs; SD = 1.4 yrs) and 21 males (M = 16.9 yrs; SD = 0.9 yrs). Prior to the investigation, informed consent was presented orally by the principal investigator with minimal technical jargon and the aid of pictures about the test tasks. In an additional student/parent meeting dedicated to inform both the students and their parents about this research project the students received an informed consent form to take home. They were asked to return these documents within the same week if they intended to participate in the study. These written consents (from both the participants and their legal guardians) were collected by the principal investigator.

The control group consisted of thirty age (M = 16.9 yrs; SD = 0.8 yrs) and gender matched students recruited from various upper secondary schools in the same region. These participants were recruited in cooperation with the district's responsible PE teacher. From three nearby schools that showed interest in participating, a sample of 30 was randomly selected. Demographic data on the participants are provided in Table 3.

TABLE 3 Demographic data of adolescents with and without AS

	Adolescents with AS (N=30)		Adolescents without AS (N=30)	
	M±SD	Min-Max	M±SD	Min-Max
Age (yrs)	17.2 ± 1.2	15-21	16.9 ± 0.8	16-19
Height (cm)	173.1 ± 7.3	158-191	171.5 ± 8.1	155-188
Weight (kg)	63.7 ± 14.8	47-122	62.7 ± 9.0	47-84
BMI (kg/m2)	21.3 ± 4.8	16-39	21.0 ± 2.0	18-26

Note: No significant differences observed

STUDY III
In study III a total of 90 people participated: 45 high-functioning adolescents/adults with a formal diagnosis of Asperger syndrome aged 15 to 43 years (M = 19.6 yrs, SD = 6.6 yrs) and 45 age and gender matched controls (M = 19.4 yrs, SD = 6.1 yrs, range 16-42). The participants were recruited from vocational training units and via advertisements in the national journal for ASD. Thirty out of 45 participants with AS were the same young adults from different vocational education programs as in studies I and II. The other 15 participants enrolled via different ads in the national journal for ASD. They had all been diagnosed with AS according to ICD-10 criteria and had been in contact

by phone or email with the principal investigator prior to participation. The same inclusion and exclusion criteria were used as described above. The group with AS consisted of 33 males and 12 females and this uneven gender distribution is in line with the most recent epidemiological studies where males outnumber females (Ehlers, Gillberg, & Wing, 1999; Mattila et al., 2007).

STUDY IV
In study IV twenty adolescents diagnosed with AS, a subgroup of the group with AS used in studies I-II, volunteered as participants. The group consisted of sixteen males and 4 females with average age of around 17 years (M = 16.8 yrs, SD= 0.8 yrs) following vocational training.

4.2 Procedures

4.2.1 Procedures of comparisons in senso-motor domain

STUDY I & II
A team of three licensed therapists (two physiotherapists and one occupational therapist) with 5-10 years of experience in working with individuals with AS assessed the individuals with and without AS in the beginning of the school year 2007-2008. This assessment consisted of 3 main parts: a motor competence (I)- and a physical fitness (II) test battery, and a physical activity research questionnaire (II). Each assessment was initiated with a short (approximately 10 minutes) informative session, briefing the participants about the test situation. The verbal presentation was supported by pictures of test environments and of the test items. Thereafter, the participants responded to the physical activity research questionnaire (PARQ; see 4.3.3). Breaks were built in and this first session took approximately one hour.

Over the next few days, the students took in a second session part in the different fitness tests, conducted in small groups from 4 to 8 persons in their own school's gymnasium. The same selection of fitness tests and same testing procedures were used for both index (group with AS) and control group. Students wore suitable loose-fit clothing, so that movement was not restricted in any way. After a 10-minute warm up the motor- and fitness tests were administered. A demonstration of every single task was given prior to test administration. Additionally, every station had a laminated information sheet, describing the specific test. These included pictures of the test position and guidelines for administration. The student-teacher ratio was 3:1. This second test session took around 1.5 hours, including built-in breaks. A week after completion of all sub-tests, the participants met the principal investigator. They received verbal and written feedback in regards to their performance and they spoke about their own physical activity goals.

STUDY III

For study III all 90 participants filled out the Adolescent/Adult Sensory Profile self-report questionnaire in their preferred way as a paper/pencil or computer version in a quiet room at school or at home. This computer version was created in SPSS Mr. Interviewer and had 8-13 questions per screen. This is in line with the format in the original paper version of the AASP. One could only get to the next screen if all questions were answered. Standard instructions from the test manual were given and where required clarifications were made. The benefits of doing the computer-based questionnaire is that one can adapt the format for individual preference, such as for example font size and amount of questions per screen. Most of the participants in this study were experienced computer and internet users and felt therefore as acquainted to do on online survey as to fill out a paper/pencil form. Additionally motor competence data from the 30 participants with AS following vocational training (I) were used to evaluate sensory processing over varied levels of motor competence.

4.2.2 Design of exercise training program

STUDY IV

Study IV made use of a quasi-experimental equivalent-control-group design with a follow-up measurement, which is a widespread experimental design in educational research and particularly appropriate to research in schools (Thomas, Nelson, & Silverman, 2005). Three observations were made each 3 months apart (Pre-test - Intervention - Post-test - Follow-up) over a total period of 6 months. The follow-up observation was added to the pre-post -test design to see whether possible effect of treatment was maintained over time. The 20 participants with AS were divided into two groups matched for age, gender, and initial motor competence (M-ABC-II) scores. Groups were randomly assigned to either the intervention or control group. The same team of three experienced therapists assessed the participants these 3 times, each 12 weeks apart, in 2008.

The intervention group received an intensive 12-week exercise training program, whereas the other group of 10 served as the control group and did not receive the intensive program. This exercise training program, called "Move your body & Stretch your mind", consisted of a variety of motor activities easily available to the student and her/his family and explained in simple text with pictures.

The participants exercised 3 times per week, for an hour per session. The program consisted of **three main parts**: an extra-curricular physical exercise program in the community, an exercise program with stations focusing on core and stretching, and an aerobic physical activity of choice. **First**, once a week a voluntary extra-curricular training was organized right after school in a sports center nearby and was lead by the principal investigator. The activities promoted positive attitudes towards physical activity and encouraged the participants to be active in leisure time by providing activities and games that can be easily transferred towards leisure time (e.g., floor ball, soccer, badminton). **Second**, students were supposed to do at home a core exercise program with stations including warm-up, core work out and stretching. These core exercises help strengthen core muscles and also improve balance and overall coordination. All students got personal training and instruction about the exercises prior to the home program and received a printout of the exercises with pictures. **Third**, students were asked to be an hour engaged in an aerobic physical activity of choice, such as biking, swimming, running, Nordic walking, aerobics, within their own community setting. The first part of the intervention was led by the student's physical education teacher (in this case principal investigator), whereas the second and third parts were done at home with their guardians as co-teachers.

A written exercise contract, about what, where, when and with whom to do the home program, was made between each student and the researcher and a copy was given to their parents. This type of contract has been identified as an effective reinforcer in our program for students with AS to increase participation and improve exercise adherence. Research across several decades has shown that similar contracts work well with students of all ages and ability levels, and in general education, special education, and home settings (Nelson & Rutherford, 1998).

All participants were also asked to carefully complete their exercise diary. The participants regularly asked questions about their training and received weekly reminders about their training diaries from the principal investigator. During the project there was also regular contact with teachers and guardians. Informal contact was made and the teachers and guardians were briefed about the specific schedule of the intervention and received a copy of the exercise contract to inform of what was going to happen. This way they could provide support and assistance to fulfill the exercise requirements when needed. Teachers and guardians were encouraged to contact the primary investigator if there were any challenges or if they had recommendations to more appropriate activities for their participants.

The same three testers were involved in administering the PARQ, M-ABC-II and the EUROFIT at the three scheduled stages of assessment. Testers were well-trained therapists who all had previous motor testing experience. Test sessions and several exercise sessions were videotaped to be able to give students visual feedback of their performances.

4.3 Measurements

The measurements used in the studies are listed in Table 4 and further described in this chapter, including an elaboration on the use of the M-ABC-II in this study (Appendix 4). For more detailed information the reader is referred to the original reports.

4.3.1 Motor competence (I, III, IV)

4.3.1.1 The updated version of the M-ABC

The updated version of the Movement Assessment Battery for Children, the M-ABC-II, was used as the primary assessment tool (Henderson, Sugden, & Barnett, 2007). Additionally, the student's classroom teachers completed the M-ABC-II checklist at the beginning of the intervention program. Checklist scores were only used for optimizing the individualized intervention plans.

TABLE 4 Measurements of present research project

	M-ABC-II	Eurofit	AASP	PARQ/HPA	Informal Questionnaire
Study I	X			X	
Study II		X		X	
Study III	X		X		
Study IV	X	X		X	X

The M-ABC-II test (Appendix 4) is divided into three age bands (3-6, 7-10, and 11-16) with movement tasks getting more difficult with increasing age. The M-ABC-II test contains eight tasks that assess three components of functioning: manual dexterity, balance and ball skills. The manual dexterity tasks for the 11-16 year olds include: turning pegs both with preferred and non-preferred hand, a bimanual task to make a triangle with nuts and bolts, and a drawing trail. The tests for ball skills include aiming and throwing at a wall target, as well as catching a ball with one hand. Balance items consist of two-board balance, walking toe-to-heel backwards, and zigzag hopping.

The test provides objective, quantitative data on motor skills. Performance differences between typically developing boys and girls are reported to be minimal, so the M-ABC-II manual provides only a single set of norms. The raw scores obtained for each item were first converted to standard scores and summed to obtain a total test score using age related norms. This total test score was used for data-analysis in studies III and IV. The test provides also percentiles for each age group through 16. According to the M-ABC-II manual scores at or below the 5th percentile (total test score ≤ 56) are considered indicative of significant motor difficulty and scores between the 6th and 15th percentile suggest being at risk for having motor problems. In addition to the quantitative data derived from formal testing, the assessment is also paralleled by item-specific observations, designed to increase understanding of the perceptual-motor aspects of the individual's performance. Both quantitative data as well as qualitative clinical impressions, are included in this study to help describe and characterize some specific motor related challenges of individuals with AS.

To our knowledge currently there is no specific norm referenced motor skill test available for this age range, which includes ball skills, as well as both fine and gross motor skills. We therefore opted for the M-ABC-II as different versions of this test have been commonly used in motor competence research with individuals with AS (Green et al., 2002; Manjiviona & Prior, 1995; Miyahara et al., 1997; Siaperas, Holland, & Ring, 2006) and its careful use offers trained professionals valuable clinical information to plan an intervention. The M-ABC-II test has proven reliable and valid in a 'normal' population (Chow & Henderson, 2003; Faber & Nijhuis van der Sanden, 2004; Henderson, et al., 2007). Additionally, good discriminative validity for the use with children with AS has been found (Siaperas, Holland, & Ring, 2006). The test has sensitivity for our group of young adults with AS because their motor skills have not yet reached optimal levels and large variability is still observed.

4.3.1.2 The validity of the M-ABC-II in this study

It is of highest importance to clarify some issues regarding the use of the M-ABC-II in this body of research. The necessity of this elaboration lies within a simple reason: this research heavily depends on the scores derived from the M-ABC-II but the test was used beyond its known psychometric boundaries. To be more precise: we used the M-ABC-II test scores both as a measure for the motor profile (I), a main topic within this inquiry, as for splitting the groups in study (III, IV), thus underlying a critical differentiation were a number of further analyses depend on, and conclusions are drawn upon. Where the M-ABC-II is originally designed for children up to 16 years old in this study it was used with youngsters diagnosed with Asperger syndrome whose average age was 17.2 years.

A number of questions arose: Can we use normed or rough scores? Does the (sub)score reflect a single underlying concept as in the control group? Is the score a valid tool for splitting the sample in two subgroups? What does the M-ABC-II score tells us anyway within this research? Why is the choice for the M-ABC-II in this study not only defendable, but even preferable? These issues will be addressed, in this specific order.

Are normed scores possible for our AS-group or must scores remain limited to the rough scores?

Although hardcore methodologists would argue that these normed scores could not be used in any way, we opted for a more pragmatic approach, thereby using these normed scores in a responsible way. This decision is based upon a number of reasons: first, only a minority of the subjects is off the preferred limit of 16 years; second, they are beyond normative boundaries only for few weeks, months and hardly a year; third, extrapolating from the norms of different ages, the norms are very unlikely to show a significant shift once crossed from age 16 to age 17 – most certainly in this specific group with AS, the M-ABC-II registered very sensitive, there was an abundance of variance to be observed and no ceiling effect whatsoever; fourth, numerous studies exist applying the M-ABC-II norms beyond age 16, with success (Faber & Nijhuis van der Sanden, 2004); and fifth, some hypotheses in this research could not be tested or calculated on the raw item scores only, and therefore left no other solution than to make use of the norms for 16 year olds.

Nevertheless, besides these good arguments for using the normed scores of M-ABC-II, a cautious mind for handling and interpreting results and conclusions, remains necessary. Let it be clear that this research itself is not jeopardized by using the normed scores off limit. Only the direct comparison with other studies where the M-ABC-II is used, is a little less self evident as it should be since the numbers yielded by norming in this study might be a slight under or over estimation of the actual score.

Does the subscore reflect the identical concept in the group with AS as in the control group?

Once again it must be stated that the motor profile of adolescents with AS is diffuse. Motor deficiencies in AS manifest themselves in a diffuse, generalized way, preventing a single, detailed, deficiency profile typical for AS to be formulated. Therefore, a direct detailed comparison between subscores for adolescents with AS and the controls pinpointing in great depth of detail the defining "typical" AS profile, is left behind. This means that an investigation in the construct validity has lost its relevance. In other words, subscores from the group with AS do not by force need to reflect the identical underlying concept.

Nevertheless a preliminary, tentative investigation was made, not to prove that the use of the M-ABC-II was correct, but to rule out indications that it was not good. The primitive tool used for this job, was the Cronbach's alpha. Originally appropriate for Likert-scale, the use of Cronbach's alpha was needed since no valuable equivalent exists to answer the question raised here. Since Cronbach's alpha was used out of the ordinary, the findings are not interpreted as such, but only in direct comparison with the controls. In other words: it was not up to us to make statements about the construct validity of the M-ABC-II used in a over aged group of AS – simply because it was both impossible as beyond the scope of this research – but by comparing the Cronbach's alpha from the group with AS to those of the control group, we tried to have an indication whether the score resulted from a equal/different number of underlying sources. The Cronbach's alphas are more than similar; they are even sometimes almost identical (for details see article I). This supports the use of these subtest scores in this study.

Is the M-ABC-II thereby a valid tool for creating two subsamples?

Yes, it is by any means. The key element is, here as it is for the entire use of the M-ABC-II throughout this study, that there exists sufficient, even abundant, variance, both within the AS group (so between the individuals with AS) as between pre and post measurement. This variance proves a strong sensitivity for motor profiling within the AS group – although we cannot, but do not need to, be sure that the test is sensitive to identical underlying constructs as in the normed population. So even if the split would not reflect the original construct, it remains a split based upon a variance that's underlying a great deal of this body of research. The conclusions drawn from the statistical analyses are interpreted accordingly.

So what conclusions can be drawn from these scores?
All results and all conclusions in this thesis are interpreted within the frame drawn above. All checks for reliability and validity did not point out problems, so diminishing chances that systematic or non-systematic errors would confound the conclusions. Besides these methodological checks, the most fundamental reassurance for the use of the M-ABC-II is the amount of overall variance and its sensitivity. Since thought and care was given to these issues, we can be confident of having used the M-ABC-II in a responsible way, allowing for firm conclusions.

4.3.2 Physical fitness (II, IV)

Physical fitness was assessed using selected items of the European test of physical fitness (Eurofit)(Adam, Klissouras, Ravazzolo, Renson, & Tuxworth, 1998), which is widely employed within European schools. Most of these test items were used annually in adapted physical education assessments in the participating schools. For this reason, students had a certain familiarity level with the test items. Considering the difficulty these individuals may have with change and new routines, this familiarity was an important reason for choosing the Eurofit. The selected test items are also similar to the items of other widely used tests such as the popular Brockport Physical Fitness Test in the US (Winnick & Short, 1999).

The information collected included the assessment of the following components: demographic information, flexibility, musculoskeletal fitness (tests for muscle strength and endurance), motor fitness (tests for balance and speed of movement), and aerobic fitness (test for cardio-respiratory endurance). The items of this test battery, used to measure the aforementioned components, have found to be reliable and valid for adolescent males with and without intellectual disabilities (Mac Donncha, Watson, McSweeney, & O'Donovan, 1999). Additionally, this instrument is commonly used to measure physical fitness in children and adults in Europe. A detailed description of the test items is given in Oja and Tuxworth (1995). Guidelines from the Eurofit manual were followed and both the group with AS and control group were given the same test set-up.

Demographic information includes age, height, weight, and body mass index (BMI) (see Table 1). BMI was defined as body mass (kg, measured using an electronic weighing scale to the nearest 0.1kg) divided by height (m, measured to the nearest 0.1cm) squared.

The items used from the Eurofit measured the following physical fitness components:

Flexibility was measured using the sit-and reach test (SAR). This test involves sitting on the floor with legs out straight ahead. Feet (shoes off) were placed with the soles flat against the sit and reach box, shoulder-width apart. The tester held both knees flat against the floor. Subjects reached as far as possible forward in a smooth and slow movement without twisting the shoulders. The knees were held in extended position by the investigator throughout the test. The better of the two trials was recorded to the nearest 1 cm.

Muscle strength was measured by handgrip strength (HGR) using a handgrip dynamometer (JAMAR Hydraulic Hand Dynamometer) that was squeezed as forcefully as possible with the preferred hand. Subjects sat in a straight-backed chair with feet flat on the floor, shoulders adducted in a neutral position, arms unsupported, elbows flexed at 90 degrees and forearm in neutral rotation. The better of two trials was recorded to the nearest 1 kg.

Explosive muscle strength was measured by a standing broad jump (SBJ), using a tape measure on a foam mat. Participants were asked to stand behind the line and jump forward as far as possible using an arm swing and knee bend before jumping. The distance jumped was recorded from the take-off line to the landing point closest to the aforementioned take-off line. The better of two trials was measured to the nearest 1 cm.

Muscular endurance was measured as the number of correctly completed sit-ups in 30 seconds (SUP). This test was performed with the hands placed at the side of the head, fingertips touching the back of the earlobes, knees bent 90°, and the subject's feet being held by the tester. A correct sit-up was defined as touching the knees with the elbows and returning the shoulders to the ground.

Balance [Single leg balance test (SLB)] was measured as the number of attempts needed by the individuals to achieve a total duration of 30s in balance. This test was performed on a flat firm surface on their preferred foot with eyes closed. For reasons of safety and test familiarization this test was performed with eyes open first.

Speed and coordination of limb movement [plate tapping (PLT)] was assessed using a plate tapping table on which two rubber discs at 80 cm distance have to be touched alternately with the preferred hand as quickly as possible. The score was the amount of time needed to complete 25 cycles. The better result of the two attempts (recorded in tenths of a second) was the score.

Running speed was assessed using a 10 by 5m shuttle run (SHR5). Each participant was required to sprint 10 times between two lines placed 5m apart. The track was 1.3m wide. The result was recorded to the nearest tenth of a second.

While the previous items were from the Eurofit for children, we opted to estimate **aerobic fitness** (cardio-respiratory endurance) by using the 2 km walking test of the Eurofit for adults (UWT2). Due to possible motivational challenges of individuals with AS with regard to intensive physical activity, the Cooper test and 20m Shuttle-run (both recommended endurance tests of the Eurofit for children), which typically require minimal coordination skills, were not administered. From our clinical experience, our students with AS were unlikely to persist these tasks at their very best, typically giving up earlier. The 2 km walking test was considered to be less demanding and targets a population that would have difficulty completing a running test (e.g., Laukkanen, Oja, Ojala, Pasanen, & Vuori, 1992). The 2-km walking test was administered outdoors on a hard, even surface. Participants warmed up for 10 minutes by walking to the testing track. The track was marked with colorful cones and one loop was 400 meter. Participants walked 5 laps at a brisk continuous pace, without running. The walking time was recorded to the nearest second. Heart rate at the end of the test was monitored with a heart rate monitor (Polar FS1, Polar, Kempele, Finland).

4.3.3 Physical activity (I, II, IV)

A physical activity research questionnaire (PARQ) was designed especially for this study to assess the participants' physical activity background with questions about the participants' demographic information, knowledge about physical fitness, feelings towards physical activity, and perceived physical activity level. This paper-pencil questionnaire was filled out during regular school hours under the supervision of the primary investigator. The questionnaire was completed in small groups of three to five. During an average administration time of half an hour, participants had the opportunity to ask questions regarding the questionnaire. An expert panel, existing from three licensed therapists (2 physiotherapist and an occupational therapist), discussed the PARQ questionnaire and unanimously judged that the content of the questionnaire had adequate coverage on participants' physical activity background needed to plan future intervention.

To earn specific knowledge about perceived physical activity levels, a questionnaire developed by Baecke (Baecke, Burema, & Frijters, 1982) for measurement of a person's Habitual Physical Activity (HPA) was included as an important part of the PARQ. This HPA questionnaire evaluates physical activity over the previous 12 months. The HPA makes use of easy to understand scales to assess the magnitude of physical activity and separates physical activity into three distinct dimensions, including work activity, sports activity, and leisure activity. Although each dimension had a precise set of questions, for this study we only used the 'sports activity' part of the questionnaire, as we were interested in their specific sport activities during leisure time. This section included questions on sport and physical exercise in leisure time and consisted of four main questions, scored on a five point scale: whether or not you play sports in general; whether, compared to your own age group, you think you are more or less active, whether or not you sweat during leisure time, and whether or not you play sports in leisure time. If a participant answered affirmatively to the first question, six more questions followed to gather date regarding their most frequently played sports. These questions included information on intensity and regularity of their sport activities. Baecke and colleagues divided sport intensity into three levels: (1) low level (e.g., billiards, sailing, bowling, golf) with an average energy expenditure of 0.76 MJ/h; (2) middle level (e.g., badminton, cycling, dancing, swimming, tennis) with an average energy expenditure of 1.26 MJ/h; (3) high level (e.g., boxing, basketball, football, rugby, rowing) with an average energy expenditure of 1.76 MJ/h. Based on this, a simple sport score (SSS) for the participants' most (SSS1) and second most (SSS2) frequently played sport as well as a physical exercise in leisure time score (PEL) were calculated. A simple sport score was calculated by multiplying the values for intensity, weekly time and number of months spent on their most frequently played sports. The total sport score was calculated by adding both SSS's together. The PEL score was determined by dividing the sum of the points on the four parameters by four. A number of studies have shown good reliability indices for Baecke's HPA questionnaire. The values for physical exercise score were of r=0.93 for Belgian adult males (Phillipaerts & Lefevre, 1998). Another study showed that the questionnaire can correctly classify elderly people as low or highly active, but does a poorer job for moderately active individuals (Hertogh, Monninkhof, Schouten, Peeters, & Schuit, 2008). Other data by Pols et al. (1995) showed that repeatability of the questionnaire is good and evidence based on relations to other variables (in Pols' case an activity diary) is moderate.

4.3.4 Sensory processing (III)

Sensory processing preferences were examined using The Adolescent/Adult Sensory Profile (AASP; Dunn, 2002). The obtained sensory profile, filled in by the students themselves, enabled more informed intervention planning, which takes into consideration the individuals´ particular needs and preferences. The AASP is a 60-item self-questionnaire for evaluating behavioral responses to everyday sensory experiences. It provides a standard method to profile the effect of sensory processing on functional performance. An individual answers to questions regarding how she or he generally responds to various sensory experiences on a five-point scale (1 = almost never, 2 = seldom, 3 = occasionally, 4 = frequently, 5 = almost always).

The profile is based on Dunn's Model of Sensory Processing (Dunn, 1997) where neurological thresholds and behavioral responses are presented as a continuum that interacts with each other (see Table 5). The neurological threshold, which can be high on one end or low on the other end of the continuum, refers to the amount of stimuli for a human neuronal system to respond. The behavioral response refers to the way in which a person responds to her/his sensory thresholds. A person may respond passively or in other words in accordance with his threshold at one end of this continuum, while at the other end a person responds actively to counteract the thresholds. The interaction between these two continuums forms the following four sensory quadrants: low registration, sensation seeking, sensory sensitivity and sensation avoiding (see Table 5).

Low registration items refer to a high neurological threshold in combination with a passive behavioral response. These items identify behaviors such as slowed responses and missing stimuli. For example items like 'I don't seem to notice when someone touches my arm or back' or 'I have to ask people to repeat things' address this quadrant.

Sensation seeking items refer to a high neurological threshold in combination with an active behavioral response. These items identify responses and characteristics where one pursues sensory stimuli. Items like 'I like to wear colorful clothing' or 'I like how it feels to get my hair cut' cover the sensation seeking quadrant.

Sensory sensitivity items refer to a low neurological threshold combined with passive behavioral responses. These specific items identify responses such as discomfort with sensory stimuli and distraction. Example items are 'I dislike the movement of riding in a car' or 'I am distracted if there is a lot of noise around me'.

Sensation avoiding items refer to low neurological threshold in combination with active behavioral response. These items identify behaviors such as reducing sensory stimuli or make exposure to stimuli predictable. For example 'I avoid elevators because I dislike the movement' or 'I choose to shop in smaller stores because I'm overwhelmed in large stores' are example items of the sensation avoidance quadrant. There are 15 questions per quadrant and these cover different sensory processing categories such as Taste/Smell, Movement, Visual, Touch, Activity Level, and Auditory.

TABLE 5 Relationships between behavioral response and neurological threshold according to Dunn's Model of Sensory Processing (Dunn, 1997)

Neurological threshold continuum	Behavioral response/ Self-regulation strategies	
	PASSIVE	ACTIVE
HIGH (habituation)	LOW REGISTRATION Need high intensity of sensory stimuli to be able to react and tend to be more flexible in distracting environment	SENSATION SEEKING Constantly create additional sensory stimuli and may find low-stimulus environments intolerable
LOW (sensitization)	SENSORY SENSITIVITY Easily to be distracted by sensory stimuli and discomfort caused by intense stimuli	SENSATION AVOIDING Engage in sensory avoiding behaviors to limit sensory stimuli and tolerate well being alone

In our view Dunn's model of sensory processing brings greater understanding about why individuals with AS engage in particular behaviors and why they prefer certain experiences and environments. Knowing these individual's particular preferences enables more informed intervention planning. Another advantage is that the profile is non-intrusive and is easy and quick to administer and it is compatible for the use in school settings like ours.

Internal consistency reliability (Cronbach's alpha) for the different quadrants of the AASP, used with neurotypicals, is acceptable, ranging between .64 and .78 (Brown & Dunn, 2002).

4.3.5 Informal descriptive questionnaire (IV)

A short informal descriptive questionnaire (Informal Q) was developed to gather some simple anecdotal comments about the student's feelings towards the exercise training program. Questions about their likes and dislikes concerning the exercise program were answered with open responses. The aim was to better understand and support the current findings and improve the program for the future use.

4.4 Statistical analyses

In chapter 3 the major aims and research questions of this study were formulated. In this section the operationalization and the appropriate statistic to put these research questions to the test will be articulated. In order to preserve a clear overview and to allow quick and correct reference between different chapters, a simple alphanumeric code is used, based upon the study and the order within that particular study as first described in chapter 3. For example, the reference I-3 indicates the third question and analysis of the first study.

All statistical analyses were computed using the statistical software PASW version 17 (SPSS, 2009); a $p < 0.05$ was accepted as statistically significant in all analyses. Effect sizes are reported and are analysed according to Cohen with an effect size of 0.2 reported as a "small" effect, an effect size around 0.5 as a "medium" effect and an effect size of more than 0.8 as a "large" effect (Cohen, 1988).

4.4.1 Motor competence (I)

(I-1). As a measure for motor competence, the M-ABC-II was used. A detailed survey into the separate items offers a first, both detailed and comprehensive, image of the profile of the group with AS. The statistical analysis best suited to test the question about differences in motor profile was a MANOVA-model[1] using summation of all raw scores to reflect the total test score as well as combinations of raw scores to reflect the component scores of the M-ABC-II. As

[1] The choice for presenting the results as a MANOVA-analysis was based upon the more accurate calculation of the effect-size as compared to non-parametric equivalents. The same analysis was performed using non-parametric statistics, with exactly the same outcome. For the purpose of clarity, all results are presented solely as MANOVA. This applies to all consequent MANOVA's.

explained in 4.3.1.2 (Use and validity M-ABC-II), raw scores were used because out of our 60 participants, 40 were older than 16 years, placing them beyond normative range. The expectation is that the group with AS would score significantly lower than the control group on overall motor ability as well as on the three components.

In order to be able to compare the individual performance to some sort of reference, the normative percentile scores of the M-ABC-II were used, thus revealing which subjects would be at risk for motor impairment. Knowing that this usage is a little beyond valid clearance, this comparison is to be seen as a mere tentative one without further consequences.

(I-2). Exploring the motor competence of the AS group also includes the question whether or not a gender difference can be observed. Heuristic as it is, no specific direction of the difference was postulated in an a priori hypothesis. Copying the MANOVA-model from I-1, gender was added as a covariate in a MANCOVA-model to address for possible gender differences.

(I-3). Next, besides gender, age progression was another point of interest in this exploration of the motor competence in the group with AS. The control group, with an average age above 16 years, was expected to have their motor competence fully grown and consolidated, so no differences should be expected between the younger half and the elder half of the control group. Contrary, the group with AS has a margin for growth left (as the lower initial score suggests), an improvement related to practice and thus age. The hypothesis with the group with AS was that there would be a difference on the scores in favor of the older group. Although the variance of age was limited, this hypothesis is tested by splitting both the index group and the control group in half, using age as the criterion, creating two groups: younger and older. This younger group (with the fifteen youngest) was compared to the older group (with the fifteen oldest) within both index and control group. The statistics used was a MANOVA, similar to the previous one, using summation of raw scores to reflect motor competence. Effect sizes based on means (Cohen's d; Cohen, 1988) were calculated for the individual test items to help us to know whether the differences observed between the groups are differences that practically (clinically) matter.

(I-4). The next analysis performed, is not contents related but methodology related. It is therefore written as a goal, not as a hypothesis. The goal was to provide exploratory information for further development and normation of future measurements for young adults with AS. The M-ABC-II's underlying construction allows for an analysis of the items for internal consistency (validity). We used the Cronbach's alpha to measure how well the set of items per component in the M-ABC-II measures the proposed latent construct and as an indicator of validity of this test for our age specific group (cfr. 4.3.1.2 Validity of M-ABC-II). Given the nature of the test and the small sample size, we do want to stress that it is only an indicator.

4.4.2 Physical fitness and activity (II)

(II-1). The first goal of study II was to collect some basic information on the level of fitness, therefore some descriptive statistics were gathered based upon the scores of the Eurofit. Second, the obvious question was whether adolescents with AS are less fit than their peers, and if a gender difference could be observed within those differences. The hypothesis was that adolescents with AS would have a lower score on the Eurofit (as a measure of overall physical fitness) than their peers. Regarding the gender difference, no direction for the hypothesis was formulated. The statistics used to investigate this composite hypothesis, is a 2 X 2 (group by gender) MANOVA-model on the combined items of the Eurofit. As follow-up procedures in order to evaluate differences on the different physical fitness tests with regard to groups and gender, univariate F-tests as well as effect size statistics (partial eta-squared) were used.

(II-2). Another scope of study II was on the level of physical activity adolescents with AS engage in. The hypothesis is that adolescents with AS are less physically active than their peers. The measure for physical activity consisted of the answers from the self-report questionnaire. The statistic used to test this hypothesis was a 2 X 2 MANOVA-model similar to the one above (II-1).

(II-3). In line with study I, the influence of age on the level of fitness was explored. Hypothesis was that the level of fitness would improve over age in both the group of AS as well as the control group (thus giving the two 'old' subgroups a higher score on the EUROFIT than the 'young' subgroups). This hypothesis was tested with a MANOVA. Consequently the effect of age on PA was examined, although the hypothesis was that no differences would be observed. Since PA can be represented through a single score (RPAL: reported physical activity level), an ANOVA was used to explore the effect of age on the level of physical activity.

4.4.3 Sensory processing (III)

(III-1). First, a methodological issue was tackled before turning to the AS related hypotheses, as exploratory information on the use of AASP with adolescents and adults with AS needs to be provided. Whereas the theoretical framework of the AASP and the psychometric evidence given in the manual (Brown & Dunn, 2002) provide a basis for the claim that scores from the sensory profile can provide reliable and valid inferences about an individual's sensory processing patterns, more evidence is needed to support its use. According to testing standard (AERA et al., 1999) the test user is ultimately responsible for evaluating the reliability and validity evidence in the particular setting in which the test is to be used. To date, very little reliability data is available to support the use of the AASP with our specific population, even though the AASP underlying construction allows for an analysis of the items for internal consistency (validity). Cronbach's alpha was used to assess how well the set of items per sensory quadrant in the AASP measures the proposed latent construct and as an indicator of reliability of this test for our age specific group.

Given the nature of the test and the small sample size, it needs to be stressed that it is merely an indication.

(III-2). Given the nature of AS and the role that sensory issues play, it could not be expected otherwise that the sensory profile of adolescents with AS would differ from the sensory profile of their peers. Using the AASP for profiling sensory issues, the hypothesis is that adolescents with AS differ in all four quadrants of the test (as well as the 'overall' score), as compared to their peers. To test this hypothesis, the scores on all four quadrants were combined in a MANOVA-model using summation of quadrants' scores to reflect an overall sensory processing score. Univariate F-tests as well as effect size statistics, partial eta-squared, and power analyses were used as follow-up procedures in order to evaluate the significance of the different sensory quadrants between groups.

(III-3). Exploring the sensory profile of the AS group also includes the question whether or not a gender difference can be observed. A similar MANOVA-model using summation of quadrants' scores to reflect an overall sensory processing score as in III-2 was used to address for possible gender differences in both groups with AS and matched peers. Univariate F-tests as well as effect size statistics, partial eta-squared, and power analyses were used as follow-up procedures in order to evaluate the significance of the different sensory quadrants between genders.

(III-4). Sensory issues are known to flatten over age. The hypothesis is that older adolescents with AS have a less atypical sensory profile than the younger ones. This was based upon the assumption / possibility of the older participants having learned effective coping strategies for their sensory issues and therefore would show more typical sensory profiles. The effect of age was put to the test by a correlational analysis between age and overall scores on the AASP.

(III-5) So far, only means have been compared, revealing differences, but also depriving this investigation from the opportunity to make statements about the individual scores or positioning as compared to the control group. In order to obtain this meaningful comparison, a case series analysis was performed, following the same procedures as in Ramus et al. (2003). This analysis was repeated four times, once for every sensory quadrant. The first step in this analysis is to compute a cut off score, used as a demarcation point, within the control group. This score determines who is within 'typical performance' and who has a score of an 'atypical performance'. This cut off score was calculated, using the score 2 standard deviations either above or below the mean of the control group, depending on the direction of the difference. Note that prior to this calculation, some subjects of the control group were excluded from this analysis due to outlying scores that otherwise would have jeopardized the calculation. This explains the different numbers (n) in analysis. For the quadrants: low registration (n = 29), sensory sensitivity (n = 29), and sensation avoiding (n = 27) the cut off score was 2 SD above the mean (because of the higher scores of the AS group); whereas for the quadrant of sensation seeking (n = 30), the cut off was placed 2 SD below the mean (because of the lower score of the group with AS). The next step in this analysis was to compare every subject of the group with AS to that demarcation score, revealing which individual with AS has an 'atypical performance' as compared to the control group.

(III-6). In Asperger syndrome, the sensory issues and motor competence cannot be separated. The ambition to portrait a comprehensive picture of AS, or the opportunity to look into causal relationships, are beyond the boundaries of this study. Nevertheless, a simple examination of the differences in sensory processing in adolescents with AS over varied levels of motor competence, was conducted.

Due to normative age limit transgression, a choice had to be made between the use of the original standard scores of the M-ABC-II or an ad hoc solution. Because in this particular analysis a direct tool for ranking or splitting was needed two possible solutions emerged: first, a new, pseudo-total score could be formulated; second, the original norms could be used beyond the known valid limits. Since the first solution would have been almost practically impossible, no other option was left than to use the norms of the original M-ABC-II in a careful manner, as explained in 4.3.1.2 (The validity of the M-ABC-II) in this study. It needs to be emphasized, first, that these norms were only used for splitting the group, and not in the actual analysis itself. Second, the use of these norms is not far "off limit" and it is unlikely – though unproven – that the results from using this normation are crooked. The group of individuals with AS currently following vocational training (n = 30) was split (using the M-ABC-II 15th percentile score as a cut off) into a subgroup 'at risk for motor impairment' (n=19) and a subgroup 'not at risk' (n=11).

The hypothesis is that the sensory profile of the group 'at risk' for motor impairment is more atypical than the sensory profile of the subgroup 'not at risk'. The statistical test used to accept or refute this hypothesis, was an ANOVA where the SP quadrant scores were compared between the subgroup 'at risk' versus the subgroup 'not at risk'. Because of the small sample size and the near-significant effect, a non-parametric equivalent (Man Whitney U test) was also performed to enhance understanding of the results of the ANOVA.

4.4.4 Effects of intervention (IV)

Given the fact that motor competence left margin for growth, and physical fitness was low, what would be the effect of an exercise training program? And would this exercise training program maintain its impact over time? The hypothesis was that adolescents with AS benefit from an intervention, and that the effects would last, both on fitness and motor competence. The scores on the M-ABC-II were used for indicating motor competence, and the scores on the Eurofit to represent the fitness level. A measurement was carried out on three different times: pre- and post intervention, and a follow-up three months after, totalling six measurements over these two groups.

(IV-1). First and for most, in order to rule out the possible confounding effects of history (this is, effects prior to the intervention), a t-test was performed, comparing the means of the two subgroups, and thus justifying continuance of the analysis of the intervention. The main statistics used to put the hypothesis to the test, was a 2 X 3 (group by time) repeated measures (RM) ANOVA for motor competence. Post-hoc comparisons to determine significant differences of main effects were examined through one-way (time) repeated measures ANOVA for each group.

(IV-2). An identical repeated measurement ANOVA as above was performed on the EUROFIT-data. Six one-way ANOVAs were used to test the pair wise comparisons for the intervention and control groups with Bonferroni correction ($p \leq .017$ [.05/3 [i.e., pre vs. post, post vs. follow-up, and pre vs. follow-up]).

5 RESULTS

This chapter presents the results of the performed analyses that were announced in the previous chapter. The majority of these hypotheses and analyses can also be found in the original articles (added in appendixes), although sometimes the article is more elaborate, and sometimes this dissertation. The results are in the exact same order as in chapter 3 and 4.4 duplicating the alphanumeric code for quick reference.

5.1 Motor competence (I)

Quantitative (main analysis) as well as qualitative information gathered using the M-ABC-II item specific observations is provided below to highlight some interesting insights in the underlying challenges concerning motor competence in individuals with AS.

(I-1). The differences in motor competence are listed in detail in Table 6, summarizing the means and standard deviations on the separate test items of the M-ABC-II raw test scores for both groups. Next, the multivariate analysis of variance revealed statistically significant lower motor performance of the index group compared to control group on overall motor competence (Wilk's Lambda $\lambda = .49$, $F(11, 48) = 4.48$ ($p < .001$) as well as on all three motor components (manual dexterity, ball skills, and balance) of the M-ABC-II. Wilk's Lambda for manual dexterity items was $\lambda = .72$, $F(4, 55) = 5.29$ ($p < .001$); for ball skill items $\lambda = .63$, $F(3, 56) = 11.06$ ($p < .001$); and for balance items $\lambda = .65$, $F(4, 55) = 7.34$ ($p < .001$).

TABLE 6 Group means of raw scores (SD) for manual dexterity, ball skill, and balance tasks of M-ABC-II

	Group with AS (N=30)	Control group (N=30)
Manual dexterity		
Peg turning		
Preferred hand (time, s)	21.80 ± 5.22 (15-46)	17.57 ± 2.71 (13-25)
Non-preferred hand (time, s)	24.60 ± 9.12 (17-40)	19.77 ± 2.75 (15-26)
Triangle with bolt & nuts (s)	63.40 ± 34.20 (25-255)	37.60 ± 7.90 (27-47)
Drawing trail (#/errors)	1.00 ± 1.95 (0-8)	0.40 ± 1.04 (0-5)
Ball skills		
Catching		
Preferred hand (#catches/10)	4.90 ± 3.55 (0-10)	8.53 ± 2.30 (1-10)
Non-preferred hand (#catches/10)	3.80 ± 3.44 (0-10)	7.73 ± 2.32 (1-10)
Throw at target (#hits/10)	4.57 ± 1.76 (1-8)	6.77 ± 2.00 (2-10)
Balance		
Two board balance (s)	15.87 ± 11.76 (0-30)	26.67 ± 6.41 (11-30)
Toe-to-heel (#/steps)	8.03 ± 5.68 (0-15)	13.77 ± 3.04 (3-15)
Zigzag hopping		
Best leg (#/hops)	4.57 ± 1.22 (1-5)	5 ± 0.00 (5)
Other leg (#/hops)	4.23 ± 1.22 (1-5)	5 ± 0.00 (5)

Note. Mean ± Standard Deviations, values enclosed in parentheses represent range of scores.

Figure 1 plots the percentile score (of the M-ABC-II) of the subjects with AS, acting as an indication for the severity of the motor impairment in the group with AS, and allowing to determine who and how many are 'at risk'. Using the cut-off scores proposed in the M-ABC-II manual as a reference, the results suggest that of the 30 participants in the group with AS 17 had severe motor problems (scored below 5th percentile) and an additional two would be at risk for motor impairment (scored between the 5th and 15th percentile). Please remember that, although unlikely false or erratic, this labeling is based upon the use of the normative scores (cfr. 4.3.1.2 Validity and use of M-ABC-II in previous chapter).

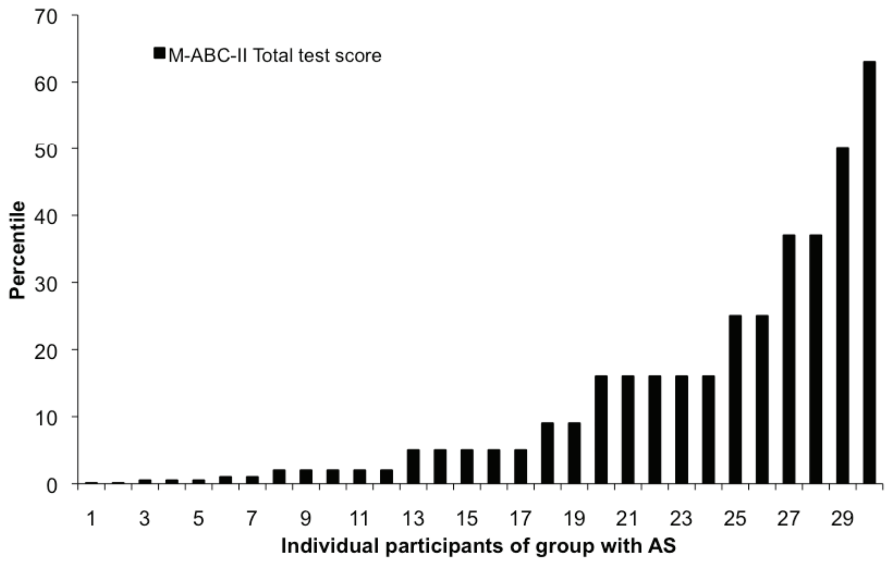
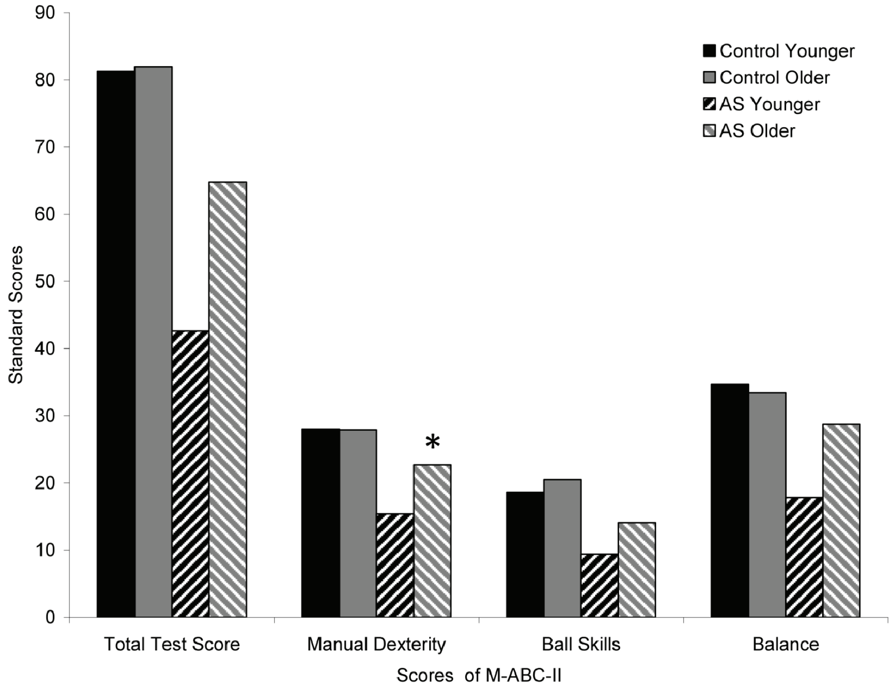


FIGURE 1 Percentile equivalents for M-ABC-II total test score for group with AS (N = 30)

(I-2). The additional MANCOVA showed no significant gender differences with Wilk's Lambda λ = .80, $F(11, 47) = 1.09$, and $p > .05$.

(I-3) The results of the MANOVA on two groups split by age showed no differences between the youngest and the oldest fifteen in the control group with Wilk's Lambda λ = .56, $F(9, 20) = 1.75$, and $p > .05$. In the group with AS, the older group scored close to 'significantly different' on the overall motor competence with Wilk's Lambda λ = .56, $F(9, 20) = 4.48$, and exact $p = .051$. This older group scored significantly better only on the component of manual dexterity with Wilk's Lambda λ = .52, $F(4, 25) = 5.72$, and $p < .01$. Whereas the differences between the younger and the older group with AS on the components of ball skills (with Wilk's Lambda λ = .86, $F(3, 26) = 1.40$, and $p > .05$) and balance (with Wilk's Lambda λ = .81, $F(4, 25) = 1.44$ and $p > .05$) were not statistically significant, the data showed relative improvement in both (see Figure 2). The older group with AS scored better on all test items but one, with effect size ranging from d = 0.1 to d = 1.05. The average effect sizes between the younger and older group with AS on items of the two other components (which were not found to differ significantly) were for ball skill items d = .38 and for balance d = .47. These effect sizes mean that the score of the average person in the older group is respectively .38 and .47 standard deviation above the average person in the group with the fifteen youngest.



Note. Level of significance *p < 0.05

FIGURE 2 Mean component- and total test scores of the M-ABC-II for both younger (n = 15) and older group (n = 15) within the groups with AS and the control groups

(I-4). Next goal was methodological by nature, providing useful data and indicators for the use of the M-ABC-II measure with our specific AS group of 16+. For the four-item component of manual dexterity, Cronbach's alpha was low, but equal in both groups with α = .44. Results showed that the bimanual task to make a triangle with nuts and bolts was covering a different underlying aspect than the other three items. If this test item were deleted Crohnbach's alpha would reach acceptable levels of internal consistency, respectively with α = .65 for control group and α = .71 for the group with AS.

The three-item component of ball skills showed a normal Cronbach's alpha for the control group with α = .73 and a higher value with α = .84 for the AS group. The overlap of catch preferred hand and catch non-preferred hand is considerable, and within the AS group the use of both items simultaneously adds no statistical or discriminative power, nor any supplemental variance.

The four item component of balance shows a lower than acceptable Cronbach's alpha in the control group with α = .35. This may be an indication that the original test is used beyond limits in this age group due to a ceiling effect. Surprisingly, the Cronbach's alpha is much higher, yet still lower than acceptable, in the group with AS with α = .57 meaning that this test has preserved some relevance and consistency in the index group. When both zigzag hopping items are left out, the Cronbach's alpha rises to a recommended level with α = .73.

5.2 Physical fitness and physical activity (II)

Besides the main analyses announced in chapter 4, additional information gained from observation and questionnaire, are included at the end of this chapter.

(II-1). Table 7 and Table 8 provide an overview of the differences between the group with AS and the control group, on both physical fitness as physical activity. As for group differences in physical fitness, the MANOVA revealed significant main effect differences between groups on physical fitness items, with Wilk's lambda respectively (λPF) = .358, $F(8,51) = 10.18$ ($p < .001$) & partial eta-squared = .56 representing a medium effect. As follow up procedures, univariate F statistics indicated group differences on all subtest of the Eurofit (see Table 7). Adolescents with Asperger syndrome scored less good than the comparison group on all physical fitness tests. Significant differences between the two groups were found in tests of balance, coordination, speed of limb movement, flexibility, strength, running speed, and cardio-respiratory endurance.

TABLE 7 Descriptive data and comparison of physical fitness profiles of adolescents with and without Asperger syndrome

	Adolescents with AS			Adolescents without AS		
	Males	Females	Total	Males	Females	Total
	(N=21)	(N=9)	(N=30)	(N=21)	(N=9)	(N=30)
SAR (cm)	22.7±11.3	26.6±11.7	23.87±11.4	34.3±11.5	37.7±9.8	35.3±10.9**
HGR (kg)	31.9±13.7	23.4±6.3	29.37±12.5	45.2±16.7	24.0±3.8	38.9±17.2*
SUP (#/30 s)	12.8±5.1	10.0±7.0	12.0±5.8	24.7±6.5	19.3±3	23.1±6.2**
SLB (#/30 s)	6.0±5.5	6.8±5.5	6.2±5.4	1.7±1.1	1.3±0.7	1.6±1.0**
PLT (0.1s)	166.5±65.0	174.2±42.1	168.8±58.5	106.8±9.8	125.6±13.2	112.4±13.8**
SBJ (cm)	145.7±35.6	123.0±19.8	138.9±33.0	218.8±30.2	147.0±16.3	197.3±42.7**
SHR5 (0.1 s)	248.7±38.1	246.0±25.9	247.9±34.5	189.0±13.2	202.9±10.5	193.2±13.9**
UWT2 (s)	1079±175	1079±175	1129±185	967±80	992±58	975.1±74.2**
HFend (bpm)	129.7±26.7	124.2±20.1	128.1±24.7	147.7±17.6	166.0±17.5	153.2±19.3**

Note: *p<0.05, **p<0.01 for comparison of total groups with and without AS; SAR-sit and reach, HGR-handgrip strength, SUP-sit-ups, SLB-single leg balance, PLT-plate tapping, SBJ-standing broad jump, SHR5- shuttle run 5X10, UWT2- 2km walking test, HF end- heart rate at end of walking test.

TABLE 8 Descriptive data and comparison of physical activity levels of adolescents with and without Asperger syndrome

	Adolescents with AS (N=30)		Adolescents without AS (N=30)	
	M±SD	Min-Max	M±SD	Min-Max
SSS1	112.9±119.8	0-406	331.1±243.4**	0-729
SSS2	22.0±45.6	0-185	80.0±126.6*	0-522
SSST	120.5±123.4	0-426	411.1±310.8**	0-1044
PEL	255.0±78.1	100-400	328.3±80.1**	175-475

Note: Level of significance *p<0.05, **p<0.01; SSS1-simple sport score 1,SSS2-simple sport score 2, SSST-simple sport score total, PEL-physical exercise in leisure time score.

(II-2). As for group differences in reported physical activity, significant differences were shown for reported physical activity levels with Wilk's lambda (λRPAL) = .651, F(4,54) = 7.35 ($p < .001$) & partial eta-squared = .30. The univariate F statistics indicated group differences on all reported physical activity variables (see Table 8).

Gender. Gender differences were incorporated in analyses II-1 and II-2. Where females and males differed significantly on the physical fitness test items (Wilk's lambda PF = .424, F(8,49) = 8.31 ($p < .001$) & partial eta-squared = .58), no gender difference was found for the levels of physical activity (Wilk's lamba = .99, F(4,53) = 0.14 ($p > .05$)). From the eight physical fitness test items, only four significantly differed between genders beyond the .05 level. As expected, males were stronger and scored higher than the females on strength items (handgrip, sit-ups, and standing broad jump). Males also scored higher on the walking test. Besides this main effect for physical fitness, no significant interactions between group and gender were found, with respectively Wilk's lambda for the mean score of physical fitness items PF = .75, F(8,49) = 2.09 ($p > .05$) and Wilk's lambda for reported physical activity level RPAL = .98, F(4,53) = 0.35 ($p > .05$).

(II-3). On fitness, the MANOVA revealed no significant effect of age for the control group (Wilk's lamba = .73, F(8,21) = .99; exact p = .48), but a near-significant overall effect of age in the group with AS (Wilk's lamba = .54, F(8,22) = 2.25; exact p = .07). When looked into more detail at the separate items, in the group with AS two items showed a significant difference (single leg balance: F(1,28) = 11.83, $p < .01$; sit-ups: F(1,28) = 6.70, p = .02) and one item near significance (shuttle run: F(1,28) = 3.39, exact p = .08). A similar picture on age differences emerges when the items in the control group are examined more closely: both shuttle run (F(1,28) = 4.42, p = .04) and sit ups (F(1,28) = 6.30, p = .02) reveal a significant difference between the age groups. All differences, in both the group with AS and the control group, were in favor of the older group, outperforming the younger. Solely for comparative reasons: single leg balance showed no significant difference between age groups in the control group ($F(1,28) = 1.8$, $p = .19$). The details on the differences are listed in Table 9.

TABLE 9 Descriptive data and comparison of physical fitness items of adolescents with and without Asperger syndrome

	Group with AS		Control group	
	Younger (n = 15)	Older (n = 15)	Younger (n = 15)	Older (n = 15)
SAR (cm)	21.3 ± 9.3	26.4 ± 13.0	32.7 ± 9.5	37.9 ± 12.0
HGR (kg)	27.5 ± 12.4	31.2 ± 12.7	36.4 ± 15.9	41.3 ± 18.6
SUP (#/30 s)	9.5 ± 4.5	14.5 ± 6.0*	20.5 ± 3.3	25.7 ± 7.3*
SLB (#/30 s)	9.1 ± 5.5	3.3 ± 3.6**	1.8 ± 1.2	1.3 ± 0.6
PLT (0.1s)	181.9 ± 70.0	155.7 ± 42.6	115.4 ± 12.1	109.4 ± 15.1
SBJ (cm)	130.1 ± 23.9	147.7 ± 39.0	192.3 ± 37.9	202.2 ± 47.8
SHR5 (0.1 s)	259.1 ± 40.4	236.8 ± 23.7	198.2 ± 8.9	188.1 ± 16.3*
UWT2 (s)	1137.4 ± 199.1	1121.3 ± 175,9	993.7 ± 56.5	957.1 ± 86.6

Note: *p<0.05, **p<0.01 for comparison of age groups of groups with and without AS; SAR-sit and reach, HGR-handgrip strength, SUP-sit-ups, SLB-single leg balance, PLT-plate tapping, SBJ-standing broad jump, SHR5- shuttle run 5X10, UWT2- 2km walking test.

There was also no statistically significant difference between age groups on physical activity in the group with AS, neither overall ($F(4,25) = .69$, $p = .61$), as on the subscores. However, although in the control group an overall effect was also absent ($F(3,26) = 1.93$, $p = .15$), there was a significant difference between age groups on reported PEL ($F(1,28) = 5.41$, $p = .03$) and ‘SSS1’ ($F(1,28) = 4.69$, $p = .04$), whereby the effect in SSS1 was strong enough to push the difference in the total score (SSST) to the edge of significance ($F(1,28) = 3.88$, $p = .06$). More details can be found in Table 10.

TABLE 10 Descriptive data on and comparison of physical fitness items of adolescents with and without Asperger syndrome

	Group with AS		Control group	
	Younger (n=15)	Older (n=15)	Younger (n=15)	Older (n=15)
SSS1	122.2 ± 118.8	103.6 ± 124.3	240.5 ± 200.3	421.7 ± 255.0*
SSS2	18.4 ± 39.3	25.5 ± 52.4	64.0 ± 149.5	96.0 ± 101.5
SSST	125.5 ± 116.7	115.6 ± 133.8	304.5 ± 313.1	517.7 ± 278.8
PEL	248.3 ± 62.3	261.7 ± 93.0	296.7 ± 76.7	360.0 ± 72.5*

Note: Level of significance *p<0.05; SSS1-simple sport score 1, SSS2-simple sport score 2, SSST-simple sport score total, PEL-physical exercise in leisure time score.

5.3 Sensory processing (III)

(III-1). First, the values of Cronbach's alpha for the various quadrants of the AASP and for both groups were at an acceptable level ranging from .66 to .84, as shown in Table 11. These results indicate good internal consistency for the specific populations.

TABLE 11 Cronbach's alpha for the different quadrants of the AASP for both index and control group

	Low registration	Sensation seeking	Sensory sensitivity	Sensation avoiding
Group with AS (N = 45)	.77	.66	.84	.81
Control group (N = 45)	.81	.81	.83	.83

Note: A commonly accepted rule of thumb is that an α of 0.7-0.8 indicates acceptable internal consistency, and 0.8 or higher indicates good internal consistency. Too high alphas (0.95 or higher) are not necessarily desirable, as this indicates that the items become redundant.

(III-2). Second, the MANOVA revealed statistically significant difference of the index group compared to the control group on overall sensory processing (Wilk's Lambda $\lambda = .77$, $F(4, 84) = 6.45$ ($p<.001$), with partial eta squared = .24, and observed power = .98) as well as on three of the four sensory quadrants (low registration, sensation seeking, and sensation avoiding). On the sensory sensitivity quadrant a nearly significant difference was obtained with exact p = .052. The effect sizes and observed power per quadrant ranged respectively from .04 to .07 and from .50 to .95 (see Table 12). Where the group with AS had higher scores on low registration, sensory sensitivity and sensation avoiding quadrants, lower scores were obtained in the sensation seeking quadrant.

(III-3) To take a closer look at **gender** differences the whole group of participants (N = 90) was split into the group with AS (n = 45) and the control group (n = 45). Only in the group with AS females and males differed significantly on overall sensory processing with Wilk's Lambda respectively $\lambda = .72$, $F(4, 40) = 3.88$ ($p < .01$), with partial eta squared = .28, observed power = .86). For the control group Wilk's Lambda was close to significant ($\lambda = .82$, $F(4, 40) = 2.17$ (exact p = .09), with partial eta squared = .18, observed power = .59). When looked into more detail at the separate quadrants, the group with AS showed a significant difference on only one of the four quadrants, namely on the sensory sensitivity quadrant ($F(1,43) = 9.84$, $p < .01$) (See Table 13). Also in the control group only one significantly differing (though different) quadrants was observed, to be exact the sensation seeking quadrant ($F(1,43) = 6.85$, $p < .05$) (See Table 13).

TABLE 12 Descriptive data for the quadrants of the AASP and comparison between groups

	Group with AS (n = 45)	Control group (n = 45)	F (1,87)	Exact p	ES	Power
Low Registration	35.11 ± 8.28 (19-58)	30.71 ± 8.33 (17-60)	6.24	.014*	.07	.70
Sensation Seeking	40.73 ± 7.40 (15-55)	45.29 ± 9.26 (23-67)	6.85	.010**	.07	.74
Sensory Sensitivity	35.64 ± 10.51 (17-58)	31.84 ± 8.19 (18-54)	3.87	.052	.04	.50
Sensation Avoiding	39.13 ± 9.82 (22-62)	32.33 ± 7.81 (20-60)	13.13	.000**	.13	.95

Note. Mean ± Standard Deviations, values enclosed in parentheses represent range of scores; ES = effect size; both groups have equal size of N=45. Level of significance *p < 0.05 and **p < 0.01

TABLE 13 Descriptive data for the quadrants of the AASP and comparison between gender groups in both the group with Asperger syndrome and the control group

	Males (n = 33)	Females (n = 12)	F (1,43)	Exact p	ES	Power
Group with Asperger syndrome						
Low registration	34.64 ± 8.27 (23-58)	36.42 ± 8.53 (19-49)	0.40	.53	.01	.095
Sensation seeking	40.76 ± 7.69 (15-54)	40.67 ± 6.85 (32-55)	0.01	.97	.00	.050
Sensory sensitivity	32.94 ± 8.89 (17-51)	43.08 ± 11.40 (24-58)	9.84	.00**	.19	.866
Sensation avoiding	38.06 ± 8.08 (25-53)	42.08 ± 13.51 (22-62)	1.49	.23	.03	.223
Control group						
Low registration	31.12 ± 8.94 (18-60)	29.58 ± 6.57 (17-39)	0.30	.952	.00	.70
Sensation seeking	43.24 ± 9.59 (23-67)	50.92 ± 5.32 (40-60)	6.86	.01*	.14	.73
Sensory sensitivity	31.67 ± 8.51 (20-54)	32.33 ± 7.56 (18-47)	0.06	.81	.00	.06
Sensation avoiding	32.67 ± 8.69 (20-60)	31.42 ± 4.81 (23-39)	0.22	.64	.01	.08

Note. Mean ± Standard Deviations, values enclosed in parentheses represent range of scores; ES = effect size; groups have unequal size. Level of significance *p < 0.05,**p < 0.01.

(III-4). Next, Pearson correlations revealed significant within-group correlations regarding age and levels of sensory processing in both groups. In the group with AS positive correlations were found between age and two of the four sensory quadrants (low registration with r-value of .34 ($p < .05$) and sensory sensitivity with r-value .35 ($p < .05$)). In the control group only one (in this case negative) correlation was observed between age and the low registration quadrant, r-value -.40 ($p < .01$).

(III-5). The results of the multiple case series analysis demonstrated that 47% of the participants in the group with AS were found to display atypical sensory processing on at least one of the four quadrants. Results demonstrated that the number of participants with extreme scores varied remarkably between the quadrants with ranges from 4% to 40% (see Table 14). From 21 participants who had atypical scores on one quadrant, 10 had atypical scores on at least two quadrants of which 3 participants on 3 quadrants. The scores of only these 21 atypical scoring participants are plotted in Table 14.

TABLE 14 Multiple case series analysis illustrating the percentage of atypical scores in the group with Asperger syndrome for each quadrant of the AASP

Participant	Low registration	Sensation seeking	Sensory sensitivity	Sensation avoiding	% of quadrants
1	■		■	■	75%
5				■	25%
6				■	25%
7				■	25%
11				■	25%
12				■	25%
15		■			25%
18		■			25%
20				■	25%
23			■	■	50%
26			■	■	50%
27	■		■	■	75%
28			■	■	50%
29	■		■	■	75%
34	■		■	■	75%
36			■	■	50%
41				■	25%
42	■		■	■	75%
43				■	25%
44			■	■	50%
45	■				25%
Number of outliers	6/45 13.3%	2/45 4.4%	10/45 22.2%	18/45 40.0%	

(III-6). Finally, differences in every sensory quadrant over varied levels of motor competence were examined. A subgroup of 30 individuals with AS was divided into a group at risk for motor problems (n=19) and a group not at risk (n=11) based on their M-ABC-II percentile score. Descriptive data of both groups are given in Table 15.

TABLE 15 Descriptive data for the quadrants of the AASP and comparison between a subgroup with AS at risk for motor impairment and another groups with AS with normal motor competence

	Group with normal motor competence (n = 11)	Group at risk for motor problems (n =19)
Low registration	36.18 ± 10.19 (23-58)	32.32 ± 8.00 (19-52)
Sensation seeking	43.91 ± 8.22 (24-54)	37.95 ± 8.16 (15-57)
Sensory sensitivity	37.36 ± 10.75 (24-58)	32.68 ± 9.44 (17-51)
Sensation avoiding	42.36 ± 10.00 (27-62)	37.58 ± 10.52 (23-60)
M-ABC-II total score	70.91 ± 7.12 (63-84)	43.79 ± 11.36 (15-60)
M-ABC-II percentile score	28.9 ± 16.1 (16-63)	3.0 ± 2.8 (0.1-9)

Note. Mean ± Standard Deviations, values enclosed in parentheses represent range of scores; both groups have different size: group at risk (n = 19), group with normal motor competence (n = 11).

No difference between the two groups on any of the four quadrants could reach significance: low registration ($F(1,28) = 1,33$; $p = .26$); sensation seeking ($F(1,28) = 3,70$; $p = .06$); sensory sensitivity ($F(1,28) = 1,55$; $p = .22$); sensation avoiding ($F(1,28) = 1,49$; $p = .23$). In order to have 'a second opinion' on the near-significant effect on sensation seeking quadrant, the non-parametric equivalent of the ANOVA, in this case a Mann Whitney U test, was added, revealing a significant effect for sensation seeking as shown in Table 16.

It is most likely that the effect should be considered significant, given the knowledge that this non-parametric test has a higher accuracy for p-values over the initially used ANOVA. The question is not whether or not this effect can be called significant, according to the statistics used, but what the difference in this quadrant signifies for both the overall image of senso-motor profile of people with Asperger and the clinical, practical side of the matter.

TABLE 16 Comparison of means between sensory profile quadrants and motor competence levels of a group with normal motor competence and a group at risk for motor impairment using Mann-Whitney U analysis

	Motor competence level	Mean rank	Z score	p
Low registration	Normal	17.50	-0.95	.34
	At risk	14.34		
Sensation seeking	Normal	20.18	-2.22	.03*
	At risk	12.79		
Sensory sensitivity	Normal	17.73	-1.06	.29
	At risk	14.21		
Sensation avoiding	Normal	18.00	-1.19	.24
	At risk	14.05		

Level of significance p < .05*

5.4 Effects of an exercise training program (IV)

Table 17 presents a total overview of the effects of the training program, including the means and SDs for motor competence and physical fitness scores of each group across the three time periods. These effects are discussed in more detail in IV-1 and IV-2. In Table 17, the most relevant statistics for our purposes are the three means reflecting these performance scores. Examination of these means suggests that the average motor competence as well as physical fitness was lowest at pre-test (before the intervention), highest at post-test (immediately after the intervention), and in between these two at follow-up (the 3-month follow-up measure).

TABLE 17 Means and SDs of motor competence and physical fitness scores of each group across the three time periods

	Motor competence total test score		Physical fitness total score	
	Intervention group	Control group	Intervention group	Control group
Time	M ± SD	M ± SD	M ± SD	M ± SD
Pre test	53.8 ± 21.6	56.6 ± 12.0	50.3 ± 7.9	49.8 ± 5.1
Post test	62.6 ± 19.2	58.9 ± 11.7	53.4 ± 5.0	49.9 ± 5.2
Follow-up	61.6 ± 19.3	56.8 ± 12.7	52.7 ± 5.5	49.3 ± 5.0

(IV-1). First the motor competence is examined, starting with ruling out the possible confounding effect of history. This was done with matched groups based upon pre-test M-ABC-II score. A confirmatory independent *t*-test, showed no significant differences at pre-test between the intervention and the control group with t (18) = 2.45; p > .05. The average pre-treatment M-ABC-II standard score was 7 for the intervention group and 6.5 for the control group, both scores within the range of at risk for motor problems. In both groups there was large within group variability with 4 participants in the intervention and 3 in the control group scoring above the 15th percentile. All but one participant in the intervention group improved their M-ABC-II score between pre- and post-test, with the average M-ABC-II score increasing from percentile 15 to percentile 25. In the control group little improvement was observed and the average M-ABC-II score stayed below the 15th percentile.

A graphic of the group results of the M-ABC-II total test score is shown in Figure 3. This figure shows a great improvement in performance between pre- and post-test for the intervention group and a slight improvement in the control group followed by a leveling off to the follow-up test for both groups.

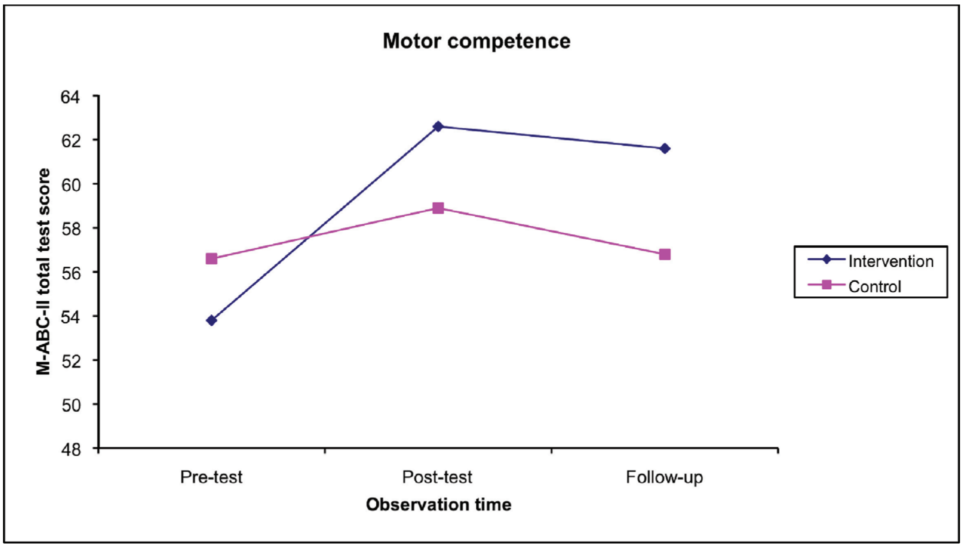


FIGURE 3 Mean total test scores of the M-ABC-II for both intervention and control groups with AS (n = 10/group)

For the M-ABC-II the 2 X 3 repeated measures ANOVA revealed a significant interaction between group and time: $F (2,36) = 6.96$; $p < 0.005$; partial eta squared = .28 representing a rather small effect. **(IV-3)**. Post-hoc comparisons through one-way (time) repeated measures ANOVA for each group revealed the following. For the intervention group there was a simple main effect for time, $F (2,18) = 10.58$, $p < 0.001$, partial eta squared = .54. The Bonferroni method indicated a significant mean difference between pre- and post-test (exact p = .002), pre-test and follow-up (exact p = .005), but not for post-test and follow-up (exact p = .64). Also for the control group a simple main effect was found for time: $F (2,18) = 7.04$; $p < 0.01$; partial eta squared = .44. Here the Bonferroni method indicated only a significant mean difference between pre- and post-test (exact p = .002), but not between post-test and follow-up (exact p

= .019), nor for pre-test and follow-up (exact p = .79), indicating that the possible gains are not maintained.

(IV-2). Similar results were observed in analyzing the data of the Eurofit. A graphic of the group results of the Eurofit total test score is shown in Figure 4. This figure shows a large improvement in performance between pre- and post-test for the intervention group and only a slight improvement in the control group followed by a levelling off to the follow-up test for both groups.

Also for the Eurofit the 2 X 3 repeated measures ANOVA revealed a significant interaction between group and time: $F(2,36) = 4.48$; $p < 0.05$; partial eta squared = .20 representing a large effect. Post-hoc comparisons through one-way (time) repeated measures ANOVA for each group revealed the following. For the intervention group there was a simple main effect for time, $F(2,18) = 4.39$, $p < 0.05$, partial eta squared = .33. The Bonferroni method indicated no significant mean differences between different test times with exact p = .11 between pre- and post-test, exact p = .96 between post-test and follow-up, and exact p = .26 for pre-test and follow-up. Also for the control group a simple main effect for time, $F(2,18) = 5.69$, $p < 0.05$, partial eta squared = .38 was found. The Bonferroni method indicated no significant mean differences between times. The exact p-values between pre- and post-test, post-test and follow-up, and pre-test and follow-up were respectively p = .99, p = .05, and p = .13.

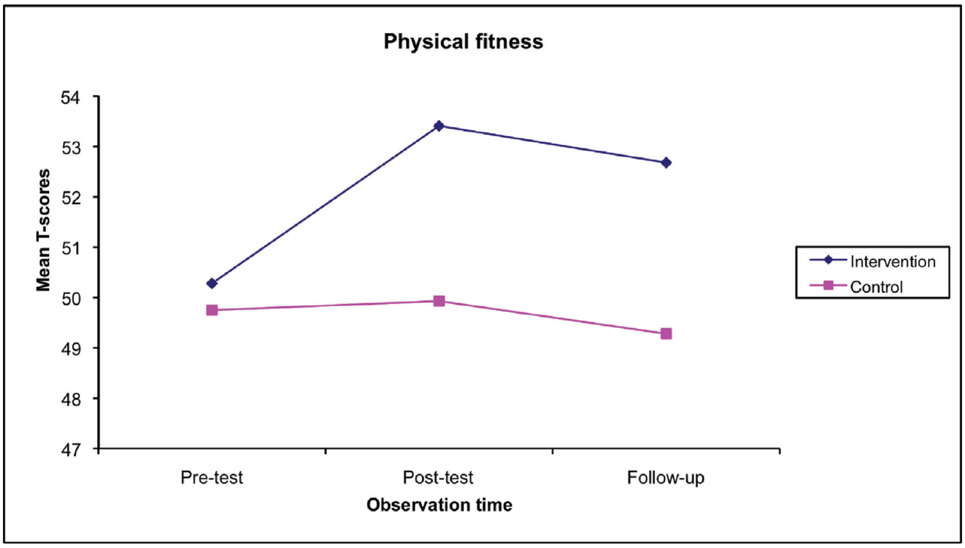


FIGURE 4 Mean total test T-scores of the Eurofit physical fitness test for both intervention and control groups with AS (n = 10/group)

Based on these results, it seems that there is an interaction effect only between pre and post-tests for both measures in that the treatment group increased their levels significantly more than the control group. However, the levels of both groups slightly decreased at the follow-up without any meaningful differences between post-test and follow-up.

6 DISCUSSION

This thesis examined young adolescents with Asperger syndrome to gain knowledge about their senso-motor and physical fitness profiles, and about the effectiveness of an exercise training program. There were four main components in this research. First, the motor competence of young adults with AS was compared to age and gender matched controls using the updated version of the standardized Movement Assessment battery for children (M-ABC-II). Second, the physical fitness profile and physical activity levels in these 30 adolescents with and without AS were evaluated. Third, the investigation of sensory processing patterns over varied levels of motor competence was conducted in individuals with AS compared to matched controls using the Adolescent/Adult Sensory Profile. And fourth, the examination of the efficacy of an exercise training program as part of an ongoing vocational training program for adolescents with AS was performed on motor competence and physical fitness. The following discussion is organized in the above-mentioned order. Additionally, to put this whole project into perspective and in order to bridge the gap between fundamental scientific research and the everyday clinical practice, a brief summary of some basic teaching strategies for working with youth with AS is provided, including assessment, instruction, activity selection, and inclusion.

6.1 Comparison of motor domain between adolescents with and without AS

The discussion of the motor domain covers the following main aspects, beginning with the comparison of motor competencies and physical fitness profile of young adults with AS and matched controls. Furthermore, gender and age differences within the groups, as well as additional findings from qualitative observation by using M-ABC-II were explored to get a more detailed picture of the motor domain.

Challenges in the motor domain

Young adults with AS continue to demonstrate motor problems and perform at a much lower level than their peers. Moreover, individuals who were assessed as having severe motor impairment were not likely to have single, isolated motor problems. Generally, the individuals with AS needed either more time to complete the M-ABC-II tasks or performed the tasks less successfully. The nature of these problems seems to be a generalized pervasive motor problem affecting both fine and gross motor abilities.

In addition to the above mentioned lower levels in motor competence, the adolescents with AS participating in the present study also had lower levels of physical fitness in balance, coordination, flexibility, muscular strength, running speed and cardio-respiratory endurance. Moreover, they had higher levels of physical inactivity when compared to age matched peers.

These significant deficits appeared consistent with previous reports of uncoordinated movements and poor performance on neurodevelopmental and senso-motor tasks (Gepner & Mestre, 2002; Ghaziuddin & Butler, 1998; Gillberg & Coleman, 1992; Lopata, Hamm, Volker, & Sowinski, 2007; Weimer, Schatz, Lincoln, Ballantyne, & Trauner, 2001). There are several explanations given in literature to explain the poor performance of individuals with AS in the motor domain. These include a deficit in proprioception (Weimer et al., 2001); impaired imitation of body movements in ASD (Smith, 2004); potential abnormal mirror neuron functioning (Mueller et al., 2004); a mental loss of the aim of the planned motor action (Vernazza-Martin et al., 2005); and perceptual-motor impairment (Mostofsky et al., 2006). Careful interpretation of these and our results suggest that the "clumsiness" often observed in AS may be the result of deficits in both sensory and motor pathways as difficulties are seen over the whole range of motor tasks. For example, ball skills often prove difficult as tasks are dependent on a motor plan of the spatio-temporal attributes of the environment as well as a sensory-motor map of one's own body schema. Additionally, successful integration of sensory information about the trajectory, arrival time and characteristics of the ball is required in order to achieve appropriately timed and synchronized locomotor, reaching and grasping actions using adequate force control.

Other than strictly sensory-motor, perhaps the most obvious explanation for these motor difficulties, may be the lack of participation in (social) games and playground activities that lead to lack of practice and lower competence (e.g., Attwood, 1998). Furthermore, failures to catch or to aim a ball successfully advertise themselves in an avoidance of these (un)motivating activities. Asperger (1991) himself remarked on these typical motor difficulties as follows: a boy named Hellmuth "stood in the middle of a group of playing children like a frozen giant. He could not possibly catch a ball, however easy one tried to make it" (Asperger, 1991, p.61).

Severity of challenges in the motor domain

The confirmatory calculation of percentiles based each individual's raw scores indicated the severity of the motor impairment. Where in the control group percentile scores ranged from the 16th to the 95th (putting all controls participants within normal range) the results in the group with AS suggest that 63% (19/30) are at risk for motor impairment. Most of the 19 individuals with AS who scored below the 15th percentile displayed a range of motor problems across the three subscales of the M-ABC-II, often with ball skills being the most affected. Another five individuals scored on the 16th percentile. These individuals were more likely to have one or two areas of relative strength, often with one score close to the 50th percentile. While their stronger areas seem to be balance and fine motor skills, ball skills were the weakest and proved to be the most difficult. According to Mostofsky et al. (2006), such a poor performance in object manipulation (in this study under form of throwing and grasping a ball) reflects that motor difficulties are rather due to a generalized praxis impairment and not solely limited to impaired imitation. This is in line with recent research by Jasmin et al. (2009) stipulating that poor performance on object manipulation tasks may be an indication of gross motor coordination and motor planning difficulties.

Additional findings form qualitative observation in using M-ABC-II

Adolescents with difficulties in the motor domain differ from each other in many ways, not only in terms of the severity and range of their motor problems but also in other aspects of their behavior. Although these results provide information about the motor problems of adolescents with AS, additional findings from observations are also provided. Respectively, observations about manual dexterity, ball skills, and balance will be summed up here.

In the manual dexterity tasks, an overall observation was a poor sitting posture with a tendency for individuals to often hold their heads too close to the task. On the turning pegs task, four individuals dropped several pegs on the floor during the trial. Often they tried to rush through the task using jerky movements and excessive force with lack of accuracy as a result. The task with the triangle was often perceived as a challenge. Holding the bolt with one hand and screwing the nut on with the other was the most challenging part in this bimanual task. About 30% of the students got muddled in the construction sequence and two out of three needed a second trial to finish the task successfully at their own pace. During the paper-pencil drawing trail task about 50% of the students had difficulties with adequate force control often using excessive force and pressing the pen very hard on the paper. About 30% of the participants finished the drawing trail successfully without any error. Other students struggled. Large variability within the group with AS was observed, with some individuals being extremely skilled in some fine motor activities, finishing the fastest of the whole study group including the controls. Typically these individuals had enhanced hand eye coordination as a result of their specific hobbies, such as knitting and building model airplanes, which both involve precise motor skill repetition.

The students' aiming and catching accuracy appeared to be particularly poor. When catching a tennis ball with one hand the movements often lacked fluency and participants had difficulty judging the accurate force of the throw. There was a tendency not to anticipate the trajectory of the ball resulting in their hand not 'giving' to meet its impact, thus gradually absorbing the ball's force. Body and arms were held rigidly, making it a challenge to move quickly to the left or to the right, forward or back, to intercept the ball. Often timing was an issue too, with their fingers closing a fraction too late. On average they could catch every second ball. Some students had difficulty changing their hand positions in preparation of a catch. They had difficulty depending on where the ball is, to execute the right movement pattern, meaning pointing the fingers up when catching a high ball and down when catching a low one. At the end of the formal testing students were allowed to catch with both hands and also use their body in their attempt to catch successfully. Throwing at the wall target was easier; with on average of every second ball hitting the target. When some participants started off unsuccessfully with one hand they changed hands during the trial with variable force control.

On the balance tasks 25% of the students could stand for 30 seconds on the boards. The ones who could not balance often showed exaggerated movements of both arms and trunk to stay in balance. In the walking toe-to-heel test, it was very difficult for some participants to keep both legs on the line at the start. The ones who were not so successful often went too fast for accuracy in an attempt to overcome wobbliness when placing their feet on the line. In the zigzag hopping most students were successful after the second attempt with some having problems stopping at the end, causing stumbling on landing.

<u>Age- and gender differences in motor domain</u>

Where no differences between the younger and the older in the control group were found, the results did show a nearly statistically significant overall motor competence and physical fitness difference between the age groups with AS. Despite possible improvement with increasing age, difficulties in the motor domain continue to be present into young adulthood among individuals with AS. With this small sample size, statistical significance should not misguide us when focusing on effect size. Relative improvements were found in many components including manual dexterity, ball skill, balance and agility. Nonetheless, the summary of these findings only partially reflects the complexity of the actual data where a far more variable picture presides. Because these findings were consistent with those of other studies of children with AS (Green, et al., 2002; Manjiviona & Prior, 1995) and also in adults (Freitag, Kleser, Schneider, & von Gontard, 2007; Sahlander, Mattsson, & Bejerot, 2008) we can suggest that motor impairment follows children with AS into adulthood. Longitudinal studies using standardized measures are recommended to support this idea, as due to the small sample size and the unavailability of equal groups at each age level any actual developmental trend difference may have been unable to be detected.

As expected, gender differences were minimal in both groups on the motor tasks of the M-ABC-II which is in line with previous research using the M-ABC-II (Henderson, Sugden, & Barnett, 2007). On the Eurofit tasks, on the other hand, some anticipated differences were observed with males being stronger than the females on strength items (handgrip, sit-ups, and standing broad jump) and scoring higher on the walking test. These differences were not surprising as it is generally accepted that males do have more strength and endurance than females.

<u>The use of the M-ABC-II with adolescents with AS</u>

An additional goal of this study was to provide a preliminary exploration of the use of the M-ABC-II in young adults with AS. The data suggest that the M-ABC-II provides preliminary evidence of validity for young adults with AS since the test is able to distinguish between groups of individuals who might be expected to have movement difficulties (as with our index group) and those whose motor development is typical for their age (as with our control group). According to the tentative statistical analyses (as Cronbach's alpha), the M-ABC-II test has a rather low degree of validity, with Cronbach's alpha being higher in the group with AS than in the control group. Therefore, careful interpretation of the current findings is suggested since considerable variability within and between the groups was also observed. While ceiling levels were reached in the control group on many of the test items, all test items but one (zigzag hopping) were still challenging enough and differentiate between individual's abilities in the group with AS. In the present study, based upon statistical analysis, internal consistency would have been at a more acceptable level if for example, trail drawing and zigzag hopping had been omitted. There is a need to further elaborate on the eventual need to omit and/or adapt some of the test items. Careful attention to potential limitations of the chosen measures for their sensitivity for lower as well as higher skills is necessary in order not to limit the evaluation of this population's motor domain. For example, while in zigzag hopping a ceiling effect was observed, in another balance task, namely single leg balance of the Eurofit, many students scored very poorly, suggesting that this test shows floor effects, i.e. lack of sensitivity to poor performance. Future research using both M-ABC-II and/or Eurofit with adults should address the population specific psychometric properties in order to give a clearer recommendation to fine-tune these test instruments.

Even though establishing age norms for adults is needed, it is recommended to use the M-ABC-II assessment battery with young adults with AS in clinical practice when test results are interpreted alongside other data (for example form the Eurofit). Information should be taken into account both formally and informally, and classification of individuals as impaired/not impaired should not be drawn from a single score from one test. For young adults with AS, motor performance may be expected to improve after the age of 16. It seems that the M-ABC-II test may be sensitive to monitor these strengths and weaknesses.

To summarize, whether or not problems in coordination and motor planning should be seen as a diagnostic criterion, there is no doubt that when such problems with “clumsiness” do occur it can have a significant effect on adolescents’ development and future. It is, therefore, recommended that youth with AS have a comprehensive assessment by a trained professional to determine the nature and degree of any problems in the motor domain. Based upon clinical observation in combination with the use of standardized tests (such as M-ABC-II or Eurofit) strategies to improve particular skills can be derived. Some specific guidelines and examples are stipulated below in section 6.6.

6.2 Comparison of physical activity levels in adolescents with and without AS

Besides having lower levels of physical fitness and motor competence, adolescents with AS also had higher levels of physical inactivity when compared to age matched peers. This is in line with some of the few published physical activity studies that have included youth with ASD (Pan & Frey, 2006), indicating that youth with ASD are less active than peers without disabilities. However, Pan and Frey (2006) did report that other aspects of physical activity behavior, such as PA declination with increasing age and the fact that youth do not regularly engage in moderate to vigorous physical activity, are similar to those observed in peers without disabilities. In addition, Rosser and Frey (2005) did also observe low levels of moderate to vigorous physical activity during physical education in children with ASD, alwhile physical education still presents an important opportunity to engage in physical activity.

Unfortunately, it appears that adolescents with AS are at similar risk for health problems associated with inactivity as those without disabilities. While it is recommended that adolescents accumulate 60 minutes or more of engagement in an active lifestyle in order to improve their overall fitness, only few meet this norm. Additionally, motivating adolescents with AS to adhere to such an active lifestyle is a major challenge, as it is well documented that physical activity significantly decreases from childhood to adulthood in the general population (Telama et al., 2005). In order to inspire adolescents with AS to become more active, more emphasis should be placed on delivery of quality and tailor-made instruction, and on the selection of the most suitable and fun physical activity options!

Regarding physical activity, additional information from the questionnaire completes the picture the numbers have already drawn. When asked in the PARQ physical activity questionnaire if they were involved in sport activities, the majority (80 %) of the group with AS reported not being involved at all or being involved in less intense physical activities once a week. On the other hand, most individuals in the control group exercised intensely at least a few times a week.

There was an obvious discrepancy in the kinds of activities the index and control group were engaged in. Adolescents with AS preferred solitary activities such as walking, swimming, and biking. Their typically developing peers were more engaged in team sports and group activities such as ice hockey, soccer, aerobic- and fitness classes. The participants with AS who were engaged in more intense activities, had often trained and participated in one particular sport (e.g., martial arts, badminton, bowling, mountain biking, indoor climbing) and had been doing so regularly for many years. We hypothesize that they had achieved greater skill level because of intensive participation in their favorite physical leisure time activity throughout their childhood with many repetitions as a key to success.

The choice of the above mentioned leisure time activities in the AS group was logical, as all activities were structured in nature, had repeated actions as well as rhythm built in. Furthermore, these activities were less competitive and, to a certain degree, predictable. For example, in an indoor climbing unit, one climbs up as high as she/he can follow a predictable route and, when finished, repels down. Belaying the climbing partner follows this. This clear "your turn/my turn" structure as well as the choice of a preset (and clearly marked) route makes indoor climbing attractive for people with AS since it is ready adapted to their specific needs.

6.3 Comparison of sensory processing patterns in adolescents with and without AS

Another aim of this project was to provide detailed results of an assessment of sensory processing in adolescents and adults with AS compared to matched controls (III). It is the first study to provide specific information on the psychometric properties of the AASP with individuals with AS, as well as on the atypical sensory processing of this group of individuals. The latter aspect involved the additional focus on the sensory profiles on an individual basis and over varied levels of motor competence.

The general conclusions of this sensory inquiry cover six main aspects, beginning with the psychometric properties of the AASP used. The results confirm the acceptable to good internal consistency reliability given in the manual (Brown & Dunn, 2002). Acceptable internal consistency reliability of the AASP was observed for both the group with AS, and the control group in our Finnish sample. These findings provide important information about the consistency of responses to the different questions of the AASP, for each sensory quadrant. These results confirm our choice of the AASP as a reliable tool to screen for atypical sensory processing patterns in individuals with AS.

Secondly, significant differences on overall sensory processing of the group with AS as compared to the control group were found. These findings contribute additional evidence to the overall picture of AS. The specific quadrants with distinct differences were low registration, sensation seeking, and sensation avoidance with effect sizes (ES) ranging from .40 to .77, indicating medium to large effect differences between the groups. These effect sizes can be interpreted in terms of the percentage of non-overlap of scores between both groups. An ES of .40 indicates a non-overlap of 27.4% whereas an ES of .77 indicates a non-overlap of 44% in the two distributions. These findings of atypical sensory processing patterns in AS, are in line with the body of knowledge in the ASD literature suggesting a high prevalence of sensory processing challenges (Crane, Goddard, & Pring, 2009; Dunn, Myles, & Orr, 2002; Kern, et al., 2006; Kern, et al., 2007; Kientz & Dunn, 1997). An interesting comparison between our data can be made with the results found by Crane et al. (2009) in their adult high functioning autism/AS group. Where their effect sizes ranged from 1.17 to a striking 2.20 (indicating a non-overlap of their distribution ranging from 60 to over 80%), our results showed much lower effect sizes. This indicates that the sample in the present study had less deviant sensory processing patterns than the sample used in this earlier research. Other reasons for the differences might be due to the small sample sizes used in both studies (which increase the possibility of sampling error) as well as the diversity of scores observed within the groups with AS.

When the average scores of both the group with AS and the control group are compared to the norms given in the AASP manual, only the score from the sensation seeking quadrant of the group with AS would be classified as deviant from most people's scores. The group with AS seems to engage less in sensation seeking behavior than most people, which was also observed in previous research (e.g., Crane, et al., 2009; Dunn, et al., 2002). This 'less than most people'-score means that their average score fell between 2% and 15% of the scores of the standardization population. On the three other quadrants (low registration, sensory sensitivity, and sensation avoiding) the group with AS fell within the 'similar to most people'-category, indicating that their scores fell between 16% and 84% of the scores of the standardization population. When taking a closer look at these results, it is observed that on two of these three quadrants (low registration and sensation avoiding) the group with AS scored close to the 'more than most people'- category. Not surprisingly, significant group differences were found exactly in the low registration, sensation seeking and sensation avoiding, between the group with AS and the control group. One reason for the differences in sensory profile found by different research teams might be due to a cross-cultural effect. Where the standardization sample was recruited from the mid-west United States, our index and control groups were recruited from Finland, a country were one's own peace and freedom are traditionally highly appreciated.

Third, our inquiry on gender differences yielded interesting results as it showed significant gender differences on overall sensory processing in the group with AS. When taking a closer look on these differences, only one of the quadrants, namely sensory sensitivity, showed significant differences with females scoring lower than males. These results are not in line with previous research in individuals with ASD (Kern et al., 2007) were no significant gender differences were found. Because the AASP manual only provides one set of norms for all individuals (female and male), the need to investigate possible gender differences might have been neglected. Once again, these differences highlight the importance of using individually and tailor-made assessment strategies.

The fourth goal was to examine the relationships with respect to sensory quadrants and age. The correlational investigation revealed significant positive within-AS-group correlations regarding the low registration and the sensory sensitivity quadrants. This suggests that specific unusual processing patterns dissipate with increasing age. These results are in line with others suggesting that the levels of atypical processing fade out with increasing age (Kern, et al., 2007). However, the results of this study contrast with those of Crane et al. (2009), who suggested that levels of unusual sensory processing do not dissipate across the lifespan. Despite these contradictory results in the literature, it seems plausible that individuals with AS can learn effective coping strategies for their sensory issues and that, with maturation, these strategies may continue to be refined and put more into active use. Nevertheless, for some individuals sensory issues may continue throughout their lives.

In our view, normalization of deviant sensory processing patterns starts through in-depth assessment of each individual's unique sensory profile. This can be achieved, for example, by using the AASP in combination with direct observation by a trained professional, or with new evaluation systems such as SensOR (Schoen, Miller, & Green, 2008). Evidenced based sensory exercises would ideally follow careful assessment. Future research should evaluate these sensory interventions because clear efficacy evidence of these sensory treatments has not yet been established (e.g., Dawson & Watling, 2000).

Fifth, the exploration of the patterns and extent of sensory processing differences at an individual level in the group with AS confirmed the high prevalence of atypical sensory processing. Almost 50% of our index group was found to display atypical sensory processing on at least one of the four quadrants.

The majority of the outlying scores fell in the sensation avoidance quadrant. Almost all of the individuals displaying atypical sensory processing had deviant scores on the sensation avoiding quadrant (18/21), and this in almost half of the cases in combination with atypical scores on the sensory sensitivity quadrant. The index group seems to avoid more sensory input and seems to be more sensitive to sensory information from the environment. This data yields to a trend that in adolescents and adults with AS a rather lower neurological threshold might exist. People whose thresholds are rather low tend to be overly responsive (i.e., very little stimuli causes a reaction, as when people are distracted by every stimulus). This is an important fact to take into account when designing and organizing exercise programs. Teachers could, for example, create a calm sporting environment, provide clear structure, and use simple language with one instruction at a time.

Taken together, this 'moderate' percentage of atypical scores on the Sensory Profile is in the lower range of frequencies of sensory issues reported in a review by Dawson and Watling (2000). They estimated the range of atypical scores in ASD to be between 30 and 100%. It is obvious that because the high frequency of these atypical sensory profiles, sensory issues should not be overlooked.

Finally, the examination of differences in SP quadrants over varied levels of motor competence only showed differences for the sensation seeking quadrant. Adolescents with AS at risk for motor impairment engaged less in sensation seeking behavior than their peers without motor problems. This is certainly not surprising as the sensation seeking quadrant contains statements such as 'I enjoy how it feels to move about' and 'I choose to engage in physical activities'. Despite large within groups variability being observed in both motor competence groups it might be that atypical sensory processing patterns play an important role in the deviant motor development of many individuals with AS. Individuals learn motor skills by repeating an action, and by getting a wide variety of senso-motor experiences from early on. Recently, Jasmin and colleagues (2009) found few correlations between sensory responses and motor skills with sensory seeking being correlated exactly with gross motor skills. Knowing that many individuals with AS might also meet the criteria for DCD, another interesting recent study by O'Brien and collegues (2008) in this field of research examined potential mechanisms underlying motor coordination in children with developmental coordination disorder. They suggested that there is a developmental nature to the processing of visual and auditory input and implied that the vibrotactile sensory modality may be key to the motor coordination difficulties of these children with DCD. Wilson & McKenzie (1998) also pointed out that among children with DCD the greatest area of impairment is the ability to integrate sensory information, with the impairment being relatively specific to visual-spatial processing, kinesthetic perception, and cross-modal integration. Additionally, there is clear evidence of sensory integration problems in children of autism too (e.g., Baranek, 1999; Dyck et al., 2007; Gepner & Mestre, 2002; Milne et al., 2002; Molloy et al., 2003).

Both these findings and the preliminary findings of the current investigation suggest that the atypical sensory processing seen in individuals with AS may explain some difficulties with motor skills and interfere with motor development. Once again, this highlights the need for further study of the role of sensory processing in motor (in)coordination in individuals with AS, as profound impairment in some set of integrative abilities may also characterize the motor challenges linked to the disorder. Additionally, without consideration of the 'typical' sensory processing patterns and characteristics, attempts to implement effective teaching strategies lack the depth and individuality that contribute to and support successful daily life experiences for individuals with AS.

6.4 Efficacy of an exercise training program on adolescents with Asperger syndrome

Although exercise training programs are effective in improving physical fitness and motor competence in typically developing youth, insufficient data of the impact of interventions are available in youth with Asperger syndrome. As a significant proportion of adolescents with AS have delayed motor skills and are in need of effective training programs, this project (IV) used an exercise training program that proved efficacious in improving the motor competence and physical fitness of adolescents with AS. Where the *p* value for the difference in motor competence between pre and post-test for the intervention was significant, such significance was not observed for physical fitness. Yet we claim that this difference is also meaningful because a similar upwards trend is observed as in the motor competence data (see Figures 3 & 4). Lack of statistical significance may be due to the small sample size and the high SD. Therefore, these results need to be interpreted in relation to both, statistical significance and clinical importance.

The individuals in the control group almost returned to pre-test levels at the follow-up, whereas a much slighter decline was observed for the intervention group. The intervention group ended the 6 months period with higher levels of motor competence and physical fitness. It seems that when individuals with AS invest some extra time weekly to be physically active, skill and fitness levels increase. These results follow a similar positive upward trend of increasing competence levels as other exercise interventions in children with poor motor skills (e.g., Kalverboer, 1994; Peters & Wright, 1999; Schoemaker, Hijlkema, & Watemberg, Waiserberg, Zuk, & Lerman-Sagie, 2007).

Even though the intervention was effective for the majority of participants, more research is needed to further evaluate which aspects of the exercise intervention were most successful and which aspects need to be adapted or improved. Although a multi-level approach, like the one used in the present study, makes it difficult to identify which aspects of the interventions were successful, it was discovered that such an approach is more appropriate to target adolescents' physical activity behavior, which is influenced by a diversity of factors. By offering different exercise possibilities, such as for an extra physical education class or a personal home program, students get a wider scope of possible ways to increase their healthy exercise behavior.

Additionally, in order to further highlight the importance of the exercise intervention, its clinical significance is documented according to Rapoff (2009) at the following three levels: (1) the goals of the intervention studies are relevant to interested parties; (2) the intervention procedures are acceptable to interested parties and are, therefore, more likely to be adopted if effective; and (3) the effects of our interventions are satisfactory to consumers and meet some standard of achieving clinically significant effects.

First, exercise training programs (like the one used in this study) could certainly contribute to achieve recommended PA levels, especially when integrated into the broader individualized education program. Given the variability in developmental profiles of individuals with AS, it should be expected that not all benefit equally from the interventions. There is not a one-for-all treatment; thus, the interventions must be prescribed in an individualized manner consistent with the functional goals for each student. Given that many conventional educational environments are loud, distracting and unpredictable, interventions need to consider the individualized adaptations to optimize successful participation and adherence in the exercise programs. The program and instruction should, therefore, emphasize enjoyable participation in the training program and help students develop the knowledge, attitudes, motor and behavioral skills needed to adopt and maintain physically active lifestyles.

Second, students were a very important part of the planning of the training program. Within the training program a wide variety of options were given, as similar exercise bouts could be part of their future daily (exercise) routines. Interestingly enough, most students (and also the educational staff) continued to join the extra-curricular PE class (which was one of the three parts of the exercise training program) regularly after conclusion of the present study. This participation even resulted in teaching staff continuing to schedule the class year round in the weekly teaching plan.

Third, the students enrolled in the intervention seemed to enjoy participating. When they were asked to answer a feedback questionnaire about their feelings towards particular challenges and successes with the exercise training program, the following answers appeared. In response to the question about how they feel about the program, most feelings were positive. Some students really enjoyed it and found it a very varied and attractive program. Others were quite satisfied and, for example, one explained her/his feelings as follows: “ It was okay….well I guess exercise is also good for clumsy students like me…”.

Taken together, given that there are no harmful effects and that there is evidence of positive effects on physical health status measures, ongoing physical activity promotion and implementation of exercise training programs in schools are warmly recommended!

6.5 Limitations of the study and recommendations for future research

A number of limitations of different sorts must be outlined. These limitations cover diverse aspects of this study, such as its sample size, measurement related issues and its research design.

Three sample related limitations of the present study should be emphasized: the sample size, the drawing pool of participants and their heterogeneity. First, because of the relatively small sample size, a careful interpretation of the current findings is recommended.

Second, the participating youngsters with AS in this study are drawn from preparatory training or vocational upper secondary education, and therefore might present an atypical selection of adolescents with AS since their adaptive and cognitive skills make it possible to pursue vocational training.

Third, high levels of within group variance were observed in the results, indicating that every single individual has her/his particular and unique profile.

Therefore, studies using multiple tools with larger samples are recommended to further clarify the aspects of motor competence, physical fitness, and atypical sensory processing in individuals with AS.

Besides these sample related draw-backs, it must be further recognized that the findings of the present study are limited by the use of single tests of motor impairment (I), physical fitness (II), and sensory processing (III) and, furthermore, because of the use of some of these tests went beyond their psychometric, well-known terrain. Because tests were modified to better suit the needs of our students (e.g., student's filled out a self-designed online version of the AASP (III)) and others were used beyond its age range (e.g., confirmatory analysis of total motor competence using norms of 16 year olds (I)) careful interpretation is recommended. While this study offered some important reliability and validity evidence for the used measures (e.g., section 4.3.1.2), future research using these measures (especially M-ABC-II and AASP) with adults should continue to address population specific psychometric properties in order to fine-tune these test instruments.

Although the relationship between the senso-motor domain and other important characteristics of AS – such as social interaction, intelligence and communication – was not assessed in this study, ongoing research is crucial to better understand the impact of these abilities in a physical activity environment. Future research could also examine different methods by which senso-motor competencies and activity levels of students with AS could be increased. These could include, but are not limited to, familial considerations, peer tutoring, exercise opportunities, curricular issues, pedagogical issues and last but not least 'social issues' related to welcoming (in many senses of the word) students with AS.

The third issue that should be taken into consideration is that several self-questionnaires were used in this study, such as PARQ/HPA and AASP. While some research evidence has questioned the reliability of self-reporting instruments used with children with AS and HFA (e.g., Loukusa, et al., 2007), this study preferred to get first-hand information from the participants themselves and addressed possible answering errors by allowing participants to ask for clarifications of questions in the questionnaire.

The quasi-experimental design, with a sample of convenience, used in the intervention (IV) offers the advantage of the qualitative data and close support of the principal investigator, but it nevertheless limits scientific generalizability. The logical next step in this line of research is to use a more targeted intervention program that includes both exercise training and theory-based, physical activity motivational strategies to increase not only fitness levels and motor competence, but also long-term leisure-time physical activity. Dose response to exercise and the effect of exercise on academic success are also areas that need further investigation.

Design limitations notwithstanding, the findings of this study provide meaningful information regarding the motor profiles of young adults with AS because it replicated problems in fine and gross motor skills previously found in children (I). The study also provides new information regarding the physical fitness profiles and physical activity habits of adolescents with AS. Adolescents with AS were less physical fit and active than adolescents in the control group (II). Additionally, this study provides meaningful information regarding: the reliability of the use of the AASP with adolescents and adults with AS, the sensory profiles of young adults with AS replicating substantial problems of atypical sensory processing as found in earlier research, and the exploration of sensory profiles over varied levels of motor competence in adolescents with AS (III). It can be concluded from the intervention (IV) in the current study that the exercise training program was effective in promoting motor competence and physical fitness in adolescents with AS. Because many of these adolescents are at risk for physical inactivity and do not meet the recommended physical activity levels for good health, the implementation of extracurricular interventions needs to be encouraged.

6.6 Perspective and recommendations for practice

To put this whole project into perspective, a brief summary of recommendations for practice is provided. In this and previous chapters, some practical tips and tricks for clinical practice have been revealed, both in general and for school settings more specifically. In order to bridge the gap between fundamental scientific research and the everyday clinical practice, a brief overview of these scattered basic teaching strategies for working with youth with AS is provided below, including assessment, instruction, activity selection, and inclusion.

6.6.1 A useful model for assessing the senso-motor domain in youth with Asperger syndrome

The findings of the present study highlight the need for appropriate assessment of the senso-motor domain of youth in adapted physical education. A useful model for assessing the senso-motor domain of children with AS is provided by Reid and O'Connor (2003). Within the model, the teacher examines the interaction of three factors: the individual being assessed, the environment, and the work task.

In order to derive an in-depth understanding of the individual, the teacher should first seek information about the student from different sources, including parents and staff, as well as from, for example, past assessment summaries. Additionally, it is also important to spend time developing a rapport with the students prior to assessing and, when possible, make them acquainted with the test tasks using pictures. In this study, the formal testing was done after the first term to facilitate the formation of a natural professional relationship and enable the teacher to also get first-hand information about the students' specific needs.

This brings us to the second factor that needs to be examined, namely the environment. Knowing that students with AS do have atypical sensory processing and might be over- or under sensitive to certain stimuli, the teacher should provide a working and testing environment with limited distractions, enough 'air' and also opportunity to focus on one task at a time. In the current project the focus on one task at a time was easily achieving by the using a ''first, then"-type book of pictures of the testing tasks. When one task was done, its picture card was put away in the ready box, after which the next task was tackled. Examples of these picture cards are given in Appendix 5.

The third factor of the model is the test task or in other words what you ask the students to do. In this study, young adults with AS were assessed using an (age-)appropriate test battery to gain knowledge about their strengths and challenges in the senso-motor domain. To determine if the task selected is appropriate, the following questions were considered based upon the work of Houston-Wilson (2005): Is the task age-appropriate? Is it functional? Will the information gained assist in the development of IEP goals and objectives? How about in program development and instruction? If the answer to these questions is yes, the task being assessed can be considered appropriate.

Accurate and effective assessment of an individual's senso-motor needs requires in-depth examination of the individual and her/his environments. The following summary, adapted from Myles et al (2000), highlights important considerations that can support effective assessment in physical education:

- Assessment should be carried out over a period of time, since behavior can vary from day to day as well as in different settings and with different people.
- Assess individuals across a variety of settings (e.g., not only in PE, but also in recess, social studies, lunch). A series of brief assessments

that represent students' environments is preferred to one lengthy observation in one environment.

- Observe students at different times of the day (i.e. morning, before or after lunch, afternoon) and in presence of different individuals (e.g., peers, teachers, parents).
- Examine student behavior under varied task demands (i.e. structured or unstructured work, independent or group work) and if possible also in potentially stress-invoking scenarios (i.e., too much verbal instruction, unexpected change in routine, more demanding tasks).
- Use careful informal assessment, in addition to formal assessment tools (such as AASP, M-ABC-II, EUROFIT) to provide valuable information and compare an individual's profile to those of typically developing peers.
- It is preferable to embed this formal assessment into a logical and well-structured session. When small groups are tested during PE this can be, for example, done as a circuit training. The different stations should be well marked and contain all necessary information to be successful (e.g., see Appendix 4 for cards this study used).
- Look for patterns as well as differences of performance across multiple variables (i.e., senses, motor competence, fitness) as these can provide valuable insights for developing interventions.
- Talk to the student and ask the right questions to gain first-hand insights in their specific profiles.
- Interacting with those who have Asperger will be difficult when they are pressured to respond in a fast way or feel pressured for time. To give them a little bit more time to answer your questions is very helpful!
- Assessment should also always include a careful read of the students file, including their developmental and educational history, medical information, and information from therapeutic interventions undertaken.

6.6.2 PE assessment CAN provide vital information of the senso-motor domain

It is evident that the multifaceted nature of the challenges in individuals with AS may require involvement in diagnosis and intervention from a variety of professionals working within different services. While diagnostic assessment tools (such as, for example, the ASDS (Asperger syndrome diagnostic scales, Myles et al., 2000) or the ADI-R (Autism diagnostic interview-revised, Rutter et al., 2003)) used by psychologists or psychiatrists may provide valuable information about the core symptoms of AS, physical education teachers can also provide vital and specific information, especially about the senso-motor domain, to aid the overall assessment process. As reviewed above, PE assessment may include standardized tests of motor competence and physical fitness in addition to background- and standardized questionnaires (e.g., AASP, PARQ/HPA). The use of such specialized tools may help the assessment process, but the role of qualitative, observation-based assessment remains crucial.

Students who participated in this study had an extraordinary range of test scores in the senso-motor domain, extending from above average to far below. Even though limited comparison data are available; this pattern is consistent with previous research and clinical observations (Sahlander, 2008; Attwood, 1998). Even more important, this finding is consistent with what teachers of students with AS report on a daily basis.

With such a wide variability within the group with AS, only knowing that a student has a diagnosis of AS is often of little value in understanding his or her educational strengths and weaknesses and planning an individualized education program (IEP). Moreover, reports by PE professionals, which contain no more than component and subtest scores, without specific interpretations based on observational and accompanying qualitative information, will likely be of little assistance to teachers of students with AS. Of much greater value would be individual item analysis of skills and deficits as determined within each subtest, as well as direct teacher observation of the student while engaged in physical activities. Ideally, this could still be combined with quantitative results of standardized assessments. In that way, teachers would have specific information about the strengths and weaknesses in the senso-motor domain in order to build an effective IEP. In this connection, we do recommend the use of specialized assessments, such as the M-ABC-II, Eurofit and AASP, with adolescents with AS to assess their individualized senso-motor strengths and needs to guide specific recommendations for intervention.

Although some adaptations to the assessments were made in this study (e.g., standardized test intended for a younger population), the findings do support the feasibility of using the MBC-II, Eurofit, and AASP for this group since many participants were identified as being at-risk for motor impairment or had atypical sensory processing patterns. Because of the limited norm referenced instruments in the motor domain for those above the age of 16 years, professionals working with young adults are often challenged in the selection of appropriate measurement instruments. While establishing age norms for adults is certainly a future research objective, we do recommend the 'careful' use of the M-ABC-II for young adults with AS. Together with selected items from the Eurofit, a very comprehensive profile of the students' sensomotor domain can be made. In our view, both tools are valuable in assessing motor abilities for setting up the intervention in clinical practice, either used together or alone. Despite the M-ABC having often been used in studies with people with ASD, the Eurofit also has proven its value in assessing health and skill related fitness, especially because of the functionality of the exercises and their low cost!

6.6.3 Ways to improve exercise training program adherence

To improve program adherence in persons with AS, one must develop an exercise program that is manageable, supportive and tailored to their interests and fitness levels. Too difficult or chaotic activities may discourage future involvement in physical activity. Inspiring students with AS to be active can be achieved by including students in the planning of the PA curriculum as well as listening to their specific reflections on activities. It is important to gather feedback about which parts of the activity did they enjoy most (e.g., warming-up, main part or cooling down) and which particular certain activities at certain places are more favored. For example, our students did not like ice skating "too much" at the large and empty nearby primary school ice field, but they were thrilled skating on the 'for tourists mainly' ice rink in the middle of our capital's city centre. It was not too busy during the daytime, yet attractive as most skaters were beginners and the whole skating area was well structured and organized (e.g., extensive use of pictures and short keywords, provision of information about admission fees and what is included were clearly stated). This certainly helped to facilitate our students as well as international tourists.

The student's "voice" in planning PE

Spontaneous reflections of adolescents with AS on assessment and physical activities may provide teachers with very interesting information that could be useful with regard to their pedagogical and curricular approach. Teachers can increase enjoyment and active participation of all students, including students with AS, in their group by keeping in mind some basic adapted physical education teaching strategies, such as: organizing and structuring events into routines, using language that is clear and to the point, using pictures or visual cues to illustrate the task, being aware of sensory preferences and reducing sensory overload, using prompts and positive reinforcement, and maximizing the active time spent in the physical education class.

In the present study, one week after being assessed, all students with AS voluntarily met the principal investigator for 30 minutes to discuss their test results and discuss their future physical activity goals. During this relaxed one on one conversation, valuable information was shared. For example, most participants reported that they only joined in physical education at school because it was required and would avoid participating if possible. Many have had very negative movement experiences in the past and have viewed themselves as clumsy, uncoordinated; often they were the last ones picked for a team.

One of the consequences of not being good at PE is the exclusion of the individual from some of the most popular games in the playground. Knowing that children with AS have, besides motor coordination difficulties, pervasive challenges to interact successfully with others, the need for early intervention in these areas is very important. Therefore, it is suggested that from as early age as possible parents and caregivers provide tuition and practice in all areas of the motor domain, not to be an exceptional athlete, but to ensure the child has basic motor competence to be included in age appropriate games (e.g., football, judo, swimming or adapted physical activity training programs and camps).

Another commonly stated (negative) aspect of physical education was the reliance on motor competence and not motor improvement to evaluate students' ability made during a term. This type of assessment frequently does not take into account individual differences and uniqueness, and is too performance related (e.g., the time it takes to swim 100 yards or the number of baskets they can make). This competitive environment can be traumatizing for individuals with AS and may result in decreased motivation and lower self-esteem. In our view, in a non-competitive yet stimulating environment, individuals with AS often are focused and engaged in the proposed activities whether in inclusive general PE or adapted PE. It is crucial that instructors who work with people with AS focus on their strengths rather than their weaknesses. This 'ability first' approach is an important step in establishing a respectful and long-lasting working relationship because it may lead to lifelong participation in physical activity.

Importance of stimulating healthy exercise habits

Stimulating healthy exercise habits and reinforcing positive physical activity as early in life as possible could contribute to regular participation in physical activities. This can be achieved by working with not only the students, but with the whole family to encourage engaging in fun physical activities together. Going for a swim, biking together, even a 15 min stretching session or a morning walk, are strongly recommended. Such bouts of physical activities could easily be built into the daily schedule of the whole family. Another way to stimulate exercise habits is to give the adolescents a choice of age appropriate fun activities, according to what their peers would be interested in since this drives motivation. This could include a wide range of activities ranging from basic walking or swimming to less known activities such as fencing, canoeing, orienteering, and rock climbing. Even technology-based physical activities, such as Wii boxing or tennis, may be beneficial to increase fun physical activity. Tailor made instructional strategies, such as using pictures, giving extra slow-motioned demonstration of the activity, or adapting an activity to increase success could also facilitate exercise adherence. All these together could lead to a greater appreciation of exercise, health benefits, and, as well, contribute to maximal community participation such as employment and independent living as an adult. Physical activities can, in our view, also be a way to 'burn off energy' and of achieving, mental as well as physical health. For example, it is a constructive way of expressing agitation, especially for those with AS who have emotion management difficulties.

6.6.4 How to help students with AS become more successful in PE

In (physical) education half the battle of individualizing instruction is to understand the student as thoroughly as possible. To help students with AS become more successful in an exercise environment, we urge practitioners to consider the following ideas (summarized from I & IV, Groft and Block, 2003; Houston-Wilson, 2005) when individualizing instruction for students with AS:

- Minimize any fine and gross motor clumsiness exhibited in youth with AS by working on individual skill components through one-on-one instruction, small group drills, and lead-up games with modifications rather than competitive games.
- Minimize sensory overload as sensory sensitivities are the rule rather than the exception. Time and space should be well organized and structured to increase active participation. The use of visual cues (in conjunctions with auditory cues) also allows the student to participate with minimal stress, which results in more compliant behavior.
- Be aware that students with AS often have a high level of intelligence with poor concentration skills; therefore, give them tasks to do that are simple and easy to remain on-task, but still challenging enough to stay motivated.
- Youth with AS typically have significant social challenges. They need direct instruction concerning appropriate social skills, social stories to help them understand new situations, and positive reinforcement when they respond appropriately.
- Understand that youngsters with AS may have preoccupations with abnormal interests; therefore, create (every now and then) short periods of time (a few minutes) for discussion of their specific interests.
- Youngsters with AS often have a rich expressive language but have challenges using this language in social settings. Therefore, be prepared to teach also appropriate social skills, and then create natural opportunities to practice and use these newly learned skills appropriately.

Based upon clinical experience, an increase in active physical exercise time during PE can be achieved by including key strategies such as: providing choice of developmentally appropriate physical activities, using cooperative games and activities that include all students, engaging in activities that cater to the needs and interests of all students, and making exercise enjoyable and fun. Moreover, the students who were interviewed about their experiences with the home program proposed similar strategies themselves. In their view, “fun physical exercise” rules!

6.6.5 Activity selection for youth with AS

All individuals should have the opportunity to explore as wide range of physical activities as possible. Selection of activities should always start from the needs and interests of the students (and their families). Where often activities in solitude such as swimming, biking, walking, bowling, or fencing are preferred because of their relative high probability for success, the students of this study also really enjoyed playing modified team sports. For example, when asked about which parts of the exercise program our students with AS liked the most, the common answer was the extra PE class held after school (with a very high attendance rate). The second most popular was the voluntary aerobic exercise, and the least popular was the personal exercise program. The students' preference for the group exercise training was somewhat surprising, since in earlier research (II) it was concluded that generally students with AS tend to opt for activities in solitude. It seems that when exercise training programs are group- and tailor-made, enjoyment of the exercise can be achieved more easily. At the same time, other important skills for students with AS, like social and group skills, can be worked on.

6.6.6 Recommendations for (physical) education

Although not all adolescents with AS display atypical sensory processing and motor difficulties, these types of challenges are prevalent in this population and are reported to interfere with performance in many broader developmental and functional domains. Therefore, educational programs for youth with AS need to incorporate appropriately structured physical and sensory environments that accommodate these unique sensory processing patterns and provide a wide range of opportunities for developmentally appropriate senso-motor experiences within the context of functional educational goals. Because many adolescents with AS do have lower motor competence, physical fitness, and activity levels than is recommended for good health, increased opportunities for extracurricular interventions need to be encouraged. Perhaps physical exercise programming for those with AS would have a wider appeal and application, if it were embedded in the broader context of positive behavioral and psychological change. To date the mechanism behind these broader improvements is not clear and further research is needed. From a clinical perspective, perhaps the most important areas for future research involve the evaluation of different procedures used to teach and maintain exercise, and an increase in understanding by which exercise positively influences behaviors. Given the limited scientific basis of many of the exercise intervention approaches for people with ASD, a rather conservative approach is recommended for prescribing specific senso-motor trainings. Best practice would suggest that the decision be made on an individualized clinical basis by an expert professional. According to Baranek (2002), treatments are recommend to be provided in shorter-term increments (e.g., 6 to 12 weeks) and progress documented in a systematic manner. Treatments should be adapted or discontinued if effects are not apparent within an expected time frame or if negative reactions are documented. It needs to be stipulated that exercise programs should be continued for a 'long enough' time to facilitate learning.

7 MAIN FINDINGS AND CONCLUSIONS

The present study on adolescents with Asperger syndrome provided new insights into their motor competence, physical- fitness and activity, and sensory processing, and into the effect of an exercise training program on motor competence and physical fitness. The results indicate that adolescents with AS performed motor competence and physical fitness tasks at a remarkably lower level than their peers, and that they were also less physically activity in leisure time and showed atypical sensory processing. Additionally, the results indicate the effectiveness of the exercise training program as motor competence and physical fitness improved over time.

On the basis of the results and within the limitations of the study, the research questions presented in the study aims (pages 30-31) are answered as follows:

1. **What is the motor profile of adolescents with Asperger Syndrome?** Young adults with AS performed motor tasks involving manual dexterity, balance, and ball skills at a remarkably lower level than their peers. They continued to demonstrate motor delays over age, even though motor competencies of individuals with AS seemed to improve after the adolescent years. The use of the M-ABC-II is recommended for young adults with AS as a valuable tool in assessing motor skills for setting up the intervention in educational and clinical practice.

2. **What is the fitness profile of adolescents with Asperger Syndrome?** Adolescents with AS scored significantly lower than the comparison group on all physical fitness subtests, including balance, coordination, flexibility, muscular strength, running speed and cardio-respiratory endurance. Adolescents with AS were also less physically active than their neurotypical developing peers. Engagement in physical activities is therefore warmly recommended.

3. **What is the sensory profile of adolescents with Asperger syndrome?**
   Differences in sensory processing between groups with and without AS were found on overall sensory processing as well as on three of the four sensory quadrants (low registration, sensation seeking, and sensation avoidance). Further analysis revealed that almost 50% of the group with AS reported extreme levels of sensory processing and that large variability was found within the group with AS. Differences in sensation seeking behavior of the sensory profile between the motor competence groups with AS were also found. The preliminary findings of the current investigation highlight the need for further study of role of sensory processing in motor (in)coordination in individuals with AS.

4. **What is the effect of an exercise training program on motor competence and physical fitness in adolescents with Asperger syndrome?**
   The exercise training program, as part of an ongoing vocational training program for adolescents with Asperger syndrome, was successful and indicated improved motor competence and physical fitness that was sustained over time. Implementation of similar programs is therefore recommended.

The information obtained from this study, in addition to contributing to the present knowledge about Asperger syndrome per se, can be further applied in the assessment and implementation of exercise training for individuals with special needs. Careful implementation of similar programs is recommended because the structured exercise training program was effective in improving skill levels and enjoyment in physical activity.

TIIVISTELMÄ (FINNISH SUMMARY)

Aspergerin oireyhtymä (AS) on saanut nimensä itävaltalaisen lastenlääkäri Hans Aspergerin mukaan. Oireyhtymä kuuluu autismin kirjoon, ja se on laaja-alainen neurologinen kehityshäiriö, jota luonnehtivat autismin tavoin sosiaalisen vuorovaikutuksen poikkeavuudet, omissa oloissa viihtyminen, puheen merkityssisältöjen ymmärtäminen vaikeudet, yksipuoliset ja kapea-alaiset mielenkiinnon kohteet tai harrastukset sekä rutiineihin juuttuminen. Varhaislapsuuden autismista poiketen Aspergerin oireyhtymässä ei ilmene merkittäviä kielen tai älyllisen kehityksen viivästymiä. AS-nuoren lahjakkuus ja samanaikaisesti sosiaalisen vuorovaikutuksen heikkous hämmästyttää ympäristöä. Pojilla oireyhtymää esiintyy tyttöjä enemmän, mutta varsinkin murrosiässä tyttöjen osuus kasvaa merkittävästi. Suomessa tehdyssä kartoitustutkimuksessa Aspergerin oireyhtymää esiintyi 0,4%:lla 8-vuotiaiden lasten ikäryhmässä (N=4422) (Mattila et al., 2007).

AS todetaan usein vasta koulussa, missä sosiaalisien haasteiden lisäksi motorinen kömpelyys ja hienomotoriikan puutteellisuus huomataan. Vaikka motorinen kömpelyys on yleistä oireyhtymässä, niin se ei kuitenkaan ole diagnoosin edellytys. Aspergerin oireryhmään liittyy usein myös aistitoimintojen poikkeavuutta ja aistitiedon käsittelyn vaikeutta, jotka voivat hankaloittaa esimerkiksi liikuntaryhmiin osallistumista. Erilaisuus voi ilmetä kaikilla aistialueilla ja sen piirteet vaihtelevat yksilöiden välillä ja voivat myös vaihdella yksilöllä eri aikoina. Aistien toiminta voi olla yliherkkää, jolloin henkilö reagoi pieneenkin ärsykkeeseen, tai se voi olla myös aliherkkää, jolloin esimerkiksi kipukynnys on erittäin korkea. Henkilön poikkeava reagointi fyysiseen kosketukseen, kirkkaaseen valoon, kylmään, hajuihin, meluun tai kipuun voivat aiheuttaa suuria haasteita opetustilanteissa.

Liikunnan opetuksessa tulisi paremmin huomioida AS-nuorten mahdolliset sensomotoriset tarpeet, koska tiedonpuutteen vuoksi heidät saatetaan leimata helposti käytöshäiriöisiksi tai ns. vaikeiksi oppilaiksi. Yksilöllisyyden huomioimisella voidaan paremmin tukea heitä löytämään keinoja ja toimintastrategioita oman liikunta-aktiivisuuden, fyysisen kunnon ja liikehallinnan kehittämiseksi.

Vaikka AS-aiheesta on tehty monia tutkimuksia ja tietoa löytyy varsinkin sosiaalisesta, tunne-elämästä, kognitiivisista ja kielellisistä kyvyistä (Smith, 2000), tämä edellä mainittu sensomotorinen osa-alue on jäänyt vähemmälle huomiolle. Sensomotoriikan haasteita, kuten käsin kirjoittamisen ongelmaa, toiminnanohjauksen vaikeuksia, huonoa fyysistä kuntoa ja poikkeavaa reagointia aistiärsykkeisiin on kirjallisuudessa käsitelty harvoin ja niiden yhteisvaikutuksista on saatavilla niukasti tutkittua tietoa. Sensomotorisen alueen huomioiminen on tärkeää, koska fyysisen kunnon parantuminen ja aktiivisuuden tason lisääntyminen tehokkaalla harjoittelulla parantaa AS-nuorten selviytymistä arjessa ja sopeutumista yhteiskuntaan.

Tämän tutkimuksen tavoitteena oli selvittää AS-nuorten sensomotorista profiilia vertailemalla nuorten motorisia taitoja, fyysistä kuntoa ja aktiivisuutta sekä aistien käsittelyä samanikäisten ja samaa sukupuolta olevien verrokkiryhmien kanssa. Lisäksi tutkittiin mikä vaikutus tehokkaalla liikuntaohjelmalla on AS-nuorten motoriseen suoriutumiseen ja fyysiseen kuntoon ammattiopintoihin valmentavan koulutuksen aikana. Tutkimuksesta on julkaistu neljä tieteellistä artikkelia (I-IV), ja tämä väitöskirja on yhteenveto koko tutkimusprojektista.

Tutkimus oli kaksivaiheinen. Ensimmäisessä vaiheessa kartoitettiin mahdollisimman tarkasti AS-nuorten motorinen profiili, jotta ymmärretään paremmin heidän aistiensa erilaisuus (osajulkaisut I-III). Ensimmäinen osavaihe koostui kolmesta isommasta kokonaisuudesta, jotka olivat motorinen taso (I), fyysinen kunto ja aktiivisuus (II) ja aistit (III). Tämä vaihe oli tärkeä, koska näin saatiin tietoa nuorten yksilöllisistä taidoista, tarpeista sekä haasteista, ja pystyttiin soveltamaan liikunnan opetusmenetelmiä AS-nuorille.

Toisessa vaiheessa toteutettiin tutkimus, jossa selvitettiin fyysisen liikuntaohjelman vaikutuksia AS-nuorten motoriseen kykyyn ja fyysiseen kuntoon (osajulkaisu IV). Tutkittavat AS-nuoret satunnaistettiin koe- ja kontrolliryhmiin. Koeryhmä toteutti jaksotetun 12 viikkoa kestävän fyysis-motorisen harjoitteluohjelman, joka sisälsi kolme tunnin pituista harjoittelukertaa viikossa koululiikuntatuntien lisäksi. Kerran viikossa oli kuvallinen kuntopiiri kotona, toinen harjoittelukerta oli ylimääräinen ohjattu liikuntatunti heti koulun jälkeen, ja kolmas kerta tunnin mittainen itsenäisesti valittu aerobinen harjoitteluohjelma. Kontrolliryhmä osallistui vain koulun lukujärjestyksen mukaiseen liikunnanopetukseen. Harjoitteluohjelman alkaessa tehtiin kirjallinen harjoittelusopimus, jolla nuori sitoutui ohjelmaan. Henkilö täytti myös harjoittelupäiväkirjaa jakson aikana, ja sitä käytiin läpi nuoren kanssa viikoittain. Tutkimukseen liittyvät kyselyt ja testaukset tehtiin harjoittelujakson alussa, lopussa ja kolme kuukautta jakson loppumisen jälkeen.

Tulokset osoittivat, että AS-nuoret selviytyvät motorista kykyä ja fyysistä kuntoa mittaavissa tehtävissä verrokkiryhmän ikätovereitaan selvästi huonommin (I-II). AS-nuoret saivat heikommat pisteet kaikista motorisista osatesteistä, joihin kuuluivat sorminäppäryys, tasapaino, pallotaidot, koordinaatio, notkeus, lihasvoima, juoksunopeus sekä aerobinen kunto. Tulokset osoittivat motorista viivettä ikätasoon nähden. Motorinen heikkous näkyy usein vielä aikuisuudessakin, vaikka taidot voivat parantua aktiivisen harjoittelun avulla. AS-nuoret harrastivat myös vähemmän liikuntaa, ja he suosivat usein yksilölajeja, kuten kävelyä, pyöräilyä ja uintia. Pienryhmälajit, kuten sulkapallo, keilailu sekä kiipeily, olivat suositumpia kuin liikkuminen isossa ryhmässä. Syy valintaan on eräällä tavalla looginen: lajit ovat rytmikkäitä, tiettyä liikesarjaa toistavia ja tutun kaavan mukaan toimivia. Nämä yksilölajit olivat myös vähemmän kilpailuhenkisiä ja tietyllä tasolla ennakoitavia.

Aistiprosessoinnissa (III) oli eroavaisuuksia AS- ja verrokkiryhmien välillä. AS-nuorilla näytti olevan vähemmän aistihakuisuutta, enemmän aistimuksia välttelevää käyttäytymistä ja heikompaa aistitiedon rekisteröintiä kuin verrokkiryhmällä. Jatkoanalyysissä kävi ilmi, että puolella AS-ryhmästä oli hyvin omalaatuista ja erittäin poikkeavaa aistiprosessointia, joka vaikuttaa arkielämään. Lisäksi havaittiin, että opiskelijoilla, joilla oli motorista heikkoutta, näytti olevan vielä vähemmän aistihakuisuutta kuin muilla AS-nuorilla. Tämä vaikutti heidän aktiivisuuteensa liikuntatilanteissa.

Kolmen kuukauden mittainen hyvin strukturoitu liikuntaohjelma oli onnistunut ja osoitti, että nuorten motorisia taitoja on mahdollista kehittää ja fyysistä kuntoa parantaa (IV). Motoriset ja fyysiset vaikutukset olivat pysyviä ainakin seurantamittaukseen asti. AS-nuorten liikuntaryhmän ohjauksessa yksilölliset piirteet ja tarpeet on huomioitava, ja ohjaaja joutuu selkeyttämään toimintaohjeita ja hyödyntämään visuaalisia ohjeita, kuten kuvia ja tekstejä. Tutkimustuloksista tehtiin seuraavia johtopäätöksiä AS-nuorten ohjaamiseen: Liikuntatilanteissa on tärkeää turvallisen ja strukturoidun ympäristön luominen, mutta toisaalta vähintään yhtä tärkeää on totutuista käytänteistä ja toiminnoista ´hallitusti´ poikkeaminen. Pienryhmäopetukseen pitäisi sisällyttää uusia ja kiinnostavia liikuntaharrastuksia ja aistiärsykkeitä, jotka ylittävät nuorten ärsykekynnyksen ja motivoivat heitä liikkumaan.

Tuloksia täytyy kuitenkin tulkita tietyllä varauksella, koska otos oli suhteellisen pieni (N=30). Kuitenkin nämä tutkimustulokset osoittavat, että on tarpeellista tutkia ja ymmärtää AS-henkilöiden sensomotorisia erityispiirteitä. Tulevaisuuden tavoitteena on laatia vielä tarkemmat toimintaohjeet opettajille ja ohjaajille tähän tutkimustietoon pohjautuen.

Yhteenvetona voidaan todeta, että AS-nuorten motoriikka on usein kömpelöä ja sen lisäksi aistitiedon käsittely voi olla hyvin erilaista, minkä vuoksi nuoret harvemmin innostuvat koululiikunnasta. Tehokkaalla liikuntaohjelmalla saadaan kuitenkin kohotettua motorisia taitoja ja fyysistä kuntoa. Nuoret pitivät liikkumisesta, jos se oli heille sopivalla tavalla räätälöityä. AS-nuorten kohdalla tämä tarkoittaa, että liikunnan painopiste tulisi olla liikunnan ilossa, onnistumisen elämyksissä sekä (sensomotorisen) itsetunnon kehittämisessä. AS-nuoret kaipaavat selkeyttä ja johdonmukaisuutta liikuntatunnille, missä tuttujen asioiden lisäksi on kuitenkin vaihtelua ja uusia piristyksiä. Liikuntatunnilla on annettava selkeää ja yksinkertaista verbaalista ohjeistusta, mitä tehostetaan näyttämällä opiskelijoille sekä mallisuoritus että tarvittaessa tehtäväkorttikuvaus.

Tutkimuksessa käytetty arviointisalkku, johon kuuluvat Movement ABC-II, Sensory Profile, Eurofit sekä nuorten fyysisen aktiivisuuden taustakysely, todettiin luotettavaksi mittariksi Asperger-nuorille ja sen käyttöä suositellaan sensomotorisen kartoituksen osana. Tässä tutkimuksessa toteutettua liikuntaohjelmaa voidaan hyödyntää käytännössä myös muiden samantyyppistä tukea tarvitsevien nuorten kanssa.

Aspergerin oireyhtymä on viime aikoina saanut julkisuudessa paljon huomiota. Tiedon karttuminen lisää AS-nuorten ainutlaatuisuuden ymmärtämistä ja heidän huomioimistaan. Tämä tutkimus tuo tietoa Aspergerin oireyhtymään liittyvistä erityispiirteistä ja liikunnan mahdollisuuksista tukea AS-nuorten kasvua ja kehitystä.

REFERENCES

Adam, C., Klissouras, V., Ravazzolo, M., Renson, R., & Tuxworth, W. (1988). *Eurofit: European test of physical fitness*: Council of Europe, Committee for the Development of Sport Rome, Italy.

American Educational Research Association (AERA), A. P. A., National Council on Measurement in Education. (1999). *Standards for educational and psychological testing.* Washington: American Educational Research Association.

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders (DSM-IV)* (4th ed.). Washington DC: American Psychiatric Association.

American Psychiatric Association (2000). *Diagnostic and Statistical Manual of Mental Disorders, 4th edition (Text Revision)*. Washington, DC: American Psychiatric Association.

Asperger, A. (1991, [1944]). Autistic psychopathy in childhood. In U. Firth (Ed.), *Autism and Asperger Syndrome* (pp. 37-92): Cambridge: Cambridge University Press.

Asperger, H. (1944). Die autistischen Psychopaten im Kindersalter. *Archiv fur Psychiatrie und Nervenkrankheiten* (Vol. 177, pp. 76-137).

Attwood, T. (1998). *Asperger's syndrome : a guide for parents and professionals*. London ; Philadelphia: Jessica Kingsley Publishers.

Attwood, T. (2007). *The complete guide to Asperger syndrome*. London: Jessica Kingsley Publishers.

Baecke, J. A., Burema, J., & Frijters, J. E. (1982). A short questionnaire for the measurement of habitual physical activity in epidemiological studies. *The American Journal Of Clinical Nutrition, 36*, 936-942.

Baird, G., Simonoff, E., Pickles, A., Chandler, S., Loucas, T., Meldrum, D., et al. (2006). Prevalence of disorders of the autism spectrum in a population cohort of children in South Thames: the Special Needs and Autism Project (SNAP). *Lancet, 368*, 210-215.

Baranek, G. T. (1999). Autism during infancy: a retrospective video analysis of sensory-motor and social behaviors at 9-12 months of age. *Journal of Autism and Developmental Disorders, 29*, 213-224.

Baranek, G. T. (2002). Efficacy of sensory and motor interventions for children with autism. *Journal of Autism and Developmental Disorders, 32*, 397-422.

Baranek, G. T., Boyd, B. A., Poe, M. D., David, F. J., & Watson, L. R. (2007). Hyperresponsive sensory patterns in young children with autism, developmental delay, and typical development. *American Journal of Mental Retardation, 112*, 233-245.

Ben-Sasson, A., Cermak, S. A., Orsmond, G. I., Tager-Flusberg, H., Kadlec, M. B., & Carter, A. S. (2008). Sensory clusters of toddlers with autism spectrum disorders: differences in affective symptoms. *Journal of Child Psychology & Psychiatry, 49*, 817-825.

Ben-Sasson, A., Hen, L., Fluss, R., Cermak, S., Engel-Yeger, B., & Gal, E. (2009). A Meta-Analysis of Sensory Modulation Symptoms in Individuals with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders, 39*, 1-11.

Berkeley, S., Zittel, L., Pitney, L., & Nichols, S. (2001). Locomotor and object control skills of children diagnosed with autism. *Adapted Physical Activity Quarterly, 18*, 405-416.

Bouffard, M., Watkinson, E. J., Thompson, L. P., Dunn, J. L. C., & Romanow, S. K. E. (1996). A test of the activity deficit hypothesis with children with movement difficulties. *Adapted Physical Activity Quarterly, 13*, 61-73.

Brown, C., & Dunn, W. (2002). *Adolescent/Adult Sensory Profile - User's Manual*. San Antonio: The Psychological Corporation.

Bruininks, R. H. (1978). *Bruininks-Oseretsky Test of Motor Proficiency- Owner's Manual*. Circle Pines, MN: American Guidance Service.

Chen, Y.-H., Rodgers, J., & McConachie, H. (2009). Restricted and repetitive behaviours, sensory processing and cognitive style in children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 39*, 635-642.

Cohen, J. (1988). *Statistical power for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Erlbaum.

Crane, L., Goddard, L., & Pring, L. (2009). Sensory processing in adults with autism spectrum disorders. *Autism: The International Journal of Research & Practice, 13*, 215-228.

Dawson, G., & Watling, R. (2000). Interventions to facilitate auditory, visual, and motor integration in autism: a review of the evidence. *Journal of Autism and Developmental Disorders, 30*, 415-421.

Dickie, V. A., Baranek, G. T., Schultz, B., Watson, L. R., & McComish, C. S. (2009). Parent reports of sensory experiences of preschool children with and without autism: a qualitative study. *American Journal of Occupational Therapy, 63*, 172-181.

Dunn, W., Myles, B. S., & Orr, S. (2002). Sensory processing issues associated with Asperger syndrome: a preliminary investigation. *American Journal of Occupational Therapy, 56*, 97-102.

Dunn, W., Saiter, J., & Rinner, L. (2002). Asperger Syndrome and Sensory Processing: A Conceptual Model and Guidance for Intervention Planning. *Focus on Autism and Other Developmental Disabilities, 17*, 172-185.

Dunn, W., & Westman, K. (1997). The sensory profile: the performance of a national sample of children without disabilities. *American Journal of Occupational Therapy, 51*, 25-34.

Dyck, M. J., Piek, J. P., Hay, D. A., & Hallmayer, J. F. (2007). The Relationship Between Symptoms and Abilities in Autism. *Journal of Developmental and Physical Disabilities, 19*, 251-261.

Ehlers, S., Gillberg, C., & Wing, L. (1999). A screening questionnaire for Asperger syndrome and other high-functioning autism spectrum disorders in school age children. *Journal of Autism and Developmental Disorders, 29*, 129-141.

Elliott, R. O., Jr., Dobbin, A. R., Rose, G. D., & Soper, H. V. (1994). Vigorous, aerobic exercise versus general motor training activities: effects on maladaptive and stereotypic behaviors of adults with both autism and mental retardation. *Journal of Autism and Developmental Disorders, 24*, 565-576.

Epstein, T., Saltzman-Benaiah, J., O'Hare, A., Goll, J. C., & Tuck, S. (2008). Associated features of Asperger Syndrome and their relationship to parenting stress. *Child: Care, Health and Development, 34*, 503-511.

Faber, I. R., & Nijhuis van der Sanden, M. W. G. (2004). The Movement Assessment Battery for Children. Standardisation and reliability of Age Band 5: young adults. In L. Henderson, D. Sugden & A. Barnett (Eds.), *The Movement Assessment Battery for Children-2*. (2007 ed.). London: Pearson Assessment.

Fombonne, E. (2003). Epidemiological surveys of autism and other pervasive developmental disorders: an update. *Journal of Autism and Developmental Disorders, 33*, 365-382.

Fombonne, E. (2009). Epidemiology of pervasive developmental disorders. *Pediatric Research*.

Freitag, C. M., Kleser, C., Schneider, M., & von Gontard, A. (2007). Quantitative assessment of neuromotor function in adolescents with high functioning autism and Asperger syndrome. *Journal of Autism and Developmental Disorders, 37*, 948-959.

Frith, U. (1991). *Autism and Asperger syndrome*. Cambridge: Cambridge University Press.

Gepner, B., & Mestre, D. R. (2002). Brief report: postural reactivity to fast visual motion differentiates autistic children from children with Asperger's syndrome. *Journal of Autism and Developmental Disorders, 32*, 231-238.

Ghaziuddin, M., & Butler, E. (1998). Clumsiness in autism and Asperger syndrome: a further report. *Journal of Intellectual Disability Research, 42*, 43-48.

Gillberg, C., & Coleman, M. (1992). *The biology of the autistic syndromes*. London: MacKeith Press.

Gillberg, C., & Gillberg, I. C. (1989). Asperger syndrome-Some epidemiological considerations: A research note. *Journal of Child Psychology & Psychiatry, 30*, 631-638.

Green, D., Baird, G., Barnett, A. L., Henderson, L., Huber, J. W., & Henderson, S. E. (2002). The severity and nature of motor impairment in Asperger Syndrome. . *Journal of Child Psychology and Psychiatry, 45*, 655-668.

Griswold, D. E., Barnhill, G. P., Myles, B. S., Hagiwara, T., & Simpson, R. L. (2002). Asperger Syndrome and Academic Achievement. *Focus on Autism & Other Developmental Disabilities, 17*, 94.

Groft, M., & Block, M. E. (2003). Asperger syndrome: Implications for physical education and sport. *Journal of Physical Education, Recreation, and Dance, 74*, 31-34.

Hands, B., & Larkin, D. (2006). Physical fitness differences in children with and without motor learning difficulties. *European Journal of Special Needs Education, 21*, 447-456.

Henderson, S., & Sugden, D. (1992). *The movement assessment battery for children*. London: The Psychological Corporation.

Henderson, S., Sugden, D., & Barnett, A. L. (2007). *Movement Assessment Battery for Children-2*. London: Pearson Assessment.

Hertogh, E. M., Monninkhof, E. M., Schouten, E. G., Peeters, P. H., & Schuit, A. J. (2008). Validity of the modified Baecke questionnaire: comparison with energy expenditure according to the doubly labeled water method. *International Journal of Behavioral Nutrition and Physical Activity, 5*, 30-36.

Hilton, C., Graver, K., & LaVesser, P. (2007). Relationship between Social Competence and Sensory Processing in Children with High Functioning Autism Spectrum Disorders. *Research in Autism Spectrum Disorders, 1*, 164-173.

Hoksbergen, R., Laak, J., Rijk, K., van Dijkum, C., & Stoutjesdijk, F. (2005). Post-Institutional Autistic Syndrome in Romanian Adoptees. *Journal of Autism and Developmental Disorders, 35*, 615-623.

Houston-Wilson, C. (2005). Pervasive developmental disorders. In J. P. Winnick (Ed.), *Adapted physical education and sport* (pp. 173-187). Champaign,IL: Human Kinetics.

Huettig, C., & O'Connor, J. (1999). Wellness programming for young children with disabilities. *Teaching Exceptional Children, 31*, 12-19.

Jasmin, E., McKinley, P., Reid, G., & Fombonne, E. (2009). Sensori-motor and Daily Living Skills of Preschool Children with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders, 39*, 231-241.

Kern, J. K., Garver, C. R., Carmody, T., Andrews, A. A., Trivedi, M. H., & Mehta, J. A. (2007). Examining Sensory Quadrants in Autism. *Research in Autism Spectrum Disorders, 1*, 185-193.

Kern, J. K., Garver, C. R., Grannemann, B. D., Trivedi, M. H., Carmody, T., Andrews, A. A., et al. (2007). Response to Vestibular Sensory Events in Autism. *Research in Autism Spectrum Disorders, 1*, 67-74.

Kern, J. K., Trivedi, M. H., Garver, C. R., Grannemann, B. D., Andrews, A. A., Savla, J. S., et al. (2006). The pattern of sensory processing abnormalities in autism. *Autism, 10*, 480-494.

Kientz, M. A., & Dunn, W. (1997). A comparison of the performance of children with and without autism on the Sensory Profile. *American Journal of Occupational Therapy, 51*, 530-537.

Klin, A., Volkmar, F. R., Sparrow, S. S., Cicchetti, D. V., & Rourke, B. P. (1995). Validity and neuropsychological characterization of Asperger syndrome: convergence with nonverbal learning disabilities syndrome. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 36*, 1127-1140.

Lang, R., Koegel, L. K., Ashbaugh, K., Regester, A., Ence, W., & Smith, W. Physical exercise and individuals with autism spectrum disorders: A systematic review. *Research in Autism Spectrum Disorders, In Press, Corrected Proof*.

Largo, R., Fischer, J., & Caflisch, J. (2002). *Zurcher Neuromotorik*. Zurich: AWE-Verlag.

Lopata, C., Hamm, E. M., Volker, M. A., & Sowinski, J. E. (2007). Motor and visuomotor skills of children with Asperger's disorder: preliminary findings. *Perceptual and Motor Skills, 104*, 1183-1192.

Loukusa, S., Leinonen, E., Kuusikko, S., Jussila, K., Mattila, M. L., Ryder, N., et al. (2007). Use of context in pragmatic language comprehension by children with Asperger syndrome or high-functioning autism. *Journal of Autism and Developmental Disorders, 37*, 1049-1059.

Mac Donncha, C., Watson, A. W. S., McSweeney, T., & O'Donovan, D. J. (1999). Reliability of Eurofit physical fitness items for adolescent males with and without mental retardation. *Adapted Physical Activity Quarterly, 16*, 86-95.

Manjiviona, J., & Prior, M. (1995). Comparison of Asperger syndrome and high-functioning autistic children on a test of motor impairment. *Journal of Autism and Developmental Disorders, 25*, 23-39.

Mattila, M. L., Hurtig, T., Haapsamo, H., Jussila, K., Kuusikko-Gauffin, S., Kielinen, M., et al. (2010). Comorbid Psychiatric Disorders Associated with Asperger Syndrome/High-functioning Autism: A Community- and Clinic-based Study *Journal of Autism and Developmental Disorders, Feb 23. [Epub ahead of print]*.

Mattila, M. L., Kielinen, M., Jussila, K., Linna, S. L., Bloigu, R., Ebeling, H., et al. (2007). An epidemiological and diagnostic study of Asperger syndrome according to four sets of diagnostic criteria. *Journal of the American Academy of Child and Adolescent Psychiatry, 46*, 636-646.

Menzinger, B., & Jackson, R. (2009). The effect of light intensity and noise on the classroom behaviour of pupils with Asperger syndrome. *Support for Learning, 24*, 170-175.

Milne, E., Swettenham, J., Hansen, P., Campbell, R., Jeffries, H., & Plaisted, K. (2002). High motion coherence thresholds in children with autism. *Journal of Child Psychology and Psychiatry, 43*, 255-263.

Miyahara, M., Tsujii, M., Hori, M., Nakanishi, K., Kageyama, H., & Sugiyama, T. (1997). Brief report: motor incoordination in children with Asperger syndrome and learning disabilities. *Journal of Autism and Developmental Disorders, 27*, 595-603.

Molloy, C., Dietrich, K., & Bhattacharya, A. (2003). Postural stability in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 33*, 643-652.

Mostofsky, S. H., Dubey, P., Jerath, V. K., Jansiewicz, E. M., Goldberg, M. C., & Denckla, M. B. (2006). Developmental dyspraxia is not limited to imitation in children with autism spectrum disorders. *Journal of the International Neuropsychological Society, 12*, 314-326.

Myles, B. S., Hagiwara, T., Dunn, W., Rinner, L., Reese, M., Huggins, A., et al. (2004). Sensory issues in children with Asperger syndrome and autism. *Education and Training in Developmental Disabilities, 39*, 283-290.

Myles, B. S., & Simpson, R. L. (2001). *Asperger syndrome: A guide for educators and practitioners* (2nd ed.). Austin, TX: Pro-Ed.

Myles, B. S., Tapscott Cook, K., Miller, N. E., Rinner, L., & Robbins, L. A. (2000). *Asperger syndrome and sensory issues - Practical solutions for making sense of the world*. Kansas: Autism Asperger Publishing Co.

Nelson, C. M., & Rutherford, R. B. (1998). Behavioral interventions with behaviorally disordered students. In M. D. Wang, C. Reynolds & H. J. Walberg (Eds.), *Handbook of special education: Research and practice.* (Vol. 2, pp. 125-153). New York: Pergamon Press.

Newschaffer, C. J., Croen, L. A., Daniels, J., Giarelli, E., Grether, J. K., Levy, S. E., et al. (2007). The epidemiology of autism spectrum disorders. *Annual Review of Public Health, 28*, 235-258.

Newson, E., Dawson, M., & Everaard, T. (1994). The natural history of able autistic people: Their management and functioning in a social context. *Communcation*, 19-21.

Nieminen-von Wendt, T., Paavonen, J. E., Ylisaukko-Oja, T., Sarenius, S., Kallman, T., Jarvela, I., et al. (2005). Subjective face recognition difficulties, aberrant sensibility, sleeping disturbances and aberrant eating habits in families with Asperger syndrome. *BMC Psychiatry, 5*, 20-20.

Noterdaeme, M., Wriedt, E., & Hoehne, C. (2010). Asperger's syndrome and high-functioning autism: language, motor and cognitive profiles. *European Child and Adolescent Psychiatry, 19*, 475-481.

O'Brien, J. C., Williams, H. G., Bundy, A., Lyons, J., & Mittal, A. (2008). Mechanisms that underlie coordination in children with developmental coordination disorder. *Journal of Motor Behavior, 40*, 43-61.

O'Connor, J., French, R., & Henderson, H. (2000). Use of physical activity to improve behavior of children with autism--Two for one benefits. *Palaestra, 16*, 22-29.

Oja, P., & Tuxworth, B. E. (1995). *Eurofit for adults: A test battery for the assessment of the health-related fitness of adults*: Council of Europe, Committee for the Development of Sport.

Pan, C., & Frey, G. C. (2006). Physical activity patterns in youth with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 36*, 597-606.

Peters, J. M., & Wright, A. M. (1999). Development and evaluation of a group physical activity programme for children with developmental co-ordination disorder: An interdisciplinary approach. *Physiotherapy Theory & Practice, 15*, 203-216.

Philippaerts, R. M., & Lefevre, J. (1998). Reliability and validity of three physical activity questionnaires in Flemish males. *American Journal of Epidemiology, 147*, 982-990.

Pols, M. A., Peeters, P. H., Bueno-De-Mesquita, H. B., Ocke, M. C., Wentink, C. A., Kemper, H. C., et al. (1995). Validity and repeatability of a modified Baecke questionnaire on physical activity. *International Journal of Epidemiology, 24*, 381-388.

Posserud, M., Lundervold, A. J., & Gillberg, C. (2006). Autistic features in a total population of 7 to 9-year-old children assessed by the ASSQ (Autism Spectrum Screening Questionnaire). *Journal of Child Psychology and Psychiatry, 47*, 167-175.

Ramus, F., Rosen, S., Dakin, S., Day, B. L., Castellote, J. M., & White, S. (2003). Theories of developmental dyslexia: insights from a multiple case study of dyslexic adults. *Brain, 126*, 841-865.

Rapoff, M. A. (2009). Editorial: Assessing and Enhancing Clinical Significance/Social Validity of Intervention Research in Pediatric Psychology. *Journal of Pediatric Psychology, 35*, 114-119.

Reid, G., & O'Connor, J. (2003). The autism spectrum disorders: activity selection, assessment, and program organization - part II. *Palaestra, 19*, 20-27;58.

Rosenthal-Malek, A., & Mitchell, S. (1997). Brief report: the effects of exercise on the self-stimulatory behaviors and positive responding of adolescents with autism. *Journal of Autism and Developmental Disorders, 27*, 193-202.

Rosser, D. D., & Frey, G. C. (2005). Comparisons of physical activity levels between children with and without autistic spectrum disorders. *Adapted Physical Activity Quarterly, 22*, 146-159.

Rutter, M., Andersen-Wood, L., Beckett, C., Bredenkamp, D., Castle, J., Groothues, C., et al. (1999). Quasi-autistic patterns following severe early global privation. *Journal Child Psychology Psychiatry, 40, 537–549*.

Sahlander, C., Mattsson, M., & Bejerot, S. (2008). Motor function in adults with Asperger's disorder: a comparative study. *Physiotherapy Theory and Practice, 24*, 73-81.

Sainsbury, C. (2000). *Martian in the Playground: Understanding the Schoolchild with Asperger's Syndrome*. Bristol: Lucky Duck Publishing.

Sallis, J. F., McKenzie, T. L., Kolody, B., Lewis, M., Marshall, S., & Rosengard, P. (1999). Effects of health-related physical education on academic achievement: project SPARK. *Research Quarterly for Exercise and Sport, 70*, 127-134.

Schoemaker, M. M., Hijlkema, M. G., & Kalverboer, A. F. (1994). Physiotherapy for clumsy children: an evaluation study. *Developmental Medicine and Child Neurology, 36*, 143-155.

Schoen, S. A., Miller, L. J., & Green, K. E. (2008). Pilot study of the Sensory Over-Responsivity Scales: assessment and inventory. *The American Journal Of Occupational Therapy, 62*, 393-406.

Siaperas, P., Holland, T., & Ring, H. (2006). Discriminative validity of the Movement ABC Test and Checklist for use with children with Asperger Syndrome. In S. E. Henderson, D. Sugden & A. Barnett (Eds.), *Movement Assessment Battery for Children-2* (2007 ed.). London: Pearson Assessment.

Smith, I. M. (2000). Motor functioning in Asperger syndrome. In A. e. a. E. Klin (Ed.), *Asperger syndrome* (pp. 97-124). New York: The Guilford Press. .

Smith, I. M. (2004). Motor problems in children with autistic spectrum disorders. In D. Dewey & D. E. Tupper (Eds.), *Developmental motor* *disorders: A neuropsychological perspective*. New York, NY: The Guilford Press.

SPSS (2009). *PASW Statistics 17 for Windows*. Chicago, IL.: SPSS Inc.

Sugden, D. A., & Chambers, M. E. (2003). Intervention in children with Developmental Coordination Disorder: the role of parents and teachers. *The British Journal of Educational Psychology, 73*, 545-561.

Szatmari, P., Brenner, R., & Nagy, J. (1989). Asperger's syndrome: A review of clinical features. *Canadian Journal of Psychiatry, 34*,554-560.

Tantam, D. (1991). Asperger's syndrome in adulthood. In U. Frith (Ed.), *Autism and Asperger syndrome* (pp. 147-183). Cambridge: Cambrigde University Press.

Taylor, A. F. (2009). Children With Attention Deficits Concentrate Better After Walk in the Park. *Journal of Attention Disorders, 12*, 402-409.

Taylor, B., Miller, E., Lingam, R., Andrews, N., Simmons, A., & Stowe, J. (2002). Measles, mumps, and rubella vaccination and bowel problems or development regression in children with autism: population study. *BMJ: British Medical Journal, 324*, 393-396.

Telama, R., Yang, X., Viikari, J., Valimaki, I., Wanne, O., & Raitakari, O. (2005). Physical activity from childhood to adulthood: a 21-year tracking study. *American Journal of Preventive Medicine, 28*, 267-273.

Thomas, J. R., Nelson, J. K., & Silverman, J. (2005). *Research methods in physical activity (5th ed.)*. Champaign: IL: Human kinetics.

Todd, T., & Reid, G. (2006). Increasing Physical Activity in Individuals With Autism. *Focus on Autism & Other Developmental Disabilities, 21*, 167-176.

Vernazza-Martin, S., Martin, N., Vernazza, A., Lepellec-Muller, A., Rufo, M., & Massion, J. (2005). Goal directed locomotion and balance control in autistic children. *Journal of Autism and Developmental Disorders 35*, 91-102.

Watemberg, N., Waiserberg, N., Zuk, L., & Lerman-Sagie, T. (2007). Developmental coordination disorder in children with attention-deficit-hyperactivity disorder and physical therapy intervention. *Developmental Medicine and Child Neurology, 49*, 920-925.

Weimer, A. K., Schatz, A. M., Lincoln, A., Ballantyne, A. O., & Trauner, D. A. (2001). Motor impairment in Asperger's syndrome: evidence for a deficit in proprioception. *Journal of Developmental and Behavioral Pediatrics, 22*, 92-101.

Weiss, L. A., Arking, D. E., Daly, M. J., Chakravarti, A., Brune, C. W., West, K., et al. (2009). A genome-wide linkage and association scan reveals novel loci for autism. *Nature, 461*, 802-808.

Willey, L. H. (1999). *Pretending to be normal: Living with Asperger's syndrome*. London: Jessica Kingsley Publishers.

Williams, D. (1998). *Nobody Nowhere: The Remarkable Autobiography of an Autistic Girl*. London: Jessica Kingsley Publishers.

Wilson, P. H., & McKenzie, B. E. (1998). Information processing deficits associated with developmental coordination disorder: a meta-analysis of research findings. *Journal of Child Psychology and Psychiatry, 39*, 829-840.

Wing, L. (1981). Asperger syndrome: a clinical account. *Psychological Medicine, 11*, 115-129.

Wing, L., & Gould, J. (1979). Severe impairments of social interaction and associated abnormalities in children: epidemiology and classification. *Journal of Autism and Childhood Schizophrenia, 9*, 11-29.

Wing, L., & Potter, D. (2002). The epidemiology of autistic spectrum disorders: is the prevalence rising? *Mental Retardation and Developmental Disabilities Research Reviews, 8*, 151-161.

Winnick, J. P., & Short, F. X. (1999). *The Brockport physical fitness test manual*. Champaign:IL: Human Kinetics.

World Health Organisation (1993). *International statistical classification of diseases and health-related problems, Tenth Revision (ICD-10).* Geneva: Author.

APPENDIX 1

Diagnostic criteria for Asperger 's disorder from DSM-IV-TR (APA, 2000)

A. Qualitative impairment in social interaction, as manifested by at least two of the following:
   1. marked impairment in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction
   2. failure to develop peer relationships appropriate to developmental level
   3. a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g., by a lack of showing, bringing, or pointing out objects of interest to other people)
   4. lack of social or emotional reciprocity

B. Restricted repetitive and stereotyped patterns of behavior, interests, and activities, as manifested by at least one of the following:
   1. encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus
   2. apparently inflexible adherence to specific, nonfunctional routines or rituals
   3. stereotyped and repetitive motor mannerisms (e.g., hand or finger flapping or twisting, or complex whole-body movements)
   4. persistent preoccupation with parts of objects

C. The disturbance causes clinically significant impairment in social, occupational, or other important areas of functioning.

D. There is no clinically significant general delay in language (e.g., single words used by age 2 years, communicative phrases used by age 3 years).

E. There is no clinically significant delay in cognitive development or in the development of age-appropriate self-help skills, adaptive behavior (other than in social interaction), and curiosity about the environment in childhood.

F. Criteria are not met for another specific Pervasive Developmental Disorder or Schizophrenia.

APPENDIX 2

Diagnostic criteria of Asperger's syndrome from Gillberg and Gillberg (1989)

1. Severe impairment in reciprocal social interaction (at least two of the following):
   - (a) inability to interact with peers
   - (b) lack of desire to interact with peers
   - (c) lack of appreciation of social cues
   - (d) socially and emotionally inappropriate behavior

2. All-absorbing narrow interest (at least one of the following):
   - (a) exclusion of other activities
   - (b) repetitive adherence
   - (c) more rote than meaning

3. Imposition of routines and interests (at least one of the following):
   - (a) on self, in aspects of life
   - (b) on others

4. Speech and language peculiarities (at least three of the following):
   - (a) delayed development
   - (b) superficially perfect expressive language
   - (c) formal, pedantic language
   - (d) odd prosody, peculiar voice characteristics
   - (e) impairment of comprehension including misinterpretations of literal/implied meanings

5. Non-verbal communication problems (at least one of the following):
   - (a) limited use of gestures
   - (b) clumsy/gauche body language
   - (c) limited facial expression
   - (d) inappropriate expression
   - (e) peculiar, stiff gaze

6. Motor clumsiness: poor performance on neurodevelopmental examination

Note. All six criteria must be met for confirmation of diagnosis.

APPENDIX 3

Diagnostic criteria of Asperger's syndrome from Szatmari, Bremner, and Nagy (1989)

1. **Solitary** (at least two of the following):
   No close friends
   Avoids others
   No interest in making friends
   A loner

2. **Impaired social interaction** (at least one of the following)
   Approaches others only to have own needs met
   A clumsy social approach
   One-sided responses to peers
   Difficulty sensing feelings of others
   Detached from feelings of others

3. **Impaired non-verbal communication** (at least one of the following)
   Limited facial expression
   Unable to read emotion from facial expression of child
   Unable to give message with the eyes
   Does not look at others
   Does not use hands to express onself
   Gestures are large and clumsy
   Comes too close to others

4. **Odd speech** (at least two of the following):
   Abnormalities in inflection
   Talks too much
   Talks too little
   Lack of cohesion to conversation
   Idiosyncratic use of words
   Repetitive patterns of speech

5. **Does not meet DSM-III-R criteria for Autistic Disorder**

APPENDIX 4

MOTORINEN KUNTOKARTOITUS
MOVEMENT ABC-II
Soveltaen Henderson et al. (2007)

Testilomake

Keskuspuiston ammattiopisto AIMO-tiimi

Erwin Borremans, Sanna Blair & Harriet Valovirta

Taso 3 (11-16+)

Nimi ______________________ Sukupuoli ______________

Osoite ______________________ Testauspvm ______________

______________________ Syntymäaika ______________

______________________ Ikä ______________

Koulu ______________________ Luokka ______________

____

Testaaja ______________________________________

Dominoiva käsi (kirjoituskäden mukaan arvioituna) ______________________

Muuta ______________________________________

____

YHTEENVETO TESTISUORITUKSISTA

MOVEMENT ABC II CHECKLIST PISTEET

Motor score

________ + ________ = ________

MOVEMENT ABC TESTIPISTEMÄÄRÄ

Käden taidot ________ + ________ + ________ = ________

Pallotaidot ________ + ________ = ________

Tasapaino ________ + ________ + ________ = ________

VIRHEPISTEMÄÄRÄ YHTEENSÄ ☐

YHTEENVETO LAADULLISESTA HAVAINNOINNISTA

KÄDEN TAIDOT (Kehon hallinta/asento; raajojen toimiminen; avaruudellinen tarkkuus, voiman kontrollointi, toiminnan ajoittaminen; muut havainnot kuten palautteen hyödyntäminen)

PALLOTAIDOT (Kehon hallinta/asento; raajojen toimiminen; avaruudellinen tarkkuus, voiman kontrollointi, toiminnan ajoittaminen; muut havainnot kuten palautteen hyödyntäminen)

STAATTINEN JA DYNAAMINEN TASAPAINO (Kehon hallinta/asento; raajojen toimiminen; avaruudellinen tarkkuus, voiman kontrollointi, toiminnan ajoittaminen; muut havainnot kuten palautteen hyödyntäminen)

LIIKKUMISEEN VAIKUTTAVIA MUITA TEKIJÖITÄ

Täydennä alla oleviin kohtiin ne havaitsemasi nuoren fyysiset tekijät tai käyttäytymisen piirteet, jotka mielestäsi ovat saattaneet vaikuttaa hänen motoriseen suoriutumiseensa. Otsikot (esimerkkeineen) on annettu vain viitteelliseksi ohjeeksi. Vaikka negatiiviset puolet ovat voimakkaimmin esillä, muista huomioida nuoren käyttäytymisen positiivisetkin puolet.

	Kyllä	Ei
1. **Järjestäytymätön** (vaatteet ympäri huonetta, laittaa kengät jalkaan ennen sukkia).		
2. **Unohtelevainen** (aloittaa hitaasti moniosaista tehtävää, kesken tehtävän unohtaa mitä tehdä seuraavaksi).		
3. **Passiivinen** (ei kiinnostu helposti; tarvitsee paljon rohkaisua osallistuakseen, ei yritä tarpeeksi).		
4. **Arka** (pelkää toimintoja kuten hyppääminen ja kiipeäminen, ei halua liikkua nopeasti, pyytää jatkuvasti apua).		
5. **Jännittynyt** (näyttää hermostuneelta tai vapisee, käsittelee kömpelösti pieniä esineitä, hämääntyy stressaavissa tilanteissa).		
6. **Impulsiivinen** (aloittaa ennen ohjeiden saamista, ei jaksa keskittyä yksityiskohtiin).		
7. **Häiriintyy helposti** (katselee ympärillee, kiinnittää huomiota ääniin tai liikkeeseen huoneen ulkopuolella).		
8. **Yliaktiivinen** (on vaivautunut, liikehtii levottomasti, liikkuu koko ajan kuunnellessaan ohjeita, hypistelee vaatteitaan).		
9. **Yliarvioi omat kykynsä** (yrittää vaihtaa tehtäviä vaativammiksi, yrittää tehdä asioita liian nopeasti).		
10. **Aliarvioi omat kykynsä** (sanoo tehtävien olevan liian vaikeita; arvioi epäonnistuvansa ennen kuin edes aloittaa).		
11. **Ei ole pitkäjänteinen** (luovuttaa helposti, turhautuu helposti, unelmoi).		
12. **Ahdistuu epäonnistumisesta** (näyttää itkuiselta, kieltäytyy kokeilemasta tehtävän suorittamista uudelleen).		
13. **Ei saa mielihyvää onnistumisesta** (ei reagoi palautteeseen, ei ilmaise kasvojen ilmeillään mitään).		
14. **Muu** (ole hyvä ja tarkenna)		
Vaikuttavatko yllä olevat tekijät mielestäsi henkilön kykyyn osoittaa taitonsa testin aikana? *Rastita yksi vaihtoehto*	ei ollenkaan ☐ vähän ☐ merkittävästi ☐	

TAPPIEN KÄÄNTÄMINEN — SORMINÄPPÄRYYS 1

Testitulokset

Aika sekunteina: **EO** ei osaa, **K** kieltäytyminen, **E** epäonnistunut

Dominoiva käsi	Ei-dominoiva käsi
1. yritys ________	1. yritys ________
2. yritys ________	2. yritys ________

Toinen yritys vain jos ensimmäinen tulos kestää kauemmin kuin dominoivalla kädellä 22sek (16v) ja ei-dominoivalla kädellä 26sek (16v).

Laadullinen havainnointi

Kehon hallinta/Asento

- Istumisasento on huono ☐
- Pitää päätä liian lähellä tehtävää ☐
- Pitää päätä oudossa kulmassa ☐
- Ei katso lautaa asettaessaan tappeja ☐
- Ei käytä pinsettiotetta poimiessaan tappeja ☐
- Liioittelee sormen liikkeitä irrottaessaan tapin ☐
- Ei tue toisella kädellä pitääkseen laudan vakaana ☐
- Toinen käsi *erittäin* heikko (voimakas asymmetria) ☐
- Vaihtaa kättä tai käyttää molempia käsiä ☐
- Käden liikkeet ovat nykiviä ☐
- Liikehtii levottomasti koko ajan ☐

Sopeutuminen tehtävien vaatimuksiin

- Asettaa tapit väärin reikiin nähden ☐
- Käyttää liikaa voimaa asettaessaan tappeja ☐
- On erityisen hidas/nopeus ei muutu (yritys 1-2) ☐
- Liian nopea tarkkuuteen nähden ☐

Muuta/kommentit

____

____

KOLMION KOKOAMINEN — SORMINÄPPÄRYYS 2

Testitulokset

Aika sekunteina: **EO** ei osaa, **K** kieltäytyminen, **E** epäonnistunut

1. yritys	________
2. yritys	________

Toinen yritys vain jos ensimmäinen tulos kestää kauemmin kuin 48sek (16v).

Laadullinen havainnointi

Kehon hallinta/Asento

- Istumisasento on huono ☐
- Pitää tarvikkeita liian lähellä kasvoja ☐
- Pitää päätä oudossa kulmassa ☐
- Ei katso reikää laittaessaan ruuvia ☐
- Ei käytä pinsettiotetta ☐
- Kaksikätinen työskentely hankalaa ☐
- Käden liikkeet ovat nykiviä ☐
- Liikehtii levottomasti koko ajan ☐

Sopeutuminen tehtävien vaatimuksiin

- Osuu reiän ohi mutterin päällä ☐
- Sekaantuu kokoamisprosessin aikana ☐
- Erityisen hidas, nopeus ei muutu yritysten jälkeen ☐
- Liian nopea tarkkuuteen nähden ☐

Muuta/kommentit

____

____

PIIRUSTUS POLKU 3 — SORMINÄPPÄRYYS 3

Testitulokset

Virheiden määrä: **EO** ei osaa, **K** kieltäytyminen, **E** epäonnistunut

1. yritys	__________
2. yritys	__________
käsi	__________

Toista yritystä ei tehdä jos opiskelija suoriutuu ensimmäisestä yrityksestä virheettömästi.

Laadullinen havainnointi

Kehon hallinta/Asento

- [ ] Istumisasento on huono
- [ ] Pitää kasvoja liian lähellä paperia
- [ ] Pitää päätä oudossa kulmassa
- [ ] Ei seuraa reittiä katseellaan
- [ ] Pitää kynää oudolla/epäkypsällä otteella
- [ ] Pitää kynää liian kaukaa kärjestä
- [ ] Pitää kynää liian läheltä kärkeä
- [ ] Ei pidä paperia paikallaan
- [ ] Vaihtaa kättä yrityksen aikana
- [ ] Liikehtii levottomasti koko ajan

Sopeutuminen tehtävien vaatimuksiin

- [ ] Etenee lyhyin, nykivin liikkein
- [ ] Käyttää liikaa voimaa, painaa kynää voimakkaasti
- [ ] On erityisen hidas
- [ ] Liian nopea tarkkuuteen nähden

Muuta/kommentit

____

____

YHDELLÄ KÄDELLÄ KIINNIOTTAMINEN — PALLOTAIDOT 1

Testitulokset

Oikein kiinnisaatujen määrä: **EO** ei osaa, **K** kieltäytyminen, **E** epäonnistunut

Harjoitus: Dominoiva käsi	Ei-dominoiva käsi
______________/ 5	______________/ 5

Testi: Dominoiva käsi	Ei-dominoiva käsi
______________/ 10	______________/ 10

Laadullinen havainnointi

Kehon hallinta/Asento

- [ ] Huono seisoma-asento
- [ ] Kääntää pään tai sulkee silmät pallon lähestyessä
- [ ] Ei seuraa pallon lentorataa silmillä
- [ ] Pitää kämmenet ylöspäin ja sormet jäykkinä pallon lähestyessä
- [ ] Käsivarret ja kädet leveässä asennossa, sormet ojennettuina
- [ ] Kädet ja käsivarret eivät sopeudu pallon iskuun
- [ ] Sormet sulkeutuvat liian aikaisin/myöhään
- [ ] Erittäin heikko toisella kädellä (voimakas asymmetria)
- [ ] Koko vartalo jännittynyt/jäykkä
- [ ] Liikkeistä puuttuu joustavuus

Sopeutuminen tehtävien vaatimuksiin

- [ ] Vartalon asento ei ole mukautunut kiinniottamiseen
- [ ] Jalkojen asentoa ei ole mukautettu tehtävän mukaan
- [ ] Arvioi heiton voiman huonosti (liian suuri/pieni)
- [ ] Ei mukaudu palaavan pallon korkeuteen
- [ ] Ei mukaudu palaavan pallon suuntaan
- [ ] Ei mukaudu palaavan pallon voimakkuuteen

Muuta/kommentit

____

____

HEITTO MAALITAULUUN — PALLOTAIDOT 2

Testitulokset

Maalien määrä: **EO** ei osaa, **K** kieltäytyminen, **E** epäonnistunut

Käsi __________

Harjoitus: _________/ 5

Testi: ____________/ 10

Laadullinen havainnointi

Kehon hallinta/Asento

- ☐ Tasapaino heiton aikana on huono
- ☐ Ei pidä katsetta kohteessa
- ☐ Ei seuraa heilahtavan käden mukana
- ☐ Vapauttaa pallon liian aikaisin/myöhään
- ☐ Vaihtaa kättä yritysten välillä
- ☐ Liikkeistä puuttuu joustavuus
- ☐ Vartalo ja lantio eivät kierry heittokäden tullessa eteen
- ☐ Vartalo kiertyy liikaa ja menettää tasapainon
- ☐

Sopeutuminen tehtävien vaatimuksiin

- ☐ Virheet kohdistuvat jatkuvasti toiselle puolelle maalitaulua (voimakas asymmetria)
- ☐ Arvioi heiton suunnan vaihtelevasti
- ☐ Arvioi heiton voiman heikosti (liian paljon/liian vähän)
- ☐ Voiman kontrollointi vaihtelee

Muuta/kommentit

____

____

KAHDEN JALAN TASAPAINO — TASAPAINO 1

Testitulokset

Aika sekunteina: **EO** ei osaa, **K** kieltäytyminen, **E** epäonnistunut

1. yritys __________

2. yritys __________

Toista yritystä ei tehdä jos opiskelija säilyttää tasapainon 30 sek ajan.

Laadullinen havainnointi

Kehon hallinta/Asento

- ☐ Vartalo on jäykkä
- ☐ Vartalo on veltto
- ☐ Voimakasta huojumista tasapainon ylläpitämiseksi
- ☐ Ei pidä päätä ja katsetta vakaana
- ☐ Liioitellut käsivarsien ja vartalon liikkeet häiritsevät tasapainoa
- ☐ Ei tee lainkaan käsivarren liikkeitä tasapaino säilyttämiseksi
- ☐ Ei pysty pitämään jalkoja suorassa linjassa

Muuta/kommentit

____

____

SIK-SAK HYPPÄÄMINEN — TASAPAINO 3

Testitulokset

Hyväksyttyjen hyppyjen määrä: **EO** ei osaa, **K** kieltäytyminen, **E** epäonnistunut

Oikea jalka	Vasen jalka
Yritys 1 __________/ 5	Yritys 1__________/ 5
Yritys 2 __________/ 5	Yritys 2 __________/ 5

Toista yritystä ei tehdä jos opiskelija suoriutuu ensimmäisestä yrityksestä virheettömästi.

Laadullinen havainnointi

Kehon hallinta/Asento

- [ ] Vartalo on jännittynyt/jäykkä
- [ ] Vartalo veltto
- [ ] Ei-ponnistava jalka ylhäällä vartalon edessä
- [ ] Hyppää jäykin/veltoin jaloin, tasajalkaa alas
- [ ] Joustavuus ja ponnistus puuttuu
- [ ] Liioitellut käsien liikkeet
- [ ] Ei käytä käsivarren liikkeitä hypyn apuna
- [ ] Kompastuu alastulossa
- [ ] Voimakas asymmetria

Sopeutuminen tehtävän vaatimuksiin

- [ ] Liian nopea tarkkuuteen nähden
- [ ] Ei yhdistä ylös ja alaspäin suuntautuvia liikkeitä tehokkaasti
- [ ] Yrittää liikaa
- [ ] Liikkeet ovat nykiviä

Muuta/kommentit

____

____

TAKAPERIN KÄVELEMINEN — TASAPAINO 2

Testitulokset

Oikeiden askelten määrä viivan alusta: **EO** ei osaa, **K** kieltäytyminen, **E** epäonnistunut

1. yritys __________
2. yritys __________
Koko viiva kyllä / ei

Toista yritystä ei tehdä jos opiskelija suoriutuu ensimmäisestä yrityksestä 15 oikealla askelella tai hän kävelee koko viivan alle 15:sta askeleella.

Laadullinen havainnointi

Kehon hallinta/Asento

- [ ] Vartalo on jännittynyt/jäykkä
- [ ] Vartalo veltto viivalle
- [ ] Huojuu voimakkaasti tasapainon ylläpitämiseksi
- [ ] Ei katso taaksepäin tarkistaakseen reittiään
- [ ] Ei kompensoi käsivarsilla tasapainon ylläpitämistä
- [ ] Liioitellut käsivarren liikkeet häiritsevät tasapainoa
- [ ] Huojuu voimakkaasti asettaessaan jalkoja viivalle

Sopeutuminen tehtävän vaatimuksiin

- [ ] Kulkee lian nopeasti tarkkuuteen nähden
- [ ] Yksittäisistä liikkeistä puuttuu tasaisuus/joustavuus
- [ ] Askelten jaksottaminen ei ole tasaista/pysähtelee jatkuvasti

Muuta/kommentit

____

____

APPENDIX 5
Examples of the pictorial presentation of the test items

ORIGINAL PAPERS

I

MOTOR SKILLS OF YOUNG ADULTS WITH ASPERGER SYNDROME: A COMPARATIVE STUDY

by

Borremans E, Rintala P, & McCubbin JA (2009)
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MOTOR SKILLS OF YOUNG ADULTS WITH ASPERGER SYNDROME: A COMPARATIVE STUDY

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Motor skill difficulties are mentioned as a common feature of Asperger syndrome (AS) but specific information regarding young adults is scarce. The purposes of this study were: to compare the motor skills of young adults with AS with age and gender matched controls using the updated version of the standardized Movement Assessment battery for children (M-ABC-II), and to compare the motor skills between younger and older participants within both groups (index and control group). Additionally validity and reliability of the M-ABC-II for use with the present population were explored. Young adults with AS performed these motor tasks at a remarkably lower level than their peers. They continued to demonstrate motor delays over age, even though motor competencies of individuals with AS seemed to improve after the adolescent years. The use of the M-ABC-II is recommended for young adults with AS as a valuable tool in assessing motor skills for setting up the intervention in educational and clinical practice.

KEYWORDS: Asperger syndrome, motor skills, motor competence, clumsiness, M-ABC-II, adults.

INTRODUCTION

Asperger syndrome (AS) is a neurodevelopmental disorder grouped under the broad diagnostic category of pervasive developmental disorders (PDD), also referred to as Autism Spectrum Disorders (ASD). It is characterized by the same kind of qualitative abnormalities of social interaction that typify autism, together with a restricted, stereotyped, repetitive repertoire of interests and activities. AS is considered to be at the higher end of the continuum of the autism spectrum and it differs from autism primarily in the absence of general delay or retardation in language or in cognitive development. Most individuals are of normal intelligence and it is common for them to be markedly clumsy (World Health Organisation, 1993).

The number of individuals with AS increased dramatically over the last decade, although its exact prevalence has yet to be determined. Recent research in Finland suggests that it may be as common as one in 250 people (0.4%) (Mattila et al., 2007). This number is in line with international resources, which have shown prevalence rates between one in 150 (0.6%) and one in 500 people (0.2%) (Baird et al., 2006; Fombonne, 2003; Posserud, Lundervold, & Gillberg, 2006). Epidemiological evidence indicates that the male/female ratio is 4:1 (Ehlers, Gillberg, & Wing, 1999), but recent research suggests that this female prevalence may be underestimated and that the male/female ratio could be up to 2:1 (Mattila et al., 2007).

Motor clumsiness is mentioned as a common, yet not defining, feature of Asperger syndrome in both the ICD-10 (World Health Organisation, 1993) and the DSM-IV (American Psychiatric Association, 1994). Estimates of the prevalence of these motor problems range from 50% to 85% (Attwood, 1998; Gillberg & Gillberg, 1989; Klin, Volkmar, Sparrow, Cicchetti, & Rourke, 1995; Manjiviona & Prior, 1995; Sahlander, Mattsson, & Bejerot, 2008; Smith, 2000), but the specific characteristics of the impairment remain poorly understood. These motor problems can involve different domains, including fine motor and gross motor skills, gait, balance, and ball skills. Individuals with AS may have a history of delayed acquisition of specific motor skills such as walking, pedaling a bike, catching a ball, standing on one leg, hopping, climbing parallel-bars, and so on. They are often visibly awkward, exhibiting stiff gait patterns, odd posture, poor manipulative skills, and deficits in visual-motor coordination. The pervasive nature of these motor problems, as well as the fact that more children are being diagnosed every year due to a greater awareness of AS, makes it increasingly likely that physical education teachers and coaches will have children with AS in their programs and on their teams.

Often the presence of clumsiness in AS has been defined on the basis of the clinician's subjective impression and only a limited number of studies have used standardized tests of motor skill, such as Bruininks-Oseretsky test of Motor Proficiency (BOTMP; Bruininks, 1976), Movement Assessment battery for Children (M-ABC; Henderson & Sudgen, 1992), and Zuricher Neuromotor assessment (Largo, Fischer, & Caflisch, 2002). Despite of the wide variety of test used, there seems to be agreement that motor impairment is very common among children and adolescents with AS and autism.

The M-ABC or its precursor the Test of Motor Impairment-Henderson Revision have been used in several studies on children with AS or high functioning autism (HFA)(Green et al., 2002; Manjiviona & Prior, 1995; Miyahara et al., 1997). The M-ABC is a quantitative, norm-referenced instrument for 4–12 year old children assessing manual dexterity, ball skills and balance. Manjiviona & Prior (1995) compared 21 children and adolescents between 7–17 years old with AS and HFA and did not find differences between the groups regarding the three components and the overall test scores. They reported considerable variability within both clinical groups with 50% of the children with AS and 67% of children with HFA showing a clinically significant level of motor impairment. Others using the M-ABC with children with AS as compared to other special groups (Green et al., 2002; Miyahara et al., 1997) reported similar results with 88 to 100% of the children with AS meeting the diagnosis for motor impairment.

Motor impairment has been well documented in children, whereas specific information regarding young adults remains scarce. Recently Sahlander and colleagues (Sahlander et al., 2008) used the BOTMP in a comparative study of motor function in adults with AS aged 21–35. This study indicated similar motor difficulties in adults as were also shown in children in previous research using the BOTMP (Ghaziuddin & Butler, 1998; Ghaziuddin, Butler, Tsai, & Ghaziuddin, 1994; Lopata, Hamm, Volker, & Sowinski, 2007; Sahlander et al., 2008). Freitag and colleagues (2007) compared 16 male young adults aged 14–22 years with healthy controls using the Zurich Neuromotor Assessment. Their index group had the most difficulties with dynamic balance skills and the ability to perform rapidly alternating muscular movements. Both these studies made use of a rather small number of index participants with matched controls and population specific reliability data was not provided. Because of the unavailability of normative standardized motor tests for young adults with AS information regarding this specific age group from 15 till 21 is limited. Therefore, the primary purpose of this study was to compare both quantitatively and qualitatively the motor skills of young adults with AS with age and gender matched controls. Secondly, this study compared motor skills between younger and older participants of both index and control groups. Additionally internal consistency reliability of the M-ABC-II for young adults with AS was explored.

METHOD

Participants

Thirty young adults aged 15–21 years (M = 17.2yrs; SD = 1.2) with Asperger syndrome agreed to participate in the study. Members of the group with AS were selected from a vocational education program, especially designed for young adults with ASD, in the province of southern Finland. To be included in this group, all participants were required to meet the diagnostic criteria for AS as presented in the ICD-10R (WHO, 1993) (i.e. qualitative deficiencies in reciprocal social interaction, and restricted, repetitive stereotyped patterns of behavior, interest and activities, but no clinically significant delay in language or cognitive development). A professional who had considerable experience diagnosing people on the autism spectrum made the diagnosis. Mental retardation and psychosis were used as exclusion criteria. The group enrolled consisted of 21 males (M = 16.9yrs; SD = 0.9yrs) and 9 females (M = 18.0yrs; SD = 1.4yrs). This gender disbalance is in line with the most recent epidemiological data (Ehlers, et al., 1999; Mattila, et al., 2007). Prior to all investigations, written assent was obtained from the participants and written consent from their legal guardians. The control group consisted of 30, age and gender matched, young adults (M = 16.9; SD = 0.8yrs) from an upper secondary school in the same region. They had no physical or cognitive impairments according to their own reports. The appropriate ethical committee approved this study.

Assessment

The updated version of the Movement Assessment Battery for Children, the M-ABC-II, was used as the primary assessment tool (Henderson, Sugden, & Barnett, 2007). The M-ABC-II test is divided into three age bands with movement tasks getting more difficult with increasing age. The M-ABC-II test contains eight tasks that assess three components of functioning: manual dexterity, balance and ball skills. The manual dexterity tasks include turning pegs both with preferred and non-preferred hand, a bimanual task to make a triangle with nuts and bolts, and a drawing trail. The tests for ball skills include aiming and throwing at a wall target, as well as catching a ball with one hand. Balance items consist of two-board balance, walking toe-to-heel backwards, and zigzag hopping.

The test provides objective, quantitative data on motor skills. The raw scores obtained for each item can be converted to item standard scores using age related norms. Performance differences between boys and girls are reported to be minimal, so the M-ABC-II manual provides only a single set of norms. Standard scores can be added up to produce three component scores, the sum of which provides a total test score. The test provides standard scores and percentiles for each age group through 16. According to the M-ABC-II manual scores at or below the 5th percentile are considered indicative of significant motor difficulty and scores between the 6th and 15th percentile suggest being at risk for having motor problems. In addition to the quantitative data derived from formal testing, the assessment is also paralleled by item-specific observations, designed to increase understanding of the perceptual-motor aspects of the individual's performance. Both quantitative data as well as qualitative clinical impressions, are included in this study to help describe and characterize some specific motor related challenges of individuals with AS.

To our knowledge currently there is no specific norm referenced motor skill test available for this age range, which includes ball skills, as well as both fine and gross motor abilities. We opted for the M-ABC-II as different versions of this test have been commonly used in motor competence research with individuals with AS (Green et al., 2002; Manjiviona & Prior, 1995; Miyahara et al., 1997; Siaperas, Holland, & Ring, 2006) and its careful use offers trained professionals valuable clinical information to plan an intervention. The M-ABC-II test has proven reliable and valid (Chow & Henderson, 2003; Faber & Nijhuis van der Sanden, 2004; Henderson, et al., 2007). In our view the test has sensitivity for our group of young adults with AS because their motor skills have not yet reached optimal levels and variability is still to be observed. Therefore we were interested in the suitability of the M-ABC-II test for individuals older than 16, even though 16 is the upper age limit of the normative sample. To confirm internal consistency reliability our statistical analyses included Crohnbach's Alpha.

Procedures

A team of three experienced therapists (two physiotherapists and one occupational therapist) assessed the individuals with and without AS between September 2007 and February 2008. In a quiet classroom, each assessment was initiated with a short interview and an informative briefing about the test situation supported with pictures of the test items. After that, the manual dexterity and balance tests were administered. In total, this first session took approximately half an hour. Ball skills were assessed as a part of a larger physical fitness assessment during the student's regular physical education in the school's gymnasium. These different fitness- and motor tests were conducted in small groups from two to four persons. The student-teacher ratio was 2:1.

Data analysis

Of all our 60 participants, 40 were older than 16. Therefore, the statistical analysis was performed on the raw scores due to lack of normative information for adults. A 5% level of statistical significance is being implied (.05). First, the items were combined in a MANOVA-model using summation of all raw scores to reflect the total test score as well as combinations of raw scores to reflect the component scores of the M-ABC-II. The hypothesis was that the group with AS would score significantly lower than the control group on overall motor ability as well as on the three components. In an additional analysis using the same MANOVA-model as described above, gender was used as a covariate to address for possible gender differences. For descriptive reasons and to be able to indicate the severity of the motor impairment in our index group we decided to do a confirmatory calculation of standard scores and percentiles using the norms of the 16 year olds from the M-ABC-II manual. Using these norms with a slightly older population would likely underestimate the individuals' motor competencies, because it does not account for higher scores that come with increasing age.

Second, both the index group and the control group were split in half, using age as the criterion, to get a younger and an older group. This younger group (with the fifteen youngest) was compared to the older group (with the fifteen oldest) within both index and control group. A similar MANOVA using summation of raw scores to reflect motor competence was applied. The hypothesis was that in the control group, the scores of the oldest are similar to the scores of the youngest, since motor development is supposed to have consolidated before reaching adulthood. On the other hand, the hypothesis with the group with AS was that there would be a difference on the scores in favor of the older group. This hypothesis was based upon the lower initial score of the group with AS that suggests a possible margin for growth. Effect sizes based on means (Cohen's d; Cohen, 1988) were calculated for the individual test items to help us to know whether the differences observed between the groups are differences that practically matter.

The third goal was to provide exploratory information for further development and normation of future measurements for young adults with AS. The M-ABC-II's underlying construction allows for an analysis of the items for internal consistency reliability. We used the Cronbach's alpha to measure how well the set of items per component in the M-ABC-II measure the proposed latent construct and as an indicator of reliability of this test for our age specific group. Given the nature of the test and the small sample size, we do want to stress that it is merely an indicator.

RESULTS

The means and standard deviations of the M-ABC-II raw test score of both groups are summarized in Table 1. First, the multivariate analysis of variance revealed statistically significant lower motor performance of the index group compared to control group on overall motor competence (Wilk's Lambda $\lambda = .49$, $F(11, 48) = 4.48$ ($p < .001$) as well as on all three motor components (manual dexterity, ball skills, and balance) of the M-ABC-II. Wilk's Lambda for manual dexterity items was $\lambda = .72$, $F(4, 55) = 5.29$ ($p < .001$); for ball skill items $\lambda = .63$, $F(3, 56) = 11.06$ ($p < .001$); and for balance items $\lambda = .65$, $F(4, 55) = 7.34$ ($p < .001$). The additional MANCOVA showed as expected no significant gender differences with Wilk's Lambda $\lambda = .80$, $F(11, 47) = 1.09$, and

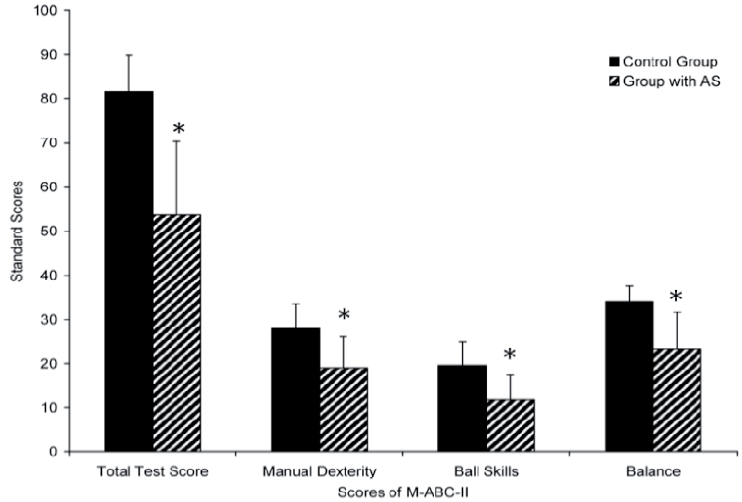
$p > .05$. The confirmatory calculation of standard scores and percentiles indicated the severity of the motor impairment in the group with AS (see Figure 1). According to the cut-off scores proposed in the M-ABC-II manual our results suggest that of the 30 participants in the group with AS 16 had severe motor problems (scored below 5th percentile) and an additional two would be at risk for motor impairment (scored between the 5th and 15th percentile) (see Figure 2).

Table 1
Group means (SD) for manual dexterity, ball skill, and balance tasks of M-ABC-II

	Group with AS (N=30)	Control group (N=30)
Manual dexterity		
Peg turning		
Preferred hand (time, s)	21.80 ± 5.22 (15–46)	17.57 ± 2.71 (13–25)
Non-preferred hand (time, s)	24.60 ± 9.12 (17–40)	19.77 ± 2.75 (15–26)
Triangle with bolt & nuts (s)	63.40 ± 34.20 (25–255)	37.60 ± 7.90 (27–47)
Drawing trail (#/errors)	1.00 ± 1.95 (0–8)	0.40 ± 1.04 (0–5)
Ball skills		
Catching		
Preferred hand (#catches/10)	4.90 ± 3.55 (0–10)	8.53 ± 2.30 (1–10)
Non-preferred hand (#catches/10)	3.80 ± 3.44 (0–10)	7.73 ± 2.32 (1–10)
Throw at target (#hits/10)	4.57 ± 1.76 (1–8)	6.77 ± 2.00 (2–10)
Balance		
Two board balance (s)	15.87 ± 11.76 (0–30)	26.67 ± 6.41 (11–30)
Toe-to-heel (#/steps)	8.03 ± 5.68 (0–15)	13.77 ± 3.04 (3–15)
Zigzag hopping		
Best leg (#/hops)	4.57 ± 1.22 (1–5)	5 ± 0.00 (5)
Other leg (#/hops)	4.23 ± 1.22 (1–5)	5 ± 0.00 (5)

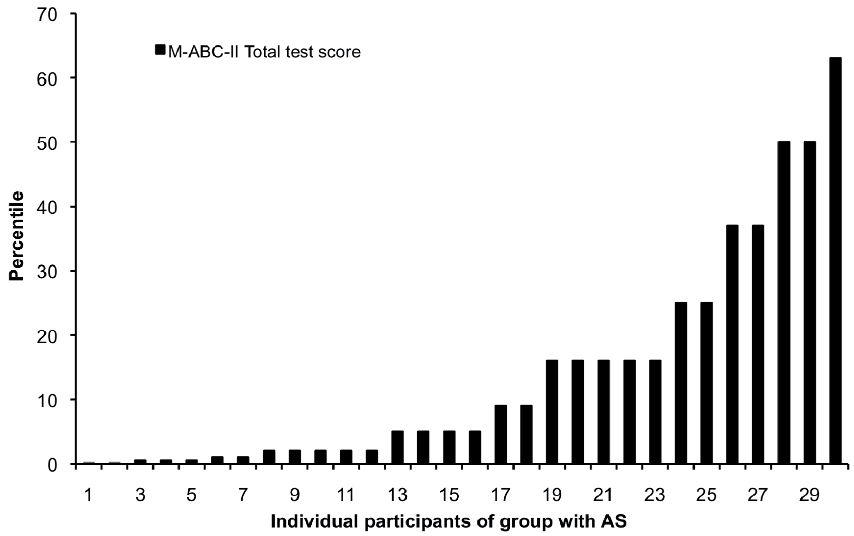
Note. Mean ± Standard Deviations, values enclosed in parentheses represent range of scores.

Figure 1. Mean component - and total test scores (+SD) of the M-ABC-II for both group with AS (N = 30) and control group (N = 30).



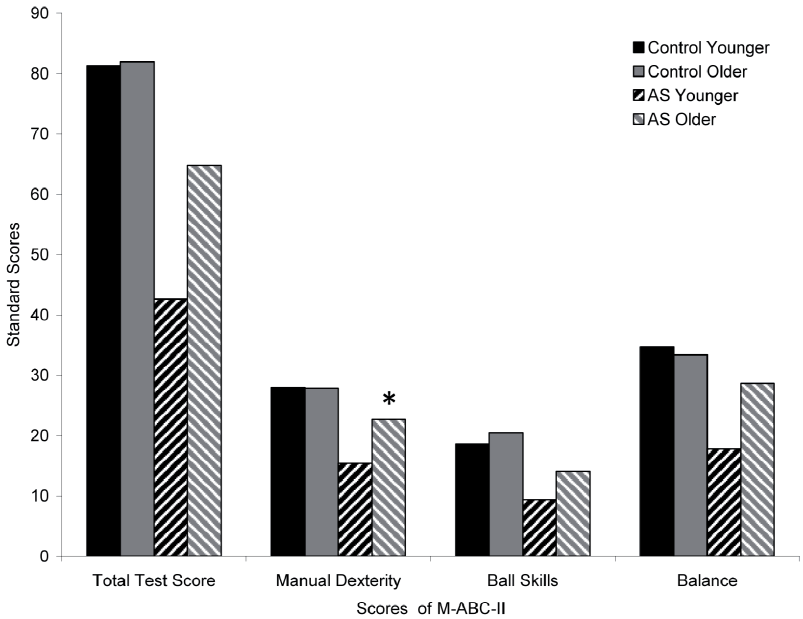
Note. Level of significance *p<0.001.

Figure 2. Percentile equivalents for M-ABC-II total test score for group with AS (N = 30).



Secondly, the results of the MANOVA on the two groups split by age showed no differences between the youngest and the oldest fifteen in the control group with Wilk's Lambda λ = .56, $F(9, 20) = 1.75$, and $p > .05$. In the group with AS, the older group scored close to 'significantly different' on the overall motor competence with Wilk's Lambda λ = .56, $F(9, 20) = 4.48$, and exact $p = .051$. This older group scored significantly better only on the component of manual dexterity with Wilk's Lambda λ = .52, $F(4, 25) = 5.72$, and $p < .01$. Whereas the differences between the younger and the older group with AS on the components ball skills (with Wilk's Lambda λ = .86, $F(3, 26) = 1.40$, and $p > .05$) and balance (with Wilk's Lambda λ = .81, $F(4, 25) = 1.44$ and $p > .05$) were not statistically significant, the data showed relative improvement in both (see Figure 3). The older group scored better on all test items but one, with effect size ranging from d = 0.1 to d = 1.05. The average effect sizes between the younger and older group with AS on items of the two other components (which were not found to differ significantly) were for ball skill items d = .38 and for balance d = .47. These effect sizes mean that the score of the average person in the older group is respectively .38 and .47 standard deviation above the average person in the group with the fifteen youngest, and hence exceeds the scores of respectively 62% and 66% of the youngest fifteen.

Figure 3. Mean component- and total test scores of the M-ABC-II for both younger (n = 15) and older group (n = 15) within the group with AS and the control group.



Note. Level of significance *p<0.01

The third goal was to provide useful data and indicators for the use of the M-ABC-II measure with our specific AS group of 16+. For the four-item component of manual dexterity, Cronbach's alpha was low, but equal in both groups with α = .44. Results showed that the bimanual task to make a triangle with nuts and bolts was covering a different underlying aspect than the other three items. If this test item would be deleted Crohnbach's alpha reaches acceptable levels of internal consistency, respectively with α = .65 for control group and α = .71 for the group with AS.

The three-item component of ball skills showed a normal Cronbach's alpha for the control group with α = .73 and a higher value with α = .84 for the AS group. The overlap of catch preferred hand and catch non-preferred hand is considerable, and within the AS group the use of both items simultaneously adds no statistical or discriminative power, nor any supplemental variance.

The four item component of balance shows a lower than acceptable Cronbach's alpha in the control group with α = .35. This may be an indication that the original test is used beyond limits in this age group due to a ceiling effect. Surprisingly, the Cronbach's alpha is much higher, yet still lower than acceptable, in the group with AS with α = .57 meaning that this test has preserved some relevance and consistency in the index group. When both zigzag hopping items are left out, the Cronbach's alpha rises to a recommended level with α = .73.

DISCUSSION

The general discussion of this article covers three main aspects, beginning with the comparison of motor competencies of young adults with AS and age and gender matched controls. Young adults with AS continue to demonstrate motor problems and perform at a much lower level than their peers. Moreover, individuals who were assessed as having severe motor impairment were not likely to have single, isolated motor problems. Generally the individuals with AS needed either more time to complete the M-ABC-II tasks or performed the tasks less successfully. The nature of these problems seems to be a generalized pervasive motor problem affecting both fine and gross motor abilities. These comparative data should be interpreted with care as the present findings reported relatively low internal consistency levels.

In this field study, based upon test scores and clinical impressions a profile of an individual's performance over the different components of the test was examined and all participants received feedback about their specific strengths and weaknesses in order to design an appropriate intervention. Qualitative and quantitative information gathered using the M-ABC-II item specific observations is provided below to highlight some interesting

insights in the underlying challenges concerning motor skills in individuals with AS.

In the manual dexterity tasks an overall observation was a poor sitting posture with tendency for individuals to hold their head often too close to the task. On the turning pegs task four individuals dropped several pegs on the floor during the trial. Often they tried to rush through the task using jerky movements and excessive force with lack of accuracy as a result. The task with the triangle was often perceived as a challenge. Holding the bolt with one hand and screwing the nut on with the other was the most challenging part in this bimanual task. About 30% of the students got muddled in the construction sequence and two out of three needed a second trial to finish the task successfully at their own pace. During the paper-pencil drawing trail task about 50% of the students had difficulties with adequate force control often using excessive force and pressing the pen very hard on the paper. About 30% of the participants finished the drawing trail successfully without any error. While many students struggled there was large variability within the group with AS, with some individuals being extremely skilled in some fine motor activities, finishing the fastest of the whole study group including the controls. Typically these individuals had enhanced hand-eye coordination, as a result of their specific hobbies, such as knitting and building model airplanes, which both involve precise motor skill repetition.

The students' 'aiming and catching' accuracy appeared to be particularly poor. When catching a tennis ball with one hand the movements often lacked fluency and participants had difficulty judging the accurate force of the throw. There was a tendency to not anticipate the trajectory of the ball resulting in their hand not 'giving' to meet its impact, thus gradually absorbing the ball's force. Body and arms were held rigidly, making it a challenge to move quickly to the left or to the right, forward or back, to intercept the ball. Often timing was an issue too, with their fingers closing a fraction too late. In average they could catch every second ball. Some students had difficulty changing their hand positions in preparation of a catch. They had difficulty depending on where the ball is, to execute the right movement pattern, meaning pointing the fingers up when catching a high ball and down when catching a low one. At the end of the formal testing students were allowed to catch with both hands and also use their body in their attempt to catch successfully. Throwing at the wall target was easier, with on average every second ball hitting the target. When some participants started off unsuccessfully with one hand they changed hands during the trial with variable force control.

On the balance tasks 25% of the students could stand for 30 seconds on the boards. The ones who could not balance often showed exaggerated movements of both arms and trunk to stay in balance. In the walking toe-to-heel test it was very difficult for some participants to keep both legs on the line at the start. The ones who were not so successful often went too fast for accuracy, in an attempt to overcome wobbliness when placing their feet on the line. In the zigzag hopping most students were successful after the second attempt with some having problems stopping at the end causing stumbling on landing.

The confirmatory calculation of percentiles based each individuals' raw scores indicated the severity of the motor impairment (See Figure 2). Our results suggest that 60% are at risk for motor impairment. Most of the 18 individuals with AS who scored below the 15th percentile displayed a range of motor problems across the three subscales of the M-ABC-II, often with ball skills being the most affected. Another five individuals scored on the 16th percentile. These individuals were more likely to have one or two areas of relative strength, often with one score close to the 50th percentile. While their stronger areas seem to be balance and fine motor skills, ball skills were the lowest and proved the most difficult. In the control group percentile scores ranged form the 16th to the 95th putting all controls participants within normal range. As expected gender differences were minimal in both groups and this is in line with previous research using the M-ABC-II (Henderson et al., 2007). Nonetheless, the summary of these findings does not reflect the complexity of the actual data where a far more variable picture presides. Because these findings were consistent with those of other studies of children with AS (Green et al., 2002; Manjiviona & Prior, 1995) and also in adults (Freitag, Kleser, Schneider, & von Gontard, 2007; Sahlander et al., 2008) we can suggest that motor impairment follows children with AS into adulthood. Longitudinal studies using standardized measures are recommended to support this idea.

Secondly, the results of the MANOVA on the two groups split by age showed, as expected, no differences between the younger and the older in the control group. On the contrary the results showed a nearly statistically significant overall motor competence difference between the groups with AS. Despite possible improvement with increasing age, motor impairment continues to be present into young adulthood among individuals with AS. With this small sample size, statistical significance should not misguide us when focusing on effect size. Relative improvements were found in all three components including the two non-significant differing ones, ball skill as well as balance. Due to the small sample size and the unavailability of equal groups at each age level we may have been unable to detect any actual developmental trend difference. Developmental research, with larger sample sizes and multiple measures over time, is needed in order to capture the proposed trend in detail.

The third goal was to provide a preliminary exploration of the use of the M-ABC-II in young adults with AS. Our data suggest that the M-ABC-II provides evidence of validity for young adults with AS as the test is able to distinguish between groups of individuals who might be expected to have movement difficulties (as our index group) and those whose motor development is typical for their age (as our control group). According to our tentative statistical analysis (as Cronbach's alpha) the M-ABC-II test has a rather low degree of validity, with Cronbach's alpha being higher in the group with AS than in the control group. Therefore careful interpretation of the current findings is suggested, as also considerable variability within and between the groups was observed. When in the control group ceiling levels were reached on many of the test items, in the group with AS all test items but one (zigzag hopping) were still challenging enough and able to differentiate between individual's ability. In the present study, based upon statistical analysis, internal consistency would have been at a more acceptable level when for example drawing trail and zigzag hopping would have been omitted. There is a need to further elaborate on the eventual need to omit and/or adapt some of the test items. Future research using the M-ABC-II with adults should address population specific psychometric properties in order to give a clearer recommendation to fine-tune this test instrument.

Even though establishing age norms for adults is needed, we recommend the use of the M-ABC-II assessment battery with young adults with AS in clinical practice when the test results are interpreted alongside other data, both formally and informally, and classification of individuals as impaired/not impaired is not drawn from a single score from one test. For young adults with AS motor performance may be expected to improve after the age of 16, and it seems that the M-ABC-II test may be sensitive to motor strengths and weaknesses of these individuals.

Further, it must be recognized that the findings of the present study are limited by the use of a single test of motor impairment with mean age of the participants above the age range of the M-ABC-II. While capturing deficits in different areas of motor functioning, it does not provide specific information on the patterns of the impairments, nor on the relationships between other important characteristics of AS such as social interaction and communication. Therefore, studies using multiple tools with larger samples are recommended to further clarify the aspects of motor coordination in individuals with AS. Design limitations notwithstanding, the findings of this study provide meaningful information regarding: the motor profiles of young adults with AS as it replicated problems in fine and gross motor skills previously found in children, and the use of the M-ABC-II with this specific population.

PERSPECTIVE

The findings of the present study highlight the need for appropriate assessment of motor skills of young adults in adapted physical education. In this study, young adults with AS were assessed using a standardized test intended for a younger population. However, the findings of our study support the feasibility of using the MBC-II for this group, as many participants were identified as being at-risk for severe motor impairment. Because of the limited norm referenced instruments for those above the age of 16 years, professionals working with young adults are often challenged in the selection of appropriate measurement instruments. Even though establishing age norms for adults is certainly a future research objective, we do recommend the 'careful' use of the M-ABC-II for young adults with AS. In our view it is a valuable tool in assessing motor abilities for setting up the intervention in clinical practice.

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REFERENCES

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders (DSM-IV)* (4th ed.). Washington DC: Author.

Attwood, T. (1998). *Asperger's syndrome : a guide for parents and professionals*. London ; Philadelphia: Jessica Kingsley Publishers.

Baird, G., Simonoff, E., Pickles, A., Chandler, S., Loucas, T., Meldrum, D., et al. (2006). Prevalence of disorders of the autism spectrum in a population cohort of children in South Thames: the Special Needs and Autism Project (SNAP). *Lancet, 368*(9531), 210–215.

Chow, S. M., & Henderson, S. E. (2003). Interrater and test-retest reliability of the Movement Assessment Battery for Chinese preschool children. *American Journal of Occupational Therapy, 57*(5), 574–577.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Lawrence Earlbaum Associates.

Ehlers, S., Gillberg, C., & Wing, L. (1999). A screening questionnaire for Asperger syndrome and other high-functioning autism spectrum disorders in school age children. *Journal of Autism and Developmental Disorders, 29*(2), 129–141.

Faber, I. R., & Nijhuis van der Sanden, M. W. G. (2004). The Movement Assessment Battery for Children. Standardisation and reliability of Age Band 5: young adults. In L. Henderson, D. Sugden & A. Barnett (Eds.), *The Movement Assessment Battery for Children-2.* (2007 ed.). London: Pearson Assessment.

Fombonne, E. (2003). Epidemiological surveys of autism and other pervasive developmental disorders: an update. *Journal of Autism and Developmental Disorders, 33*(4), 365–382.

Freitag, C. M., Kleser, C., Schneider, M., & von Gontard, A. (2007). Quantitative assessment of neuromotor function in adolescents with high functioning autism and Asperger syndrome. *Journal of Autism and Developmental Disorders, 37*(5), 948–959.

Ghaziuddin, M., & Butler, E. (1998). Clumsiness in autism and Asperger syndrome: a further report. *Journal of Intellectual Disability Research, 42*(1), 43–48.

Ghaziuddin, M., Butler, E., Tsai, L., & Ghaziuddin, N. (1994). Is clumsiness a marker for Asperger syndrome? *Journal of Intellectual Disability Research, 38*(5), 519–527.

Gillberg, I. C., & Gillberg, C. (1989). Asperger syndrome – some epidemiological considerations: a research note. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 30*(4), 631–638.

Green, D., Baird, G., Barnett, A. L., Henderson, L., Huber, J., & Henderson, S. E. (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 and Allied Disciplines, 43*(5), 655–668.

Henderson, S., Sugden, D., & Barnett, A. L. (2007). *Movement Assessment Battery for Children-2*. London: Pearson Assessment.

Klin, A., Volkmar, F. R., Sparrow, S. S., Cicchetti, D. V., & Rourke, B. P. (1995). Validity and neuropsychological characterization of Asperger syndrome: convergence with nonverbal learning disabilities syndrome. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 36*(7), 1127–1140.

Largo, R., Fischer, J., & Caflisch, J. (2002). *Zurcher Neuromotorik*. Zurich: AWE-Verlag.

Lopata, C., Hamm, E. M., Volker, M. A., & Sowinski, J. E. (2007). Motor and visuomotor skills of children with Asperger's disorder: preliminary findings. *Perceptual and Motor Skills, 104*(2), 1183–1192.

Manjiviona, J., & Prior, M. (1995). Comparison of Asperger syndrome and high-functioning autistic children on a test of motor impairment. *Journal of Autism and Developmental Disorders, 25*(1), 23–39.

Mattila, M. L., Kielinen, M., Jussila, K., Linna, S. L., Bloigu, R., Ebeling, H., et al. (2007).

An epidemiological and diagnostic study of Asperger syndrome according to four sets of diagnostic criteria. *Journal of the American Academy of Child and Adolescent Psychiatry, 46*(5), 636–646.

Miyahara, M., Tsujii, M., Hori, M., Nakanishi, K., Kageyama, H., & Sugiyama, T. (1997). Brief report: motor incoordination in children with Asperger syndrome and learning disabilities. *Journal of Autism and Developmental Disorders, 27*(5), 595–603.

Posserud, M., Lundervold, A. J., & Gillberg, C. (2006). Autistic features in a total population of 7 to 9-year-old children assessed by the ASSQ (Autism Spectrum Screening Questionnaire). *Journal of Child Psychology and Psychiatry, 47*(2), 167–175.

Sahlander, C., Mattsson, M., & Bejerot, S. (2008). Motor function in adults with Asperger's disorder: a comparative study. *Physiotherapy Theory and Practice, 24*(2), 73–81.

Siaperas, P., Holland, T., & Ring, H. (2006). Discriminative validity of the Movement ABC Test and Checklist for use with children with Asperger Syndrome. In S. E. Henderson, D. Sugden & A. Barnett (Eds.), *Movement Assessment Battery for Children-2* (2007 ed.). London: Pearson Assessment.

Smith, I. M. (2000). Motor functioning in Asperger syndrome. In A. E. Klin (Ed.), *Asperger syndrome* (pp. 97–124). New York: The Guilford Press. .

World Health Organisation (1993). *International statistical classification of diseases and health-related problems, Tenth Revision (ICD-10).* Geneva: Author.

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MOTORISCHE FERTIGKEITEN VON JUNGEN ERWACHSENEN MIT ASPERGER SYNDROM: EINE VERGLEICHSSTUDIE

(Resümee)

Störungen der motorischen Fertigkeiten werden als übliches Charakteristikum des Asperger Syndroms (AS) beschrieben, allerdings sind spezifische Informationen in Hinblick auf junge Erwachsene spärlich. Die Absicht dieser Studie war: ein Vergleich der motorischen Fertigkeiten junger Erwachsener mit AS zu einer in Alter und Geschlecht passenden Kontrollgruppe unter Verwendung einer aktualisierten Version der standardisierten Movement Assessment Battery for Children (M-ABC-II) sowie ein Vergleich der Leistungen zwischen jüngeren und älteren Teilnehmern innerhalb beider Gruppen (Versuchs- und Kontrollgruppe). Zusätzlich wurden Validität und Reliabilität der M-ABC-II für die Anwendung in der betreffenden Zielgruppe überprüft. Junge Erwachsene mit AS erbrachten die motorischen Aufgaben auf einem bemerkenswert niedrigeren Niveau als ihre Peers. Sie zeigten fortgesetzte motorische Entwicklungsverzögerungen im Altersgang, wenn es auch schien, als ob sich die motorischen Fähigkeiten der Jugendlichen mit AS nach den Entwicklungsjahren verbesserten. Die Verwendung der M-ABC-II kann für junge Erwachsene mit AS als nützliches Mittel zur Erhebung motorischer Fertigkeiten bei Interventionen in der erzieherischen und klinischen Praxis empfohlen werden.

SCHLÜSSELWÖRTER: Asperger Syndrom, motorische Fertigkeiten, motorische Fähigkeiten, Ungeschicklichkeit, M-ABC-II, Erwachsene.

COMPETENCES MOTRICES DE JEUNES ADULTES ATTEINTS DU SYNDROME D'ASPERGER MOTOR : UNE ETUDE COMPARATIVE

(Résumé)

Les difficultés liées aux compétences motrices sont décrites comme un trait commun de syndrome d'Asperger (AS), mais des informations spécifiques concernant les jeunes adultes sont rares. Les objectifs de cette étude étaient les suivants: comparer les compétences motrices de jeunes adultes avec AS avec des groupes contrôles appariés selon l'âge et le sexe, en utilisant la version mise à jour du test d'évaluation « Movement Assessment battery for children" (M-ABC-II), et de comparer les compétences motrices entre les participants les plus jeunes et les plus âgés au sein des deux groupes (groupe expérimental et groupe témoin). En outre, la validité et la fiabilité du test d'évaluation M-ABC-II pour son utilisation avec la population ont été étudiées. Les jeunes adultes avec AS ont effectué ces tâches motrices à un niveau nettement inférieur à celui de leurs pairs. Ils ont démontré que les retards moteurs perdurent avec l'avancée en âge, même si les compétences motrices des personnes atteintes d'AS semblaient s'améliorer après l'adolescence. L'utilisation du test M-ABC-II est recommandée pour les jeunes adultes avec AS comme un outil précieux dans l'évaluation des capacités motrices permettant la mise en place d'interventions dans le cadre éducatif et des pratiques cliniques.

MOTS CLEFS : Syndrome d'Asperger, habiletés motrices, compétence motrice, maladresse, M-ABC-II, adultes.

II

PHYSICAL FITNESS AND PHYSICAL ACTIVITY IN ADOLESCENTS WITH ASPERGER SYNDROME: A COMPARATIVE STUDY

by

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Physical Fitness and Physical Activity in Adolescents With Asperger Syndrome: A Comparative Study

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While physical activity is beneficial for youth with developmental disabilities, little is known about those individuals' fitness profile and levels of activity. Therefore the purpose of this study was to investigate the physical fitness profile and physical activity level of 30 adolescents with and without Asperger syndrome (AS). Evaluations were done using the Eurofit physical fitness test and the Baecke Habitual Physical Activity questionnaire. A 2 × 2 MANOVA indicated that adolescents with AS scored significantly lower than the comparison group on all physical fitness subtests, including balance, coordination, flexibility, muscular strength, running speed, and cardio-respiratory endurance ($p < .001$). Adolescents with AS were also less physically active ($p < .001$). Engagement in physical activities is therefore recommended.

Asperger syndrome (AS) is considered to be at the higher end of the continuum of Autism Spectrum Disorders (ASD). Although individuals with AS often have behavioral and social difficulties associated with autism, people with AS tend to have language and cognitive skills within or above normal range (Attwood, 1998, 2009). The disorder is characterized by qualitative impairments in social interaction and subtle communication skills and restrictive interests (American Psychiatric Association, 1994). AS may also include motor clumsiness, problems with handwriting, and being hypo- or hypersensitive to specific sensory experiences (Gillberg & Gillberg, 1989). Besides these difficulties, individuals with AS also have positive qualities including a wish to seek knowledge and truth, albeit with a different set of priorities than the norm; being direct, honest and determined; enjoying solitude; being a loyal friend; and having a distinct sense of humor (Attwood, 2009).

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Physical activity is vital for a healthy lifestyle for individuals with and without disabilities (Ploughmann, 2008). While low fitness and physical inactivity are strongly associated with each other, research evidence also suggests that individuals with poor motor coordination are less physically active than their more coordinated peers (Bouffard, Watkinson, Thompson, Dunn, & Romanow, 1996; Hands & Larkin, 2006; Sahlander, Mattsson, & Bejerot, 2008). In his classic paper on the syndrome, Hans Asperger (1944, translated in Frith, 1989) presents four case histories and all describe children with AS as motor clumsy or poorly coordinated. About a boy named Fritz he notes, "Motor milestones were rather delayed. He learned to walk at fourteen months, and for a long time was extremely clumsy and unable to do things for himself" (Asperger, p. 39). About another boy named Harro he described, "The motor clumsiness was particularly well demonstrated in physical education lessons. Even when he was following the group's leader instructions and trying for once to do a particular physical exercise, his movements would be ugly and angular. He was never able to swing with the rhythm of the group. His movements never unfolded naturally and spontaneously" (Asperger, p. 57). Similarly, major differences in motor competence between children on the autistic spectrum and typically developing children have been reported in a number of studies (Green et al., 2002; Sahlander et al., 2008; Smith, 2000). Of particular interest is a study by Green et al. (2002), focusing on children with AS. Their aim was to measure the severity and the extent of motor impairment in children with AS using the Movement ABC (M-ABC; Henderson & Sudgen, 1992). This M-ABC is a valid and reliable norm referenced motor ability test, used to identify children who are significantly behind their peers in motor development. Among 11 children with AS tested on the M-ABC, all obtained total test scores below the 15th percentile with nine being below the 5th percentile, indicating severe motor impairments.

Physical exercise is important for everyone, but especially for individuals with autism spectrum disorder. Where physical activity reduces the risk of chronic diseases including cancer, diabetes, and coronary heart disease in all people, research evidence with ASD suggests that moderate to intensive physical exercise is often associated with decreases in stereotypic behaviors, hyperactivity, aggression and self-injury, and increases in concentration (e.g., Elliott, Dobbin, Rose, & Soper, 1994; Rosenthal-Malek & Mitchell, 1997). Elliott et al. (1994) used different types of aerobic exercise with a group of adults with ASD and suggested that, while mild exercise (hr 90-120 beats per minute) seemed to have little effect on maladaptive and stereotypic behaviors, only more intensive aerobic exercise (hr above 130) resulted in significant reductions of these behaviors. Rosenthal-Malek and Mitchell (1997) reported that following moderate aerobic activity (20 minute jogging sessions), children with ASD experience increases in attention span and on-task behavior.

Recent research with youth with ASD, including AS, indicated that they were less active than their normal developing peers, were at similar risk for health problems associated with inactivity, and showed a similar decline in physical activity with increasing age (Pan & Frey, 2006). Where it is recommended that typically developing children and adolescents should do 60 minutes (1 hour) or more of physical activity each day, only few meet this standard (USDHHS, 2009). As increasing physical fitness and activity levels could be a key element in individuals' with AS habilitation process, it is important to gain insight into their physical fitness profiles and activity levels. To date, these have not been thoroughly investigated. Therefore, the purpose of this study was to assess components of physical fitness and perceived physical activity levels in adolescents with and without Asperger syndrome. Because differences in fitness levels may be related to differences in practice and training, self-reported physical activity measurements were also included in this study.

Method

Participants

Thirty young adults aged 15–21years (M = 17.2yrs; SD = 1.2) with Asperger syndrome agreed to participate in the study. Members of the group with AS were selected from an upper secondary vocational education program, especially designed for young adults with ASD, in the province of southern Finland. To be included in this group, all participants were required to meet the diagnostic criteria for AS as presented in the ICD-10R (F84.5; World Health Organization, 1993; i.e., deficiencies in social interaction and communication, but no clinically significant delay in language or cognitive development). A professional with 10 years of experience diagnosing people on the autism spectrum made the diagnosis. Mental retardation and psychosis were used as exclusion criteria. The group of participants with AS consisted of 9 females (M = 18.0 yrs; SD = 1.4 yrs) and 21 males (M = 16.9 yrs; SD = 0.9 yrs). Prior to the investigation, informed consent was presented orally by the principal investigator with minimal technical jargon and the aid of pictures about the test tasks. In a voluntarily additional student/parent meeting dedicated to inform both the students and their parents about this research project, the students received an informed consent form to take home. They were asked to return these documents within the same week if they intended to participate in the study. These written consents (from both the participants and their legal guardians) were collected by the principal investigator. The school's ethical committee approved the study, and the treatment of participants was in accordance with the ethical standards of the American Psychology Association. The control group consisted of thirty age- and gender-matched students (M = 16.9; SD = 0.8 yrs). The participants in the control group had no physical or mental disabilities according to their own reports. All participants in this study were Caucasian, followed upper secondary education, and were from the same geographic region. Demographic data on the participants are provided in Table 1.

Table 1 Demographic Data of Adolescents With and Without Asperger Syndrome (AS)

	Adolescents with AS (N = 30)		Adolescents without AS (N = 30)	
	M ± SD	Min-Max	M ± SD	Min-Max
Age	17.2 ± 1.2	15-21	16.9 ± 0.8	16-19
Height (cm)	173.1 ± 7.3	158-191	171.5 ± 8.1	155-188
Weight (kg)	63.7 ± 14.8	47-122	62.7 ± 9.0	47-84
BMI (kg/m^2)	21.3 ± 4.8	16-39	21.0 ± 2.0	18-26

Note. No significant differences observed.

Instruments

Eurofit. Physical fitness was assessed using selected items of the European test of physical fitness (Eurofit; Adam, Klissouras, Ravazzolo, Renson, & Tuxworth, 1988), which is widely employed within European schools. Most of these test items were used annually in adapted physical education assessments in the participating schools. For this reason, students had a certain familiarity level with the test items. Considering the difficulty these individuals may have with change and new routines, this familiarity was an important reason for choosing the Eurofit. The selected test items are also similar to the items of other widely used tests, such as the in the U.S. popular Brockport Physical Fitness Test (Winnick & Short, 1999).

The information collected included the assessment of the following components: demographic information, flexibility, musculoskeletal fitness (tests for muscle strength and endurance), motor fitness (tests for balance and speed of movement), and aerobic fitness (test for cardio-respiratory endurance). The items of this test battery, used to measure the aforementioned components, are reliable and valid, and this instrument is commonly used to measure physical fitness in children and adults in Europe (Mac Donncha, Watson, McSweeney, & O'Donovan, 1999). A detailed description of the test items is given in Oja and Tuxworth (1995). Guidelines from the Eurofit manual were followed and both the group with AS and control group were given the same test set-up.

Demographic information includes age, height, weight, and body mass index (BMI; see Table 1). BMI was defined as body mass (kg, measured using an electronic weighing scale to the nearest 0.1 kg) divided by height (m, measured to the nearest 0.1cm) squared. The items used from the Eurofit measured the following physical fitness components: *Flexibility* was measured using the sit-and reach test (SAR). This test involves sitting on the floor with legs out straight ahead. Feet (shoes off) were placed with the soles flat against the sit-and-reach box, shoulder-width apart. The tester held both knees flat against the floor. Subjects reach as far as possible forward in a smooth and slow movement without twisting the shoulders. The knees were held in extended position by the investigator throughout the test. The better of the two trials was recorded to the nearest 1 cm. *Muscle strength* was measured by handgrip strength (HGR) using a handgrip dynamometer (JAMAR Hydraulic Hand Dynamometer) that was squeezed as forcefully as possible with the preferred hand. Subjects sat in a straight-backed chair with feet flat on the floor, shoulders adducted in a neutral position, arms unsupported, elbows flexed at 90 degrees, and forearm in neutral rotation. The better of two trials was recorded to the nearest 1 kg. *Explosive muscle strength* was measured by a standing broad jump (SBJ), using a tape measure on a foam mat. Participants were asked to stand behind the line and jump forward as far as possible using an arm swing and knee bend before jumping. The distance jumped was recorded from the take-off line to the landing point closest to the aforementioned take-off line. The better of two trials was measured to the nearest 1 cm. *Muscular endurance* was measured as the number of correctly completed sit-ups in 30 seconds (SUP). This test was performed with the hands placed at the side of the head, fingertips touching the back of the earlobes, knees bent 90°, and the subject's feet being held by the tester. A correct sit-up was defined as touching the knees with the elbows and returning the shoulders to the ground. *Balance* (single leg balance test, SLB) was measured as the number of attempts needed by the individuals to achieve a total duration of 30 s in balance. This test was performed on a flat firm surface on their preferred foot with eyes closed. For reasons of safety and test familiarization, this test was performed with eyes open first. *Speed and coordination of limb movement* (plate tapping, PLT) was assessed using a plate tapping table on which two rubber discs at 80 cm distance have to be touched alternately with the preferred hand as quickly as possible. The score was the amount of time needed to complete 25 cycles. The better result of the two attempts (recorded in tenths of a second) was the score. *Running speed* was assessed using a 10 by 5 m shuttle run (SHR5). Each participant was required to sprint 10 times between two lines placed 5 m apart. The track was 1.3 m wide. The result was recorded to the nearest tenth of a second.

While the previous items were from the Eurofit for children, we opted to estimate *aerobic fitness* (cardio-respiratory endurance) by using the 2 km walking test of the Eurofit for adults (UWT2). Due to possible motivational challenges of individuals with AS with regard to intensive physical activity, the Cooper test and 20 m shuttle run (both recommended endurance tests of the Eurofit for children), which typically require minimal coordination skills, were not administered. From our clinical experience, our students with AS were unlikely to persist at these tasks, typically giving up on such tests. The 2 km walking test was considered to be less demanding and targets a population that would have difficulty completing a running test (e.g., Laukkanen, Oja, Ojala, Pasanen, & Vuori, 1992). The 2-km walking test was administered outdoors on a hard, even surface. Participants warmed up for 10 minutes by walking to the testing track. The track was marked with colorful cones and one loop was 400 meters. Participants walked five laps at a brisk continuous pace, without running. The walking time was recorded to the nearest second. Heart rate at the end of the test was monitored with a heart rate monitor (Polar FS1, Polar, Kempele, Finland). Descriptive data on physical fitness profiles is provided in Table 2.

Physical Activity Research Questionnaire (PARQ). A questionnaire was designed to assess the participants' physical activity background with questions about the participants' demographic information, knowledge about physical fitness, feelings toward physical activity, and perceived physical activity level. This paper-pencil questionnaire was filled out during regular school hours under the supervision of the primary investigator. The questionnaire was completed in small groups of three to five. During an average administration time of half an hour, participants had the opportunity to ask questions regarding the questionnaire. An expert panel, existing from three licensed therapists (two physiotherapists and an occupational therapist), discussed the PARQ questionnaire and unanimously judged that the content of the questionnaire had adequate coverage on participants' physical activity background needed to plan future intervention. To earn specific knowledge about perceived physical activity levels, a questionnaire developed by Baecke (Baecke, Burema, & Frijters, 1982) for measurement of a person's Habitual Physical Activity (HPA) was included as an important part of the PARQ. This HPA questionnaire evaluates physical activity over the previous 12 months. The HPA makes use of easy-to-understand scales

Table 2 Descriptive Data on and Comparison of Physical Fitness Profiles of Adolescents With and Without Asperger Syndrome

	Adolescents With AS			Adolescents Without AS		
	Males (N = 21)	Females (N = 9)	Total (N = 30)	Males (N = 21)	Females (N = 9)	Total (N = 30)
SAR (cm)	22.7 ± 11.3	26.6 ± 11.7	23.87 ± 11.4	34.3 ± 11.5	37.7 ± 9.8	35.3 ± 10.9**
HGR (kg)	31.9 ± 13.7	23.4 ± 6.3	29.37 ± 12.5	45.2 ± 16.7	24.0 ± 3.8	38.9 ± 17.2*
SUP (#/30 s)	12.8 ± 5.1	10.0 ± 7.0	12.0 ± 5.8	24.7 ± 6.5	19.3 ± 3	23.1 ± 6.2**
SLB (#/30 s)	6.0 ± 5.5	6.8 ± 5.5	6.2 ± 5.4	1.7 ± 1.1	1.3 ± 0.7	1.6 ± 1.0**
PLT (0.1s)	166.5 ± 65.0	174.2 ± 42.1	168.8 ± 58.5	106.8 ± 9.8	125.6 ± 13.2	112.4 ± 13.8**
SBJ (cm)	145.7 ± 35.6	123.0 ± 19.8	138.9 ± 33.0	218.8 ± 30.2	147.0 ±16.3	197.3 ± 42.7**
SHR5 (0.1 s)	248.7 ± 38.1	246.0 ± 25.9	247.9 ± 34.5	189.0 ± 13.2	202.9 ± 10.5	193.2 ± 13.9**
UWT2 (s)	1079 ± 175	1079 ± 175	1129 ± 185	967 ± 80	992 ± 58	975.1 ± 74.2**
HF end (bpm)	129.7 ± 26.7	124.2 ± 20.1	128.1 ± 24.7	147.7 ± 17.6	166.0 ± 17.5	153.2 ± 19.3**

Note. *$p < .05$, **$p < .01$ for comparison of total groups with and without AS; SAR-sit and reach, HGR-handgrip strength, SUP-sit-ups, SLB-single leg balance, PLT-plate tapping, SBJ-standing broad jump, SHR5- shuttle run 5X10, UWT2- 2km walking test, HF end- heart rate at end of walking test.

to assess the magnitude of physical activity and separates physical activity into three distinct dimensions, including work activity, sports activity, and leisure activity. Although each dimension had a precise set of questions, for this study we only used the "sports activity" part of the questionnaire, as we were interested in their specific sport activities during leisure time. This section included questions on sport and physical exercise in leisure time and consisted of four main questions, scored on a five-point scale: whether or not you play sports in general; whether, compared to your own age group, you think you are more or less active; whether or not you sweat during leisure time; and whether or not you play sports in leisure time. If a participant answered affirmatively to the first question, six more questions followed to gather data regarding their most frequently played sports. These questions included information on intensity and regularity of their sport activities. Baecke et al. divided sport intensity into three levels: (a) low level (e.g., billiards, sailing, bowling, golf) with an average energy expenditure of 0.76 MK/h; (b) middle level (e.g., badminton, cycling, dancing, swimming, tennis) with an average energy expenditure of 1.26 MJ/h; (c) high level (e.g., boxing, basketball, football, rugby, rowing) with an average energy expenditure of 1.76 MJ/h. Based on this, a simple sport score (SSS) for the participants' most (SSS1) and second most (SSS2) frequently played sport as well as a physical exercise in leisure time score (PEL) were calculated. A simple sport score was calculated by multiplying the values for intensity, weekly time, and number of months spent on their most frequently played sports. The total sport score was calculated by adding both SSSs together. The PEL score was found by dividing the sum of the points on the four parameters by four. A number of studies have shown good reliability indices for Baecke's HPA questionnaire. The values for physical exercise score were of $r = 0.93$ for Belgian adult males (Philippaerts & Lefevre, 1998). A second study showed that the questionnaire can correctly classify elderly people as low or highly active but does a poorer job for moderately active individuals (Hertogh, Monninkhof, Schouten, Peeters, & Schuit, 2008). Other data by Pols et al. (1995) showed that repeatability of the questionnaire is good and evidence based on relations to other variables (in Pols' case an activity diary) is moderate. Descriptive data on physical activity levels is provided in Table 3.

Table 3 Descriptive Data on and Comparison of Physical Activity Levels of Adolescents With and Without Asperger Syndrome

	Adolescents With AS (N = 30)		Adolescents Without AS (N = 30)	
	M ± SD	Min-Max	M ± SD	Min-Max
SSS1	112.9 ± 119.8	0-406	331.1 ± 243.4**	0-729
SSS2	22.0 ± 45.6	0-185	80.0 ± 126.6*	0-522
SSST	120.5 ± 123.4	0-426	411.1 ± 310.8**	0-1044
PEL	255.0 ± 78.1	100-400	328.3 ± 80.1**	175-475

Note. Level of significance $*p < .05$, $**p < .01$; SSS1-simple sport score 1,SSS2-simple sport score 2, SSST-simple sport score total, PEL-physical exercise in leisure time score.

Procedures

A team of three licensed therapists (two physiotherapists and one occupational therapist) with 5-10 years of experience in working with individuals with AS assessed the individuals with and without AS during the school year 2007-2008. Each assessment was initiated with a short (approximately 10 minutes) informative session, briefing the participants about the test situation. The verbal presentation was supported by pictures of test environments and of the test items. Thereafter, the participants responded to the PA questionnaire mentioned above. Breaks were built in and this first session took approximately one hour. Over the next few days, the students took part in the different fitness tests, conducted in small groups from 4 to 8 persons. The same selection of fitness tests and same testing procedures were used for both index (group with AS) and control group. Students wore suitable physical education clothing, so that movement was not restricted in any way. After a 10-minute warm up, the fitness tests were administered. A demonstration of every single task was given prior to test administration. Additionally, every station had a laminated information sheet, describing the specific test. These included pictures of the test position and guidelines for administration. The student-teacher ratio was 3:1. This second test session took around 1.5 hours, including build-in breaks. A week after completion of all sub-tests, the participants met the principal investigator. They received verbal and written feedback with regards to their performance and spoke about their own physical activity goals.

Data Analysis

Data were analyzed using SPSS 17 (PASW Statistics) for Windows. Descriptive statistics were obtained and the different items of the Eurofit were combined in a 2 × 2 (group by gender) MANOVA-model to assess differences between index and control group. Univariate F-tests as well as effect size statistic (partial eta-squared) were used as follow-up procedures in order to evaluate differences on the different physical fitness tests with regard to groups and gender. A 5% level of statistical significance was implied (0.05). A similar 2 × 2 MANOVA-model was used to assess differences between index and control group with regard to levels of reported physical activity.

Results

Gender is combined in description of results, because no significant interactions between group and gender were found, with, respectively, Wilk's lambda for the mean score of physical fitness items, PF = 0.746, $F(8, 49) = 2.09$ ($p > 0.05$), and Wilk's lambda for reported physical activity level RPAL = 0.975, $F(4, 53) = 0.35$ ($p > 0.05$).

Group Differences in Physical Fitness

The multivariate statistics of variance revealed significant main effect differences between groups on physical fitness items, with Wilk's lambda, respectively (λPF) = 0.358, $F(8, 51) = 10.18$ ($p < .001$) and partial eta-squared = 0.56, representing large effect. As follow up procedures, univariate F statistics indicated group differences on all subtest of the Eurofit (see Table 2). Adolescents with Asperger syndrome did not score as high as the comparison group on all physical fitness tests. Significant differences between the two groups were found in tests of balance, coordination, speed of limb movement, flexibility, strength, running speed, and cardio-respiratory endurance.

Group Differences in Reported Physical Activity

Significant differences were shown for reported physical activity levels with Wilk's lambda (λRPAL) = 0.651, $F(4, 54) = 7.35$ ($p < .001$) and partial eta-squared = 0.30, representing large effect. The univariate F statistics indicated group differences on all reported physical activity variables (see Table 3).

When asked in the PARQ physical activity questionnaire if they were involved in sports activity, the majority (80 %) of the group with AS reported not being involved at all or being involved in less intense physical activities once a week. On the other hand, most individuals in the control group exercised intensely at least a few times a week.

There was an obvious discrepancy in the kinds of activities in which the index and control group were engaged. Adolescents with AS preferred solitary activities such as walking, swimming, and biking. Their typically developing peers were more engaged in team sports and group activities such as ice hockey, soccer, aerobic, and fitness classes. The participants with AS who were engaged in more intense activity had often trained and participated in one particular sport (e.g., martial arts, badminton, bowling, mountain biking, indoor climbing) and had been doing so regularly for many years. We hypothesize that they had achieved greater skill level because of intensive participation in their favorite physical leisure time activity throughout their childhood with many repetitions as a key to success. The choice of the above mentioned leisure time activities in the AS group was logical, as all activities were structured in nature and had repeated actions as well as rhythm built in. As well, these activities were less competitive and, to a certain degree, predictable. For example, in an indoor climbing unit, one climbs up as high as she/he can following a predictable route and, when finished, repels down. This is followed by belaying the climbing partner. This clear "your turn/ my turn" structure as well as the choice of a preset (and clearly marked) route makes indoor climbing attractive for people with AS, because it is already adapted to their specific needs.

Gender Differences

Where females and males differed significantly on the physical fitness test items, Wilk's lambda PF = 0.424, $F(8, 49) = 8.31$ ($p < .001$) and partial eta-squared = 0.58, no gender difference was found for the levels of physical activity, Wilk's lambda = 0.99, $F(4, 53) = 0.14$ ($p > 0.05$). From the eight physical fitness test items, only four significantly differed between gender beyond the 0.05 level. As expected, males were stronger and scored higher than the females on strength items (handgrip, sit-ups, and standing broad jump). Females also scored lower on the walking test.

Discussion

To our knowledge, this was one of the first studies to examine physical fitness and physical activity levels in adolescents with AS. The obtained results relative to previous research, its implications for individuals with AS, as well as its limitations and recommendations for future research are presented in the discussion.

Results and Implications in Perspective

Adolescents with AS had lower levels of physical fitness in balance, coordination, flexibility, muscular strength, running speed, and cardio-respiratory endurance and had higher levels of physical inactivity when compared to age matched peers. Engagement in an active lifestyle, featuring individualized training adapted for adolescents with AS, may improve their overall fitness. Motivating adolescents with AS to adhere to such an active lifestyle, however, is a major challenge, as it is well documented that, in the general population, PA significantly decreases from childhood to adulthood (Telama et al., 2005). To improve program adherence in persons with AS, one must develop an exercise program that is manageable, supportive, and tailored to their interests and fitness levels. Too difficult or chaotic activities may discourage future involvement in physical activity. Inspiring students with AS to be active can be achieved by including students in the planning of the PA curriculum as well as listening to their specific reflections on activities. It is important to gather feedback about which parts of the activity they enjoyed most (e.g., warming-up, main part, or cooling down) and why certain activities at certain places are more favored. For example, our students did not like ice skating "too much" at the large and empty nearby primary school ice field, but they were thrilled skating on the "for tourists mainly" ice ring in the middle of our capital's city centre. It was during daytime and not too busy, but it was still cozy and attractive as it had music, video clips, and skaters of various skill levels. Spontaneous reflections of adolescents with AS on assessment and physical activities may provide teachers with very interesting information that could be useful with regard to their pedagogical and curricular approach. Teachers can increase enjoyment and active participation of all students, including students with AS, in their group by keeping in mind some basic adapted physical education teaching strategies, such as organizing and structuring events into routines, using language that is clear and to the point, using pictures or visual cues to illustrate the task, being aware of sensory preferences and reducing sensory overload, using prompts and positive reinforcement, and maximizing the active time spent in the physical education class.

In this study, one week after being assessed, all students with AS voluntarily met the principal investigator for 30 minutes to discuss their test results and discuss their future physical activity goals. During this relaxed one-on-one conversation, valuable information was shared. For example, most participants reported that they only joined in physical education at school because it was required and would avoid participating if possible. Many have had very negative movement experiences in the past and have viewed themselves as clumsy and uncoordinated; often, they were the last ones picked for a team. A commonly stated negative aspect of physical education (PE) was the reliance on motor skill improvement to evaluate students' ability. This type of assessment frequently does not take into account individual differences and uniqueness, and is too performance related (e.g., the time it takes to swim 100 yards or the number of baskets they can make). This competitive environment can be traumatizing for individuals with AS and may result in decreased motivation and lower self-esteem. In our view, in a noncompetitive yet stimulating environment, individuals with AS often are focused and engaged in the proposed activities. It is crucial that instructors who work with people with AS focus on their strengths rather than their weaknesses. This “ability first” approach is an important step in establishing a respectful and long-lasting working relationship as it may lead to lifelong participation in physical activity.

The results of this study confirm previous research results in youth with ASD (e.g., Pan & Frey, 2006) and demonstrates that adolescents with AS are less physically active in leisure time than their peers. Adolescents with AS may be at risk for developing sedentary behavior as they mature, due to potential overuse of technology-based activities during leisure time such as “surfing” the net and TV watching (e.g., one participant reported in the research questionnaire spending in average ten hours per day surfing the web or watching recorded shows on TV), small amount of physical education time in school, lack of active recess time during secondary school, and lower physical fitness associated with the disorder. Stimulating healthy exercise habits and reinforcing positive physical activity as early in life as possible could contribute to regular participation in PA. This can be achieved by working with not only the students, but with the whole family to encourage doing fun physical activities together. Going for a swim or biking together or even a 15 minute stretch session or morning walk are strongly recommended. Such bouts of physical activities could easily be built into the daily schedule of the whole family. Another way to stimulate exercise habits is to give the adolescents a choice of age appropriate fun activities, according to what their peers would be interested in as this drives motivation. This could include a wide range of activities ranging from basic walking or swimming to more less known activities such as fencing, canoeing, orienteering, and rock climbing. Even technology-based physical activities, such as Wii boxing or tennis, may be beneficial to increase fun physical activity. Also tailor made instructional strategies, such as using pictures, giving extra slow-motioned demonstration of the activity, or adapting an activity to increase success could facilitate exercise adherence. All these together could lead to a greater appreciation of exercise, health benefits, and, as well, contribute to maximal community participation such as employment and independent living as an adult.

Limitations of the Study and Recommendations for Future Research

The small sample of convenience limits generalizability. The recruitment of participants from a preparatory training for vocational upper secondary education is a limitation that must be considered when interpreting these results. Examining the effects of physical education and the influence of educational placement on motor skill and physical fitness are areas that require further research. Although we did not assess the relationship between other important characteristics of AS—such as social interaction and communication—ongoing research is crucial to better understand the impact of these abilities in a PA environment. Future research could also examine different methods by which fitness and activity levels of students with AS could be increased. These could include, but are not limited to, familial considerations, peer tutoring, exercise opportunities, curricular issues, pedagogical issues, and last but not least, "social issues" related to welcoming (in many senses of the word) students with AS.

Design limitations notwithstanding, the findings of this study provide meaningful, new information regarding the physical fitness profiles and physical activity habits of adolescents with AS. Adolescents with AS were less physically fit and active than adolescents in the control group. As students with AS are at risk for physical inactivity, engagement in physical activity—with individualized training adapted for individuals with AS—is strongly recommended.

References

Adam, C., Klissouras, V., Ravazzolo, M., Renson, R., & Tuxworth, W. (1988). *Eurofit: European test of physical fitness*. Rome, Italy: Council of Europe, Committee for the Development of Sport.

Asperger, A. (1944). Autistic psychopathology in childhood autism. Translated in U. Firth, Ed., *Autism and Asperger Syndrome* (1989, pp. 37-92): Cambridge: Cambridge University Press.

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders (DSM-IV)* (4th ed.). Washington DC: Author.

Attwood, T. (1998). *Asperger's syndrome: A guide for parents and professionals*. London, Philadelphia: Jessica Kingsley Publishers.

Attwood, T. (2009). *Asperger syndrome*. Retrieved May 21, 2009, from http://www.tonyattwood.com.au/

Baecke, J.A., Burema, J., & Frijters, J.E. (1982). A short questionnaire for the measurement of habitual physical activity in epidemiological studies. *American Journal of Clinical Nutrition, 36*, 936-942.

Bouffard, M., Watkinson, E.J., Thompson, L.P., Dunn, J.L.C., & Romanow, S.K.E. (1996). A test of the activity deficit hypothesis with children with movement difficulties. *Adapted Physical Activity Quarterly, 13*, 61-73.

Elliott, R.O., Dobbin, A.R., Rose, G.D., & Soper, H.V. (1994). Vigorous, aerobic exercise versus general motor training activities: Effects on maladaptive and stereotypic behaviors of adults with both autism and mental retardation. *Journal of Autism and Developmental Disorders, 24*, 565-576.

Gillberg, I.C., & Gillberg, C. (1989). Asperger syndrome—some epidemiological considerations: A research note. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 30*, 631-638.

Green, D., Baird, G., Barnett, A.L., Henderson, L., Huber, J.W., & Henderson, S.E. (2002). The severity and nature of motor impairment in Asperger syndrome. *Journal of Child Psychology and Psychiatry, 45*, 655-668.

Hands, B., & Larkin, D. (2006). Physical fitness differences in children with and without motor learning difficulties. *European Journal of Special Needs Education, 21*, 447-456.

Henderson, S., & Sugden, D. (1992). *The movement assessment battery for children*. London: The Psychological Corporation.

Hertogh, E.M., Monninkhof, E.M., Schouten, E.G., Peeters, P.H., & Schuit, A.J. (2008). Validity of the modified Baecke questionnaire: Comparison with energy expenditure according to the doubly labeled water method. *International Journal of Behavioral Nutrition and Physical Activity, 5*, 30.

Laukkanen, R.M., Oja, P., Ojala, K.H., Pasanen, M.E., & Vuori, I.M. (1992). Feasibility of a 2-km walking test for fitness assessment in a population study. *Scandinavian Journal of Social Medicine*, *20*, 119-126.

Mac Donncha, C., Watson, A.W.S., McSweeney, T., & O'Donovan, D.J. (1999). Reliability of Eurofit physical fitness items for adolescent males with and without mental retardation. *Adapted Physical Activity Quarterly, 16*, 86-95.

Oja, P., & Tuxworth, B.E. (1995). *Eurofit for adults: A test battery for the assessment of the health-related fitness of adults*. Rome, Italy: Council of Europe, Committee for the Development of Sport.

Pan, C.Y., & Frey, G.C. (2006). Physical activity patterns in youth with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 36*, 597-606.

Philippaerts, R.M., & Lefevre, J. (1998). Reliability and validity of three physical activity questionnaires in Flemish males. *American Journal of Epidemiology, 147*, 982-990.

Ploughmann, M. (2008). Exercise is brain food: The effects of physical activity on cognitive function. *Developmental Neurorehabilitation, 11*, 236-240.

Pols, M.A., Peeters, P.H., Bueno-De-Mesquita, H.B., Ocke, M.C., Wentink, C.A., Kemper, H.C., et al. (1995). Validity and repeatability of a modified Baecke questionnaire on physical activity. *International Journal of Epidemiology, 24*, 381-388.

Rosenthal-Malek, A., & Mitchell, S. (1997). Brief report: The effects of exercise on the self-stimulatory behaviors and positive responding of adolescents with autism. *Journal of Autism and Developmental Disorders, 27*, 193-202.

Sahlander, C., Mattsson, M., & Bejerot, S. (2008). Motor function in adults with Asperger's disorder: A comparative study. *Physiotherapy Theory and Practice, 24*, 73-81.

Smith, I.M. (2000). Motor functioning in Asperger syndrome. In A.E. Klin, Ed., *Asperger syndrome* (pp. 97-124). New York: The Guilford Press.

Telama, R., Yang, X., Viikari, J., Valimaki, I., Wanne, O., & Raitakari, O. (2005). Physical activity from childhood to adulthood: A 21-year tracking study. *American Journal of Preventive Medicine*, 28, 267-273.

USDHHS (2009). Physical activity guidelines for Americans. Retrieved May 20, 2009, from http://www.health.gov/paguidelines/guidelines/chapter3.aspx

Wing, L. (1981). Asperger syndrome: A clinical account. *Psychological Medicine, 11*, 115-129.

Winnick, J.P. & Short, F.X. (1999). *The Brockport Physical Fitness Training Guide.* Champaign, IL: Human Kinetics.

World Health Organisation (1993). *International statistical classification of diseases and health-related problems*, Tenth Revision (ICD-10). Geneva: Author.

III

SENSORY PROCESSING IN ADOLESCENTS AND ADULTS WITH ASPERGER SYNDROME: A COMPARATIVE STUDY

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Sensory processing of adolescents and adults with Asperger syndrome: A comparative study

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Abstract

The nature and severity of sensory processing problems in Asperger syndrome (AS) is a poorly known area. Atypical sensory processing patterns have been reported in individuals with autism spectrum disorders, but there is little self-reported information about high functioning adolescents and adults with AS. This study provides results of an assessment of sensory processing in 45 individuals with AS compared to matched controls using the Adolescent/Adult Sensory Profile. Additionally the sensory profiles of a subgroup of 30 individuals with AS over varied levels of motor competence were explored, using the updated version of the Movement Assessment Battery for children. A MANOVA revealed statistically significant differences between groups on overall sensory processing as well as on three of the four sensory quadrants (low registration, sensation seeking, and sensation avoidance). Case series analysis revealed that almost 50% of the group with AS reported extreme levels of sensory processing and that large variability was found within the group with AS. A Mann-Whitney U analysis revealed significant differences between the motor competence groups with AS for the sensation seeking quadrant. Implications regarding differences in profile are discussed.

(183 words)

Sensory processing of adolescents and adults with Asperger syndrome: A comparative study

Introduction

Asperger syndrome (AS) is considered to be at the higher end of the continuum of Autistic Spectrum Disorders (ASD), and is according to the DSM-IV (American Psychiatric Association, 1994) characterized by a qualitative impairment in social interaction (e.g., failure to develop friendships, impaired use of body language), a qualitative impairment in subtle communication skills (e.g., difficulties with conversation skills, a tendency to make a literal interpretation), and restrictive interests (e.g., preference for routine and consistency). People with AS often experience motor clumsiness, problems with handwriting and being hypo-or hypersensitive to specific sensory experiences, yet these characteristics are often not part of the diagnostic criteria. Due to a lack of research in sensory processing in AS, there is limited understanding of these specific sensory problems and the possible link with motor competence. Both motor problems as well as atypical sensory processing are very common in individuals with AS. Estimates of the prevalence of motor problems range from 50% to 85% (Attwood, 1998; Borremans, Rintala, & McCubbin, 2009; Sahlander, Mattsson, & Bejerot, 2008; Smith, 2000). Also the prevalence of sensory abnormalities is relatively high with estimates ranging from 30-100% (Dawson & Watling, 2000). In a Finnish study by Nieminen-von Wendt and co-workers (2005) the corresponding figure for subjectively reported presence of atypical sensibilities was 91%.

While the nature and severity of atypical sensory processing is still poorly understood in AS, a growing body of knowledge suggests that these individuals may have atypical sensory processing (Crane, Goddard, & Pring, 2009; Dunn, Myles, & Orr, 2002). Hypo- and hypersensitivity can occur across the full range of sensations and is commonly associated with challenging behavior (Dunn et al., 2002). People with AS are often sensitive to: tactile input, including light touch, texture, sudden changes in temperature; auditory input such as noise and unexpected sounds; and visual stimuli, being easily distracted in chaotic environments. They may show deficits in their ability to place their bodies in the space around them and guide speed and direction of movement. Recent evidence suggests that sensory processing is also linked with other important characteristics of AS, such as intelligence and social competence. Crane et al. (2009) hypothesized in their pilot study that high non-verbal IQ scores in adults with ASD may serve as a protective factor against sensory processing abnormalities. They reasoned these adults (with a higher IQ) may be more adept in implementing strategies to reduce the effects of deviant sensory processing. Evidence about the relationship between social competence and sensory processing is given by (Hilton, Graver, & LaVesser, 2007). They concluded that the relationship between the sensory profile quadrants (Dunn, 1999) and the Social Responsiveness Scale (Constantino & Gruber, 2005) indicated that the sensory quadrant scores are related to autism severity. Both previous mentioned studies support the importance of examining and addressing sensory processing issues in the evaluation and intervention of individuals with AS.

In a school setting, sensory issues can prove overwhelming to an individual and make it difficult to perform daily activities such as cueing in line, using a fork and knife, tying shoelaces, handwriting, regular physical education classes and recreation settings. These difficulties may also be influenced by deficits in executive functions (Happe, Booth, Charlton, & Hughes, 2006). With proper assessment of these sensory differences, more effective and tailor made interventions can be designed. A widely used way to assess unusual sensory responses in clinical practice is by questionnaires, often administered to parents or caregivers, such as the Sensory Profile (Dunn, 1999) or the Sensory Sensitivity Questionnaire (SSQ-R; Talay-Ongan & Wood, 2000). The most popular questionnaire is the Sensory Profile (SP) which provides information on how well children process sensory information in everyday situations, and which specific sensory systems effect most on functional performance. Often caregivers or parents fill in these questionnaires. Myles and colleagues (2004) found differences in sensory characteristics of children with autism and children with AS using the SP. Another recent study (Kern, Garver et al., 2007) examined the sensory quadrants using the same Sensory Profile over a wide age range including adults. They found that all sensory quadrants were different between a group of persons with autism aged 3-43 years, as compared to community controls. Results indicated that the older persons in their index group scored closer to the controls than the younger persons.

Although the amount of evidence of unusual sensory processing in ASD is growing (e.g., Baranek, Boyd, Poe, David, & Watson, 2007; Crane et al., 2009; Dawson & Watling, 2000; Dickie, Baranek, Schultz, Watson, & McComish, 2009; Kern, Garver et al., 2007; Kern et al., 2006; Sahlander et al., 2008), specific self-reported information regarding adolescents and adults with AS is very scarce. Only one study has empirically examined self-reported sensory processing in adults with ASD. Crane et al. (2009) administered the Adolescent/Adult Sensory Profile (AASP) to a small group of 18 adults, of which 16 had a formal diagnosis of Asperger syndrome, and found significant sensory processing differences between both groups, with almost 95% of the group with ASD reporting extreme levels of sensory processing on at least one of the sensory quadrants. In their conclusion they referred to the importance of objective measures of sensory processing being developed, yet did not report the reliability assessment of the instrument used for their specific sample.

Whereas the theoretical framework of the AASP and the psychometric evidence given in the manual (Brown & Dunn, 2002) provide a basis for the claim that scores from the sensory profile can provide reliable and valid inferences about an individual's sensory processing patterns, more evidence is needed to support its use. According to testing standard (AERA et al., 1999) the test user is ultimately responsible for evaluating the reliability and validity evidence in the particular setting in which the test is to be used. To date, very little reliability data is available to support the use of the AASP with our specific population. Therefore, the purposes of this study are: to examine internal consistency reliability of the sensory quadrants of the AASP; to examine differences in sensory processing between the group with and without AS, to examine the relationship between SP and age, to explore the patterns and extent of sensory processing differences at an individual level in the group with AS, and finally to examine differences in sensory processing in adolescents with AS over varied levels of motor competence.

Method

Participants

A total of 90 people participated in this study: 45 high-functioning adolescents/adults with a formal diagnosis of Asperger syndrome aged 15 to 43 years (M = 19.62, SD = 6.59) and 45 age and gender matched controls from the same region (M = 19.42, SD = 6.13, range 16-42). The participants were recruited from vocational training units and via advertisements in the national journal for ASD. Thirty out of 45 participants with AS were young adults aged 15-21years (M = 17.2yrs; SD = 1.2) from different vocational education programs, the other 15 participants enrolled via different ads in the national journal. To be included in the group with AS, all participants were required to have been diagnosed with AS by a trained professional and meet the diagnostic criteria for AS as presented in the ICD-10R (F 84.5; WHO, 1993) (i.e. qualitative deficiencies in reciprocal social interaction, and restricted, repetitive stereotyped patterns of behavior, interest and activities, but no clinically significant delay in language or cognitive development). Mental retardation and psychosis were used as exclusion criteria. The group with AS consisted of 33 males and 12 females and this uneven gender distribution is in line with the most recent epidemiological data that male/female ratio is 1/3 (Ehlers, Gillberg, & Wing, 1999; Mattila et al., 2007). No specific IQ scores were available, but the knowledge that all participants fell within normal range.

The participants of the control group were recruited from various upper secondary schools and social groups in the same region. They had no physical or mental disabilities according to self-reports. Prior to all investigations, informed consent was obtained from all participants and when appropriate also from their legal guardians. Ethical approval was obtained from the appropriate committee.

Instruments

AASP

The Adult/Adolescent Sensory Profile (AASP: Brown and Dunn, 2002) was used as the primary assessment tool. The AASP is a 60-item self-questionnaire for evaluating behavioral responses to everyday sensory experiences. It provides a standard method to profile the effect of sensory processing on functional performance. An individual answers questions regarding how she or he generally responds to various sensory experiences on a five-point scale (1 = almost never, 2 = seldom, 3 = occasionally, 4 = frequently, 5 = almost always). The profile is based on Dunn's Model of Sensory Processing (Dunn, 1997) where neurological thresholds and behavioral responses are presented as a continuum that interacts with each other (see Table 1). The neurological threshold, which can be high on one end or low on the other end of the continuum, refers to the amount of stimuli for a human neuronal system to respond. The behavioral response refers to the way in which a person responds to her/his sensory thresholds. A person may respond passively or in other words in accordance with his threshold at one end of this continuum, while at the other end a person responds actively to counteract the thresholds. The interaction between these two continuums forms the following four sensory quadrants: low registration, sensation seeking, sensory sensitivity and sensation avoidance (see Table 1).

Insert Table 1 around here

Low registration items refer to a high neurological threshold in combination with a passive behavioral response. These items identify behaviors such as slowed responses and missing stimuli. For example items like ‘I don’t seem to notice when someone touches my arm or back’ or ‘I have to ask people to repeat things’ address this quadrant.

Sensation seeking items refer to a high neurological threshold in combination with an active behavioral response. These items identify responses and characteristics where one pursues sensory stimuli. Items like ‘I like to wear colorful clothing’ or ‘I like how it feels to get my hair cut’ cover the sensation seeking quadrant.

Sensory sensitivity items refer to a low neurological threshold combined with passive behavioral responses. These specific items identify responses such as discomfort with sensory stimuli and distraction. Example items are ‘I dislike the movement of riding in a car’ or ‘I am distracted if there is a lot of noise around me’.

Sensation avoiding items refer to low neurological threshold in combination with active behavioral response. These items identify behaviors such as reducing sensory stimuli or make exposure to stimuli predictable. For example ‘I avoid elevators because I dislike the movement’ or ‘I choose to shop in smaller stores because I’m overwhelmed in large stores’ are example items of the sensation avoidance quadrant. There are 15 questions per quadrant and these cover different sensory processing categories such as Taste/Smell, Movement, Visual, Touch, Activity Level, and Auditory.

In our view Dunn's model of sensory processing brings greater understanding about why individuals engage in particular behaviors and why they prefer certain experiences and environments. Knowing these individual's particular preferences enables more informed intervention planning. Another advantage is that the profile is non-intrusive and is easy and quick to administer and it is compatible for the use in school settings like ours.

Internal consistency reliability (Cronbach's alpha) for the different quadrants of the AASP, used with neurotypicals, is moderate to acceptable, ranging between .64 and .78 (Brown & Dunn, 2002).

M-ABC-II

The updated version of the Movement Assessment Battery for Children, the M-ABC-II, was used as a secondary assessment tool (Henderson, Sugden, & Barnett, 2007). The M-ABC-II test contains eight items that assess three components of functioning: manual dexterity, balance and ball skills. The test provides objective, quantitative data on motor competence. The raw scores obtained for each item can be converted to item standard scores using age related norms. The test provides also percentile scores for each age group through 16. According to the M-ABC-II manual scores at or below the 5th percentile are considered indicative of significant motor difficulty and scores between the 6th and 15th percentile suggest being at risk for having motor problems.

The M-ABC-II test has proven reliable and valid (Chow & Henderson, 2003; Faber & Nijhuis van der Sanden, 2004; Henderson, Sugden, & Barnett, 2007) and has been recommended for use with the present population (Borremans et al., 2009).

Procedures

All participants filled out the AASP self-report questionnaire in their preferred way as a paper/pencil or computer version in a quiet room at school or at home. This computer version was created in SPSS Mr. Interviewer and had 8-13 questions per screen. This is in line with the format in the original paper version of the AASP. One could only get to the next screen if all questions were answered. Standard instructions from the test manual were given and where required clarifications were made. The benefits of doing the computer based questionnaire is that one can adapt the format for individual preference, such as for example font size and amount of questions per screen. Most of the participants in this study were experienced using computers and the internet and felt more attracted to do the online survey rather than to fill out the paper/pencil form.

The 30 participants with AS following vocational training were also administered the M-ABC-II as a part of a larger investigation. A team of three experienced therapists assessed these adolescents. Each assessment was initiated an informative briefing about the test situation supported with pictures of the test items, whereafter the motor tests were administered in the classroom and/or school's gymnasium. This motor competence assessment took approximately 45 minutes.

Data analysis

The first purpose was to provide exploratory information for the use of the AASP with adolescents and adults with AS. The AASP underlying construction allows for an analysis of the items for internal consistency reliability. Cronbach's alpha was used to assess how well the set of items per sensory quadrant in the AASP measure the proposed latent construct and as an indicator of reliability of this test for our age specific group. Given the nature of the test and the small sample size, it needs to be stressed that it is merely an indicator.

Second, the scores on all four quadrants were combined in a MANOVA-model (computed using alpha = .05) using summation of quadrants scores to reflect an overall sensory processing score. Univariate F-tests as well as effect size statistics, partial eta-squared, and power analyses were used as follow-up procedures in order to evaluate the significance of the different sensory quadrants between groups. The hypothesis was that the group with AS would score significantly different than the control group on overall sensory processing as well as on all four quadrants.

Third, correlational analysis was used to assess the relationship between sensory processing and age. A significance level of $p < 0.05$ (two-tailed) was set. This analysis was based upon the possibility of the older participants having learned effective coping strategies for their sensory issues and therefore would show more typical sensory profiles.

The fourth purpose was to explore the patterns and extent of sensory processing differences at an individual level in the group with AS. As in previous research (Crane et al., 2009; Hill & Bird, 2006) we opted to use case series analysis as it provides a conservative way to use the t-distribution for identifying participants that fall below the 5^{th} or above the 95^{th} percentile of the normal performance. The results of this preliminary analysis were used to focus the direction of the subsequent analyses, that of the multiple case series. The main focus was on the number of participants whose scores fell in the 5% extreme scores in the deviant tail of the normal curve of the control group. Because the group with AS, when compared to the control group, had higher scores in low registration, sensory sensitivity, and sensation avoiding, their cut-off score was calculated as the mean of the control group plus two standard deviations. The group with AS had lower scores in sensation seeking and therefore was the cut-off score calculated as the mean of the control group minus two standard deviations. The same method as in Ramus et al. (2003) was followed for defining the normal range. First, the control mean and standard deviation (SD) were calculated among control participants and those control participants who qualified for atypical performance (falling below the 5th percentile of the t-distribution) were removed (in our case: two with one atypical score and one with atypical scores on three quadrants). Second, the control mean, SD and number of cases were recalculated and the AS participants falling below or above the 5% cut-off were identified and considered as atypical performers.

Finally, to examine differences in sensory processing in adolescents with AS over varied levels of motor competence, the individuals with AS currently following vocational training (n = 30), were divided based upon the percentile scores of the M-ABC-II. A group at risk for motor impairment (scoring at or below the 15th percentile) was compared to the participants scoring above the 15th percentile. A Mann-Whitney *U analysis* was used to compare the SP quadrant scores between the group at risk for motor impairment versus the group not at risk. A P-level of .05 was set prior to data-analysis.

Results

First, the values of Cronbach's alpha for the various quadrants and for both groups were at an acceptable level ranging from .66 to .84, as shown in Table 2. These results indicate good reliability for our specific populations.

Insert Table 2 about here

Second, the multivariate analysis of variance revealed statistically significant difference of the index group compared to the control group on overall sensory processing (Wilk's Lambda

$\lambda = .765$, $F(4, 84) = 6.45$ ($p<.001$), with partial eta squared = .235, observed power = .98) as well as on three of the four sensory quadrants (low registration, sensation seeking, and sensation avoidance). On the sensory sensitivity quadrant a nearly significant difference was obtained with exact p = .052. The effect sizes and observed power per quadrant ranged respectively from .40 to .77 and from .50 to .95 (see Table 3). Where the group with AS had higher scores on the low registration, sensory sensitivity and sensation avoiding quadrants, lower scores were obtained in the sensation seeking quadrant.

Insert Table 3 around here

Third, Pearson correlations revealed significant within-group correlations regarding age and levels of sensory processing in both groups. In the group with AS positive correlations were found between age and two of the four sensory quadrants (low registration with r-value of .34 ($p < .05$) and sensory sensitivity with r-value .35 ($p < .05$)). In the control group only one (in this case negative) correlation was observed between age and the low registration quadrant (r-value -.40 ($p < .01$).

Fourth, the results of the multiple case series analysis demonstrated that 48.8% of the participants in the group with AS were found to display atypical sensory processing on at least one of the four quadrants. Results demonstrated that the number of participants with extreme scores varied remarkably between the quadrants with ranges from 4% to 40% (see Table 4). From the 22 participants who had atypical scores on one quadrant, 7 had atypical scores on two quadrants and 3 on 3 quadrants. The scores of only these 22 atypical scoring participants are plotted in Table 4.

Insert Table 4 around here

Finally, differences in sensory quadrant over varied levels of motor competence were examined. A subgroup of 30 individuals with AS was divided into a group at risk for motor problems and a group not at risk based on their M-ABC-II percentile score. The group at risk contained 19 of the 30 individuals. Descriptive data of both groups are given in Table 5. The Mann-Whitney U analysis revealed significant differences between the motor competence groups with AS for only one of the four sensory quadrants (sensation seeking). Table 6 contains these data.

Insert Tables 5 and 6 around here

Discussion

This study provides detailed results of an assessment of sensory processing in adolescents and adults with AS compared to matched controls. It is the first study to provide specific information on the psychometric properties of the AASP with individuals with AS, as well as on the atypical sensory processing of this group of individuals with an additional focus on the sensory profiles on an individual basis, and over varied levels of motor competence. The general conclusions of this article cover five main aspects, beginning with the psychometric properties of the AASP used. The results confirm the acceptable to good internal consistency reliability given in the manual (Brown & Dunn, 2002). Acceptable internal consistency reliability of the AASP was observed for both the group with AS, and the control group in our Finnish sample. These findings provide important information about the consistency of responses to the different questions of the AASP, for each sensory quadrant. These results confirm our choice of the AASP as a reliable tool to screen for atypical sensory processing patterns in individuals with AS.

Secondly, the results of the MANOVA showed significant difference of the index group compared to control group on overall sensory processing and contribute additional evidence to the overall picture of AS. The specific quadrants with distinct differences were low registration, sensation seeking, and sensation avoidance with effect sizes (ES) ranging from .40 to .77 indicating medium to large effect differences between the groups. These effect sizes can be interpreted in terms of the percentage of nonoverlap of scores between both groups. An ES of .40 indicates a nonoverlap of 27.4% whereas an ES of .77 indicates a nonoverlap of 44% in the two distributions. These findings of atypical sensory processing patterns in AS, are in line with the body of knowledge in the ASD literature suggesting a high prevalence of sensory processing challenges (Crane et al., 2009; Dunn et al., 2002; Kern et al., 2006; Kern, Trivedi et al., 2007; Kientz & Dunn, 1997). An interesting comparison between our data can be made with the results found by Crane et al. (2009) in their adult high functioning autism/AS group. Where their effect sizes ranged from 1.17 to a striking 2.20 (indicating a nonoverlap of their distribution ranging from 60 to over 80%), our results showed much lower effect sizes. This indicates that the sample in the present study had less deviant sensory processing patterns than the sample used in this earlier research.

When we compared the average scores, of both our group with AS and our control group, to the norms given in the AASP manual, only the score from the sensation seeking quadrant of our group with AS would be classified as deviant from most people's scores. Our group with AS seems to engage less in sensation seeking behavior than most people, which was also observed in previous research (e.g., Crane et al., 2009; Dunn et al., 2002). This 'less than most people'-score means that their average score fell between 2% and 15% of the scores of the standardization population. On the three other quadrants (low registration, sensory sensitivity, and sensation avoiding) our group with AS fell within the ‘similar to most people’-category, indicating that their scores fell between 16% and 84% of the scores of the standardization population. When taking a closer look at these results, it is observed that on two of these three quadrants (low registration and sensation avoiding) our group with AS scored close to the ‘more than most people’- category. Not surprisingly, exactly in the low registration, sensation seeking and sensation avoiding significant group differences were found between our group with AS and our control group. One reason of the differences in sensory profile found by different research teams might be due to a cross-cultural effect. Where the standardization sample was recruited form the mid-west United States, our index and control group were recruited from Finland, a country were one’s own peace and freedom are traditionally highly appreciated.

The third goal was to examine the relationships with respect to sensory quadrants and age. The correlational investigation revealed significant positive within-AS-group correlations regarding the low registration and the sensory sensititvity quadrants. This suggests that specific unusual processing patterns dissipate with increasing age. These results are in line with others suggesting that the levels of atypical processing fade out with increasing age (Kern, Trivedi et al., 2007). However, our results contrast with those of Crane et al. (2009), who suggested that levels of unusual sensory processing do not dissipate across the lifespan. Despite these contradicting results in literature, it seems plausible that individuals with AS can learn effective coping strategies for their sensory issues and that, with maturation, these strategies may continue to be refined and put more into active use. In our view, normalization of deviant sensory processing patterns starts through in-depth assessment of each individual’s unique sensory profile. This can be achieved for example by: using the AASP in combination with direct observation by a trained professional, or with new evaluation systems such as SensOR (Schoen, Miller, & Green, 2008). Evidenced based sensory exercises would ideally follow careful assessment. Future research should evaluate these sensory interventions as clear efficacy evidence of these sensory treatments has not yet been established (e.g., Dawson & Watling, 2000).

Fourth, the exploration of the patterns and extent of sensory processing differences at an individual level in the group with AS confirmed the high prevalence of atypical sensory processing. Almost 50% of our index group was found to display atypical sensory processing on at least one of the four quadrants. The majority of the outlying scores fell in the sensation avoidance quadrant. Almost all of the individuals displaying atypical sensory processing had deviant scores on the sensation avoiding quadrant (18/22), and this in almost half of the cases in combination with atypical scores on the sensory sensitivity quadrant. The index group seems to avoid more sensory input and seems to be more sensitive to sensory information from the environment. This data yields to a trend that in adolescents and adults with AS a rather lower neurological threshold might exist. People whose thresholds are rather low tend to be overly responsive (i.e., very little stimuli causes a reaction, as when people are distracted by every stimulus). Because of the relatively small sample size careful interpretation of the current findings is suggested, as also considerable variability within and between the groups was observed. Future research using the AASP with adults should address population specific psychometric properties in order to fine-tune this test instrument.

Finally, the examination of differences in SP quadrants over varied levels of motor competence showed differences for only the sensation seeking quadrant. Adolescents with AS at risk for motor impairment engaged less in sensation seeking behavior than their peers without motor problems. This is certainly not surprising as the sensation seeking quadrant contains statements such as ‘I enjoy how it feels to move about’ and ‘I choose to engage in physical activities’. Eventhough in both motor competence groups large within groups variability can be observed, it might be that atypical sensory processing patterns play an important role in the deviant motor development of many individuals with AS. Individuals learn motor skills by doing, over and over again, and by getting a wide variety of sensorimotor experiences from early on. Knowing that many individuals with AS might also meet the criteria for DCD, an interesting recent study by O'Brien and collegues (2008) in this field of research examined potential mechanisms underlying motor coordination in children with developmental coordination disorder. They suggested that there is a developmental nature in the processing of visual and auditory input and implied that the vibrotactile sensory modality may be key to the motor coordination difficulties of these children with DCD. Both these findings and the preliminary findings of the current investigation highlight the need for further study of role of sensory processing in motor (in)coordination in individuals with AS.

Further, it must be recognized that the findings of the present study are limited by the use of a single test of sensory processing. While capturing deficits in different areas of sensory processing, it does not provide specific information on the patterns of the impairments, nor on the relationships between other important characteristics of AS such as intelligence, social interaction, or communication. Therefore, studies using multiple tools with larger samples are recommended to further clarify the aspects of atypical sensory processing in individuals with AS. Another issue that should be taken into consideration is that the AASP is a self-questionnaire. While some research evidence has questioned the self-reporting reliability of instruments used with children with AS and HFA (e.g., Loukusa et al., 2007) we opted in this study to get our participants first hand information and addressed possible answering errors by allowing participants to ask questions to clarify some questions in the AASP.

Design limitations notwithstanding, the findings of this study provide meaningful information regarding: the reliability of the use of the AASP with adolescents and adults with AS, the sensory profiles of young adults with AS as it replicated substantial problems of atypical sensory processing as found in earlier research, and the exploration of sensory profiles over varied levels of motor competence in adolescents with AS.

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References

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders (DSM-IV)* (4th ed.). Washington DC: Author.

Attwood, T. (1998). *Asperger's syndrome : a guide for parents and professionals*. London ; Philadelphia: Jessica Kingsley Publishers.

Baranek, G. T., Boyd, B. A., Poe, M. D., David, F. J., & Watson, L. R. (2007). Hyperresponsive sensory patterns in young children with autism, developmental delay, and typical development. *American Journal of Mental Retardation, 112*(4), 233-245.

Borremans, E., Rintala, P., & McCubbin, J. A. (2009). Motor skills of young adults with Asperger syndrome: A comparative study. *European Journal of Adapted Physical Activity, 2*(1), 21-33.

Brown, C., & Dunn, W. (2002). *Adolescent/Adult Sensory Profile - User's Manual*. San Antonio: The Psychological Corporation.

Chow, S. M., & Henderson, S. E. (2003). Interrater and test-retest reliability of the Movement Assessment Battery for Chinese preschool children. *American Journal of Occupational Therapy, 57*(5), 574-577.

Constantino, J. N., & Gruber, C. P. (2005). *Social responsiveness scale*. Los Angeles: Western Psychological Services.

Crane, L., Goddard, L., & Pring, L. (2009). Sensory processing in adults with autism spectrum disorders. *Autism: The International Journal of Research & Practice, 13*(3), 215-228.

Dawson, G., & Watling, R. (2000). Interventions to facilitate auditory, visual, and motor integration in autism: a review of the evidence. *Journal of Autism and Developmental Disorders, 30*(5), 415-421.

Dickie, V. A., Baranek, G. T., Schultz, B., Watson, L. R., & McComish, C. S. (2009). Parent reports of sensory experiences of preschool children with and without autism: a qualitative study. *American Journal of Occupational Therapy, 63*(2), 172-181.

Dunn, W. (1999). *Sensory Profile: User's Manual*. San Antonio, TX: Psychological Cooperation.

Dunn, W., Myles, B. S., & Orr, S. (2002). Sensory processing issues associated with Asperger syndrome: a preliminary investigation. *American Journal of Occupational Therapy, 56*(1), 97-102.

Ehlers, S., Gillberg, C., & Wing, L. (1999). A screening questionnaire for Asperger syndrome and other high-functioning autism spectrum disorders in school age children. *Journal of Autism and Developmental Disorders, 29*(2), 129-141.

Faber, I. R., & Nijhuis van der Sanden, M. W. G. (2004). The Movement Assessment Battery for Children. Standardisation and reliability of Age Band 5: young adults. In L. Henderson, D. Sugden & A. Barnett (Eds.), *The Movement Assessment Battery for Children-2.* (2007 ed.). London: Pearson Assessment.

Happe, F., Booth, R., Charlton, R., & Hughes, C. (2006). Executive function deficits in autism spectrum disorders and attention-deficit/hyperactivity disorder: examining profiles across domains and ages. *Brain and Cognition, 61*(1), 25-39.

Henderson, S., Sugden, D., & Barnett, A. L. (2007). *Movement Assessment Battery for Children-2*. London: Pearson Assessment.

Hill, E. L., & Bird, C. M. (2006). Executive processes in Asperger syndrome: patterns of performance in a multiple case series. *Neuropsychologia, 44*(14), 2822-2835.

Hilton, C., Graver, K., & LaVesser, P. (2007). Relationship between Social Competence and Sensory Processing in Children with High Functioning Autism Spectrum Disorders. *Research in Autism Spectrum Disorders, 1*(2), 164-173.

Kern, J. K., Garver, C. R., Carmody, T., Andrews, A. A., Trivedi, M. H., & Mehta, J. A. (2007). Examining Sensory Quadrants in Autism. *Research in Autism Spectrum Disorders, 1*(2), 185-193.

Kern, J. K., Trivedi, M. H., Garver, C. R., Grannemann, B. D., Andrews, A. A., Savla, J. S., et al. (2006). The Pattern of Sensory Processing Abnormalities in Autism. *Autism: The International Journal of Research & Practice, 10*(5), 480-494.

Kern, J. K., Trivedi, M. H., Grannemann, B. D., Garver, C. R., Johnson, D. G., Andrews, A. A., et al. (2007). Sensory Correlations in Autism. *Autism: The International Journal of Research & Practice, 11*(2), 123-134.

Kientz, M. A., & Dunn, W. (1997). A comparison of the performance of children with and without autism on the Sensory Profile. *American Journal of Occupational Therapy, 51*(7), 530-537.

Loukusa, S., Leinonen, E., Jussila, K., Mattila, M. L., Ryder, N., Ebeling, H., et al. (2007). Answering contextually demanding questions: pragmatic errors produced by children with Asperger syndrome or high-functioning autism. *Journal of Communication Disorders, 40*(5), 357-381.

Mattila, M. L., Kielinen, M., Jussila, K., Linna, S. L., Bloigu, R., Ebeling, H., et al. (2007). An epidemiological and diagnostic study of Asperger syndrome according to four sets of diagnostic criteria. *Journal of the American Academy of Child and Adolescent Psychiatry, 46*(5), 636-646.

O'Brien, J. C., Williams, H. G., Bundy, A., Lyons, J., & Mittal, A. (2008). Mechanisms that underlie coordination in children with developmental coordination disorder. *J Mot Behav, 40*(1), 43-61.

Sahlander, C., Mattsson, M., & Bejerot, S. (2008). Motor function in adults with Asperger's disorder: a comparative study. *Physiotherapy Theory and Practice, 24*(2), 73-81.

Schoen, S. A., Miller, L. J., & Green, K. E. (2008). Pilot study of the Sensory Over-Responsivity Scales: assessment and inventory. *The American Journal Of Occupational Therapy, 62*(4), 393-406.

Smith, I. M. (2000). Motor functioning in Asperger syndrome. In A. e. a. E. Klin (Ed.), *Asperger syndrome* (pp. 97-124). New York: The Guilford Press. .

Talay-Ongan, A., & Wood, K. (2000). Unusual Sensory Sensitivities in Autism: A Possible Crossroads. *International Journal of Disability, Development and Education, 47*(2), 201-212.

Table 1

Relationships between behavioral response and neurological thresholds according to Dunn's Model of Sensory Processing

Neurological threshold continuum	Behavioral response/ Self-regulation strategies	
	PASSIVE	ACTIVE
HIGH (habituation)	LOW REGISTRATION Need high intensity of sensory stimuli to be able to react and tend to be more flexible in distracting environment	SENSATION SEEKING Constantly create additional sensory stimuli and may find low-stimulus environments intolerable
LOW (sensitization)	SENSORY SENSITIVITY Easily to be distracted by sensory stimuli and discomfort caused by intense stimuli	SENSATION AVOIDING Engage in sensory avoiding behaviors to limit sensory stimuli and tolerate well being alone

Note. Adapted from Dunn (1997).

Table 2

Crohnbach's alpha for the different quadrants of the AASP for both index and control group

	Low registration	Sensation seeking	Sensory sensitivity	Sensation avoiding
Group with AS (N = 45)	.770	.664	.836	.809
Control group (N = 45)	.809	.808	.828	.830

Note: A commonly accepted rule of thumb is that an α of 0.7-0.8 indicates acceptable reliability, and 0.8 or higher indicates good reliability. Too high reliabilities (0.95 or higher) are not necessarily desirable, as this indicates that the items may be entirely redundant.

Table 3

Descriptive data for the quadrants of the AASP and comparison between groups

	Group with AS	Control group	F (1,87)	Exact p	ES	Power
Low registration	35.11 ± 8.28 (19-58)	30.71 ± 8.33 (17-60)	6.24	.014*	.07	.70
Sensation seeking	40.73 ± 7.40 (15-55)	45.29 ± 9.26 (23-67)	6.85	.010**	.07	.74
Sensory sensitivity	35.64 ± 10.51 (17-58)	31.84 ± 8.19 (18-54)	3.87	.052	.04	.50
Sensation avoiding	39.13 ± 9.82 (22-62)	32.33 ± 7.81 (20-60)	13.13	.000**	.13	.95

Note. Mean ± Standard Deviations, values enclosed in parentheses represent range of scores; ES = effect size; both groups have equal size of N=45. Level of significance *p < 0.05 and **p < 0.01

Table 4

Multiple case series analysis illustrating the percentage of atypical scores in the group with Asperger syndrome for each quadrant of the AASP

Participant	Low registration	Sensation seeking	Sensory sensitivity	Sensation avoiding	% of quadrants
1					75%
5					25%
6					25%
7					25%
11					25%
12					25%
15					25%
18					25%
20					25%
23					50%
26					50%
27					75%
28					50%
29					75%
34					75%
36					50%
41					25%
42					75%
43					25%
44					50%
45					25%
Number of outliers (%)	6/45 13.3%	2/45 4.4%	10/45 22.2%	18/45 40.0%	

Note. Only the participants with atypical scores on at least one quadrant are plotted above, 23 participants with AS did NOT have any atypical score.

Table 5

Descriptive data for the quadrants of the AASP and comparison between a subgroup with AS at risk for motor impairment and another groups with AS with normal motor competence

	Group with normal motor competence (n = 11)	Group at risk for motor problems (n =19)
Low registration	36.18 ± 10.19 (23-58)	32.32 ± 8.00 (19-52)
Sensation seeking	43.91 ± 8.22 (24-54)	37.95 ± 8.16 (15-57)
Sensory sensitivity	37.36 ± 10.75 (24-58)	32.68 ± 9.44 (17-51)
Sensation avoiding	42.36 ± 10.00 (27-62)	37.58 ± 10.52 (23-60)
M-ABC-II total score	70.91 ± 7.12 (63-84)	43.79 ± 11.36 (15-60)
M-ABC-II percentile score	28.9 ± 16.1 (16-63)	3.0 ± 2.8 (0.1-9)

Note. Mean ± Standard Deviations, values enclosed in parentheses represent range of scores; both groups have different size: group at risk (n = 19), group with normal motor competence (n = 11).

Table 6

Comparison of means between sensory profile quadrants and motor competence levels of a group with normal motor competence and a group at risk for motor impairment using Mann-Withney U analysis

	Motor competence level	Mean rank	Z score	p
Low registration	Normal	17.50	-0.95	.34
	At risk	14.34		
Sensation seeking	Normal	20.18	-2.22	.03*
	At risk	12.79		
Sensory sensitivity	Normal	17.73	-1.06	.29
	At risk	14.21		
Sensation avoiding	Normal	18.00	-1.19	.24
	At risk	14.05		

Level of significance $^{*}p < 0.05$.

IV

EFFECTIVENESS OF AN EXERCISE TRAINING PROGRAM ON YOUTH WITH ASPERGER SYNDROME

by

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EFFECTIVENESS OF AN EXERCISE TRAINING PROGRAM ON YOUTH WITH ASPERGER SYNDROME

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Although exercise training programs are effective in improving physical fitness and motor competence in typically developing youth, insufficient data of the impact of interventions are available in youth with Asperger syndrome (AS). The purpose of this study was to examine the efficacy of an exercise program as part of an ongoing vocational training program for adolescents with AS on motor competence and physical fitness. Twenty adolescents with AS (mean age = 16.8yrs) were enrolled in this study. A quasi-experimental nonequivalent-control-group design with a follow-up measurement over a period of six months was followed. The intervention group received a 12-week physical exercise program focusing on improving motor competence and physical fitness. The structured activity program was applied 3 days a week for 1 hour. Data collection included pre-, post-, and follow-up evaluations using the Movement Assessment Battery for Children (M-ABC-II) and the EUROFIT physical fitness test together with training diaries and comments from teachers and guardians. Two 2X3 repeated measures ANOVAs indicated improved motor competence and physical fitness that was sustained over time. The exercise training program was successful with adolescents with AS and implementation of similar programs is therefore recommended.

KEYWORDS: Asperger syndrome, exercise, training program, physical activity, motor skills, physical fitness, M-ABC-II, EUROFIT, youth.

INTRODUCTION

The promotion of physical exercise and activity through physical education is very important for all, but especially for individuals with special needs, like youth with Asperger syndrome (AS). Since the earliest descriptions of AS, individuals with this neurological disorder have been observed to exhibit, besides difficulties in social interaction and communication, poor motor skills and clumsiness (Frith, 1991). Estimates of the prevalence of these motor problems range up to 85% (Attwood, 1998, 2007; Borremans, Rintala, & McCubbin, 2009; Gillberg & Gillberg, 1989; Klin, Volkmar, Sparrow, Cicchetti, & Rourke, 1995; Manjiviona & Prior, 1995; Sahlander, Mattsson, & Bejerot, 2008; Smith, 2000).

According to previous research (Borremans, Rintala, & McCubbin, 2008; Borremans et al., 2009) this lower motor competence is reflected by difficulties in throwing or catching balls, keeping balance, or mastering more complex movements like hopping or skipping. Common features also include stiff awkward gait patterns, difficulties to run as fast as their peers, and being unable to perform some everyday tasks that require fine motor skills like tying shoe laces. Most of the participating adolescents with AS in the Borremans et al. studies were at risk for physical inactivity and scored significantly lower than an age and gender matched comparison group on the second edition of the Movement Assessment Battery for Children (M-ABC-II) and on the EUROFIT physical fitness test (Borremans et al., 2008, 2009). Differences were found in all components of both test batteries, including fine motor skills, balance, ball skills, coordination, flexibility, muscular strength, running speed and cardiorespiratory endurance. In line with our observations this combination of motor and fitness challenges is likely a major reason why regular physical education is often disliked by youth with Asperger syndrome.

There has been an increase in number of descriptive investigations on AS in the areas of identification, assessment, characteristics and associated symptoms. However, intervention studies have been scarce, especially those to improve motor skills, physical fitness, and ability to function in everyday life. Several intervention studies with individuals with motor impairment, such as developmental coordination disorder (DCD), have shown positive learning results (Peters & Wright, 1999; Schoemaker, Hijlkema, & Kalverboer, 1994; Sugden & Chambers, 2003; Watemberg, Waiserberg, Zuk, & Lerman-Sagie, 2007). In these studies various methods, such as process and task oriented approaches, specific group exercise programs or other approaches used by physiotherapist, were proven effective. Research by Peters and Wright (1999) reported improved motor competence using the M-ABC in a group of fourteen children with DCD after participating in a 10-week (for 1 hour a week) specific group exercise program designed by a physiotherapist. Also Sudgen and Chambers (2003) found significant improvement in motor skills after conducting a 40-week (3 times around 20 minutes) exercise program with 31 children with DCD using parents and teachers as co-therapists. Watemberg et al. (2007) reported improvements in motor competence after their intervention with children who had a combination of attention-deficit-hyperactivity disorder (ADHD) and DCD. The provided intensive physical therapy intervention had a marked impact on the motor performance of these children.

It is not surprising that such an expert input from skilled professionals would work. However, it is clear that with a relatively high prevalence of 0.4% (Mattila et al., 2007), exploring means of support other than through specialized service providers has become a priority and we are convinced that adequate physical exercise can play an important role to fill this need. The widespread problem of physical inactivity, along with lower levels of motor competence and physical fitness, underscores the need to promote healthy lifestyles in adolescents with AS through regular exercise. Within our vocational training setting there was a need to create more exercise opportunities, as physical well-being is also key to academic success (Sallis et al., 1999). To date, the effectiveness of an exercise training program has not yet been evaluated on individuals with AS. Therefore, the purpose of this study was to examine the effects of a structured exercise training program on motor competence and physical fitness of adolescents with AS.

METHOD

Participants and study design

Twenty adolescents diagnosed with Asperger syndrome volunteered as participants. The group was recruited from different vocational training units in Southern Finland and consisted of sixteen males and 4 females with average age of 16 years and 9 months (SD 10months). This gender distribution is in line with the most recent epidemiological data where males outnumber females (Ehlers, Gillberg, & Wing, 1999; Mattila et al., 2007). All participants met the diagnostic criteria for AS as presented in the ICD-10 (World Health Organisation, 1993) and were diagnosed prior to enrollment by a professional with considerable experience diagnosing people with AS. Intellectual disability and psychosis were used as exclusion criteria. Prior to all investigations, written assent was obtained from the participants and written consent from their legal guardians. The institutional ethical committee approved the study design and participant recruitment.

This study made use of a quasi-experimental nonequivalent-control-group design with a follow-up measurement, which is a widespread experimental design in educational research and particularly appropriate to research in schools (Thomas, Nelson, & Silverman, 2005). Three observations were made each 3 months apart (Pre-test - Intervention - Post-test - Follow-up) over a total period of 6 months. The follow-up observation was added to the pre-post -test design to see whether possible effect of treatment was maintained over time. The participants were divided into two groups matched for age, gender, and initial M-ABC-II scores. Groups were randomly assigned to either the intervention or control group. The investigator was not blinded to the intervention offered.

Intervention

The intervention group received an intensive 12-week exercise training program, whereas the other group of 10 served as the control group and did not receive the intensive program. This exercise training program, called “Move your body & Stretch your mind”, consisted of a variety of motor activities easily available to the student and her/his family, and explained in simple text with pictures. When planning the program some additional considerations were made such as: student preferences, lifetime sports and activities, regional and seasonal sports and games, alternative sports and activities that are easily accessible in the community (e.g. swimming, running, skating). Conducting activities that provide for maximum involvement, as well as develop the necessary physical, social, and cognitive skills needed for physical fitness, were prioritized. This approach encouraged students to take a personal responsibility for fitness and develop an exercise training program for use both in and out of school.

The participants were supposed to exercise 3 times per week, for an hour per session. The program consisted of three main parts: an extra-curricular physical exercise program in the community, an exercise program with stations focusing on core and stretching, and an aerobic physical activity of choice. **First**, once a week a voluntary extra-curricular training was organized right after school in a sports center nearby and was lead by the principal investigator. The activities promoted positive attitudes towards physical activity and encouraged the participants to be active in leisure time by providing activities and games that can be easily transferred towards leisure time (e.g., floor ball, soccer, badminton). **Second**, students were supposed to do at home a core exercise program with stations including warm-up, core work out and stretching. These core exercises help strengthen core muscles and also improve balance and overall coordination. All students got personal training and instruction about the exercises prior to the home program and received a printout of the exercises with pictures. **Third**, students were asked to be engaged for an hour in an aerobic physical activity of their choice, such as biking, swimming, running, Nordic walking, aerobics, within their own community setting. The first part of the intervention was led by the student’s physical education teacher (in this case principal investigator), whereas the second and third parts were done at home with their guardians as co-teachers.

A written exercise contract, about what, where, when and with whom to do the home program, was made between each student and the researcher. This type of contract has been identified as an effective reinforcer in our program for students with AS to increase participation and improve exercise adherence. All participants were also asked to carefully complete their exercise diary. The participants regularly asked questions about their training and received weekly reminders about their training diaries from the principal investigator. During the project there were also regular contact with teachers and guardians. Informal contact was made and the teachers and guardians were briefed about the specific schedule of the intervention and received a copy of the exercise contract to inform of what was going to happen. This way they could provide support and assistance to fulfill the exercise requirements when needed. Teachers and guardians were encouraged to contact the primary investigator if there were any challenges or if they had recommendations to more appropriate activities for their participants.

Instruments

Movement ABC-II

Motor competence was assessed with the updated version of the Movement Assessment Battery for Children, the M-ABC-II (Henderson, Sugden, & Barnett, 2007). This M-ABC-II test has proven reliable and valid (Chow & Henderson, 2003; Faber & Nijhuis van der Sanden, 2004; Henderson et al., 2007) and previous versions of it have been commonly used in motor competence research with individuals with AS (Green et al., 2002; Manjiviona & Prior, 1995; Miyahara et al., 1997; Siaperas, Holland, & Ring, 2006). The M-ABC-II test contains eight tasks that assess three components of functioning: manual dexterity, balance, and ball skills. The manual dexterity tasks include turning pegs both with preferred and non-preferred hand, a bimanual task to make a triangle with nuts and bolts, and a drawing trail. The tests for ball skills include aiming and throwing at a wall target, as well as catching a ball with one hand. Balance items consist of two-board balancing, toe-to-heel backwards walking, and zigzag hopping. The three domains were assessed in all participants. The raw scores obtained for each item were first converted to standard scores and summed to obtain a total test score using age related norms. This total test score was used for data-analysis. The test provides also percentiles for each age group through 16. According to the M-ABC-II manual scores at or below the 5th percentile (total test score ≤ 56) are considered indicative of significant motor difficulty and scores between the 6th and 15th percentile suggest being at risk for having motor problems.

EUROFIT

Physical fitness was assessed using selected items of the EUROFIT, the European test of physical fitness. The EUROFIT test items were chosen because they are widely employed within European schools and used annually in adapted physical education assessments in the participating schools. For this reason students had a certain familiarity level with the test items. Considering the difficulty individuals with AS may have with change and new routine, this familiarity is an important reason for choosing the EUROFIT. A detailed description of the test items is given in Oja & Tuxworth (1995) and in Borremans et al. (2008). The battery of fitness tests used in this study contained 8 tasks and included the assessment of the following components: flexibility (sit-and-reach), musculoskeletal fitness (sit-up, handgrip strength, standing broad jump), motor fitness (tests for balance (single leg balance) and speed of movement (plate tapping and 5 x10 shuttle run)) and aerobic fitness (2 km walking test). The items of this test battery are reliable and valid and this instrument is commonly used to measure physical fitness in children and adults in Europe (e.g., Mac Donncha, Watson, McSweeney, & O'Donovan, 1999). Because the EUROFIT manual does not provide a total fitness score, a T-score based on the sum of all subtests T-scores' divided by the amount of tests, was calculated to achieve a more total physical fitness score.

Informal descriptive questionnaire

A short questionnaire was developed to gather some simple anecdotal comments about the student's feelings towards the intervention program. Questions about their likes and dislikes concerning the exercise program were answered with open responses. The aim was to better understand and support the current findings and improve the program for the future use. The information obtained from this questionnaire is not included in the main analysis, but findings are taken into consideration in the discussion.

Procedures

A team of three experienced clinicians (two physiotherapists and one occupational therapist) assessed the participants 3 times, each 12 weeks apart, in 2008. In a quiet classroom, the assessment was initiated with a short interview and an informative briefing about the test situation supported with pictures of the test items. The manual dexterity, balance, ball and physical fitness tests were then administered. In total, this session took approximately 1.5 hours.

Data analysis

Two 2 X 3 (group by time) repeated measures (RM) ANOVA was used to examine differences in motor competence and physical fitness between intervention- and control group at different times. Post-hoc comparisons to determine significant differences of main effects were examined through one-way (time) repeated measures ANOVA for each group. Six one-way RM ANOVAs (three for each measure) were used to test the pairwise comparisons for the intervention and control groups with Bonferroni correction ($p \leq .017$ [.05/3 [i.e., pre vs. post, post vs. follow-up, and pre vs. follow-up]). All statistical analyses were computed using the statistical software PASW version 17 (SPSS, 2009).

RESULTS

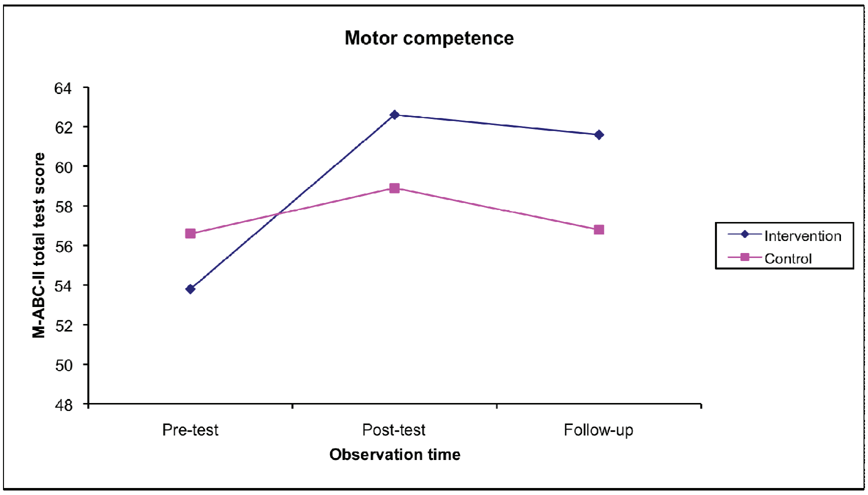
Table 1 presents the means and SDs for motor competence and physical fitness scores of each group across the three time periods. The most relevant statistics for our purposes are the three means reflecting these performance scores. Examination of these means suggests that the average motor competence as well as physical fitness for the intervention group was lowest at pre-test (before the intervention), highest at post-test (immediately after the intervention), and in between these two at follow-up (the 3-month follow-up measure).

Table 1
Means and SDs for motor competence and physical fitness scores of each group across the three time periods

	Motor competence total test score		Physical fitness total score	
	Intervention group	Control group	Intervention group	Control group
Time	M ± SD	M ± SD	M ± SD	M ± SD
Pre test	53.8 ± 21.6	56.6 ± 12.0	50.3 ± 7.9	49.8 ± 5.1
Post test	62.6 ± 19.2	58.9 ± 11.7	53.4 ± 5.0	49.9 ± 5.2
Follow-up	61.6 ± 19.3	56.8 ± 12.7	52.7 ± 5.5	49.3 ± 5.0

A graphic picture of the group results of the M-ABC-II total test score is shown in Figure 1. This figure shows a great improvement in performance between pre- and post-test for the intervention group and a slight improvement in the control group followed by a leveling off to the follow-up test for both groups.

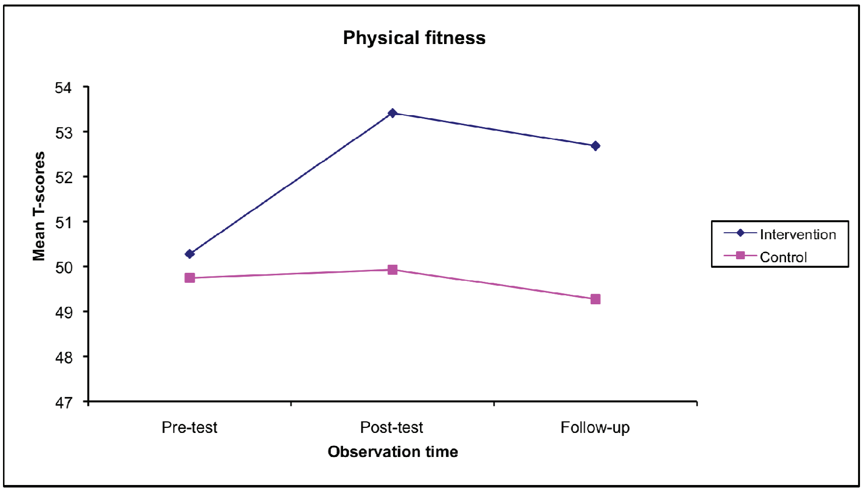
Figure 1
Mean total test scores of the M-ABC-II for both intervention and control group with AS (n = 10/group)



For the M-ABC-II the 2 X 3 repeated measures ANOVA revealed a significant interaction between group and time: $F(2,36) = 6.96$; $p < 0.005$; partial eta squared = .28 representing a large effect. Post-hoc comparisons through one-way (time) repeated measures ANOVA for each group revealed the following. For the intervention group there was a simple main effect for time, $F(2,18) = 10.58$, $p < 0.001$, partial eta squared = .54. The Bonferroni method indicated a significant mean difference between pre- and post-test (exact p = .002), pre-test and follow-up (exact p = .005), but not for post-test and follow-up (exact p = .64). Also for the control group a simple main effect was found for time: $F(2,18) = 7.04$; $p < 0.01$; partial eta squared = .44. Here the Bonferroni method indicated only a significant mean difference between pre- and post-test (exact p = .002), but not between post-test and follow-up (exact p = .019), nor for pre-test and follow-up (exact p = .79), indicating that the possible gains are not maintained.

Similar results were observed by analyzing the graphic picture and data of the EUROFIT. A graphic picture of the group results of the EUROFIT total test score is shown in Figure 2. This figure shows a large improvement in performance between pre- and post-test for the intervention group and only a slight improvement in the control group followed by a leveling off to the follow-up test for both groups.

Figure 2
Mean total test T-scores of the EUROFIT physical fitness test for both intervention and control group with AS (n = 10/group).



Also for the EUROFIT the 2 X 3 repeated measures ANOVA revealed a significant interaction between group and time: $F (2,36) = 4.48$; $p < 0.05$; partial eta squared = .20 representing a large effect. Post-hoc comparisons through one-way (time) repeated measures ANOVA for each group revealed the following. For the intervention group there was a simple main effect for time, $F (2,18) = 4.39$, $p < 0.05$, partial eta squared = .33. The Bonferroni method indicated no significant mean differences between different test times with exact p = .11 between pre- and post-test, exact p = .96 between post-test and follow-up, and exact p = .26 for pre-test and follow-up. Also for the control group a simple main effect for time, $F (2,18) = 5.69$, $p < 0.05$, partial eta squared = .38 was found. The Bonferroni method indicated no significant mean differences between times. The exact p-values between pre- and post-test, post-test and follow-up, and pre-test and follow-up were respectively p = .99, p = .05, and p = .13.

Based on these results, it seems that there is an interaction effect only between pre- and post-tests for both measures, in that the treatment group increased their levels significantly more than the control group. However, the levels of both groups slightly decreased at the follow-up without any meaningful differences between post-test and follow-up.

To address the effects of history, matched groups were established based upon pre-test M-ABC-II score. A confirmatory independent *t*-test, showed no significant differences at pre-test between the intervention and the control group with $t (18) = 2.45$; $p > .05$. The average pre-treatment M-ABC-II percentile score was 15 (SD 20) for the intervention group and 12 (SD 14) for the control group, both scores within the range of at risk for motor problems. In both groups there was large within group variability with 4 participants in the intervention and 3 in the control group scoring above the 15^{th} percentile. All but one participant in the intervention group improved their M-ABC-II score between pre- and post-test, with the average M-ABC-II score increasing from percentile 15 to percentile 25. In the control group little improvement was observed and the average M-ABC-II score stayed below the 15^{th} percentile.

DISCUSSION

A significant proportion of adolescents with AS have delayed motor development and are in need of effective programs to improve motor competence and physical fitness (Borremans et al., 2008, 2009). The present study used an exercise training program that proved efficacious in improving the motor competence and physical fitness of adolescents with AS. Where the *p* value for the difference in motor competence between pre and post-test for the intervention was significant, such a significance was not observed for physical fitness, yet we claim that also this difference is meaningful as a similar upwards trend is observed as in motor competence (see Figures 1 & 2). Lack of statistical significance may be due to the small sample size and the high SD. Therefore, these results need to be interpreted in relation to both, statistical significance and clinical importance.

The individuals in the control group returned to pre-test levels of motor competence and physical fitness at the follow-up, whereas a much slighter decline was observed for the intervention group. The intervention group ended the 6 months period with higher levels of motor competence and physical fitness. When individuals with AS invest some extra time weekly to be physically active, skill and fitness levels increase. These results follow a similar positive upwards trend of increasing competence levels as other exercise interventions in children with poor motor skills (e.g., Peters & Wright, 1999; Schoemaker et al., 1994; Watemberg et al., 2007).

Even though the intervention was effective for the majority of participants, more research is needed to further evaluate which aspects of the exercise intervention were most successful and which aspects need to be adapted or improved. Although a multi-level approach, like the one used in the present study, makes it difficult to identify which aspects of the interventions were successful, we discovered that such an approach is more appropriate to target adolescents' physical activity behavior, which is influenced by a diversity of factors. By offering different exercise possibilities such as an extra physical education class or a personal home program students get a wider scope of possible ways to increase their healthy exercise behavior.

Some recommendations for clinical practice

Because many adolescents with AS have lower motor competence, physical fitness, and activity levels than recommended for good health, increased opportunities for extracurricular interventions need to be encouraged (Borremans et al., 2008, 2009). Based upon our experience an increase in active physical exercise time can be achieved by including key strategies such as: providing choice of developmentally appropriate physical activities, the use of cooperative games and activities that include all students, engagement in activities that cater to the needs and interests of all students, and making exercise enjoyable and fun. Also the students who were interviewed about their experiences with the home program proposed themselves similar strategies. In their view "fun physical exercise" rules!

When asked about which parts of the exercise program they liked the most, the common answer was the extra exercise class held after school (with a very high attendance rate). The second most popular was the voluntary aerobic exercise and the least popular was the personal exercise program. On average the students in the intervention group were able, according to their own records, to exercise around 2/3 of the recommended exercise time. The students' preference for the group exercise training was little surprising, as in earlier research it was concluded that students with AS in general rather tend to opt for activities in solitude (Borremans et al., 2008). When exercise training programs are tailor-made, enjoying the exercise can be achieved more easily. At the same time other important skills, like social and group skills, could be worked on. While planning exercise program we recommend that educators not only teach movement skills, but they should also teach key socially appropriate behavioral skills, such as goal setting, self-monitoring, and enlisting support for physical activity.

The extra-curricular exercise program of this study has proven to be effective in promoting skill and fitness and such a program could contribute to achieve recommended PA levels when integrated into the broader individualized education program. Given the variability in developmental profiles of individuals with AS, it should be expected that not all benefit equally from the interventions. There is not a one-for-all treatment thus the interventions must be prescribed in an individualized manner consistent with the functional goals for each student. Given that many conventional educational environments are loud, distracting and unpredictable, interventions need to consider the individualized adaptations to optimize successful participation and adherence in the exercise programs. The program and instruction should therefore emphasize enjoyable participation in the training program and help students develop the knowledge, attitudes, motor and behavioral skills needed to adopt and maintain physically active lifestyles.

Limitations of the study and recommendations for future research

Although statistically our small sample size represents a study limitation, it is noteworthy to state that meaningful differences in motor competence and physical fitness levels were found that provide support for the exercise training program effectiveness. The quasi-experimental design, with sample of convenience, also limits generalizability. Although we did not assess the relationship between other important characteristics of AS such as social interaction, communication, and also sensory processing, ongoing research is crucial to better understand the impact of these abilities in an exercise environment. The logical next step in this line of research is to use a more targeted intervention program that includes both exercise training and theory-based, physical activity motivational strategies to increase not only fitness levels and motor competence, but also long-term leisure-time physical activity. Also dose response to exercise and the effect of exercise on academic success are areas that need further investigation.

Conclusion

Design limitations notwithstanding, it can be concluded that the exercise training program was effective in promoting motor competence and physical fitness in adolescents with AS. Because many of these adolescents are at risk for physical inactivity and do not meet the recommended physical activity levels for good health, the implementation of extracurricular interventions needs to be encouraged.

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REFERENCES

Attwood, T. (1998). *Asperger's syndrome : a guide for parents and professionals*. London: Jessica Kingsley Publishers.

Attwood, T. (2007). *The complete guide to Asperger syndrome*. London: Jessica Kingsley Publishers.

Borremans, E., Rintala, P., & McCubbin, J. A. (2008). *Physical fitness and physical activity in adolescents with Asperger syndrome: A comparative study*. Manuscript submitted for publication.

Borremans, E., Rintala, P., & McCubbin, J. A. (2009). Motor skills of young adults with Asperger syndrome: A comparative study. *European Journal of Adapted Physical Activity, 2(1)*, 21-33. Retrieved september 3, 2009, from http://www.eufapa.upol.cz/www/images/stories/files/Journals/vol1_2/02Borremans.pdf

Chow, S. M., & Henderson, S. E. (2003). Interrater and test-retest reliability of the Movement Assessment Battery for Chinese preschool children. *American Journal of Occupational Therapy, 57*, 574-577.

Ehlers, S., Gillberg, C., & Wing, L. (1999). A screening questionnaire for Asperger syndrome and other high-functioning autism spectrum disorders in school age children. *Journal of Autism and Developmental Disorders, 29*, 129-141.

Faber, I. R., & Nijhuis van der Sanden, M. W. G. (2004). The Movement Assessment Battery for Children. Standardisation and reliability of Age Band 5: young adults. In S.E. Henderson, D. Sugden & A. Barnett (Eds.), *The Movement Assessment Battery for Children-2.* (2007 ed.). London: Pearson Assessment.

Frith, U. (1991). *Autism and Asperger syndrome*. Cambridge: Cambridge University Press.

Gillberg, I. C., & Gillberg, C. (1989). Asperger syndrome - some epidemiological considerations: a research note. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 30*, 631-638.

Green, D., Baird, G., Barnett, A. L., Henderson, L., Huber, J., & Henderson, S. E. (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 and Allied Disciplines, 43*, 655-668.

Henderson, S., Sugden, D., & Barnett, A. L. (2007). *Movement Assessment Battery for Children-2*. London: Pearson Assessment.

Klin, A., Volkmar, F. R., Sparrow, S. S., Cicchetti, D. V., & Rourke, B. P. (1995). Validity and neuropsychological characterization of Asperger syndrome: convergence with nonverbal learning disabilities syndrome. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 36*, 1127-1140.

Mac Donncha, C., Watson, A. W. S., McSweeney, T., & O'Donovan, D. J. (1999). Reliability of Eurofit physical fitness items for adolescent males with and without mental retardation. *Adapted Physical Activity Quarterly, 16*, 86-95.

Manjiviona, J., & Prior, M. (1995). Comparison of Asperger syndrome and high-functioning autistic children on a test of motor impairment. *Journal of Autism and Developmental Disorders, 25*, 23-39.

Mattila, M. L., Kielinen, M., Jussila, K., Linna, S. L., Bloigu, R., Ebeling, H., et al. (2007). An epidemiological and diagnostic study of Asperger syndrome according to four sets of diagnostic criteria. *Journal of the American Academy of Child and Adolescent Psychiatry, 46*, 636-646.

Miyahara, M., Tsujii, M., Hori, M., Nakanishi, K., Kageyama, H., & Sugiyama, T. (1997). Brief report: motor incoordination in children with Asperger syndrome and learning disabilities. *Journal of Autism and Developmental Disorders, 27*, 595-603.

Oja, P., & Tuxworth, B. E. (1995). *Eurofit for adults: A test battery for the assessment of the health-related fitness of adults*: Council of Europe, Committee for the Development of Sport.

Peters, J. M., & Wright, A. M. (1999). Development and evaluation of a group physical activity programme for children with developmental co-ordination disorder: An interdisciplinary approach. *Physiotherapy Theory & Practice, 15*, 203-216.

Sahlander, C., Mattsson, M., & Bejerot, S. (2008). Motor function in adults with Asperger's disorder: a comparative study. *Physiotherapy Theory and Practice, 24*, 73-81.

Sallis, J. F., McKenzie, T. L., Kolody, B., Lewis, M., Marshall, S., & Rosengard, P. (1999). Effects of health-related physical education on academic achievement: project SPARK. *Research Quarterly for Exercise and Sport, 70*, 127-134.

Schoemaker, M. M., Hijlkema, M. G., & Kalverboer, A. F. (1994). Physiotherapy for clumsy children: an evaluation study. *Developmental Medicine and Child Neurology, 36*, 143-155.

Siaperas, P., Holland, T., & Ring, H. (2006). Discriminative validity of the Movement ABC Test and Checklist for use with children with Asperger syndrome. In S. E. Henderson, D. Sugden & A. Barnett (Eds.), *Movement Assessment Battery for Children-2* (2007 ed.). London: Pearson Assessment.

Smith, I. M. (2000). Motor functioning in Asperger syndrome. In A. e. a. E. Klin (Ed.), *Asperger syndrome* (pp. 97-124). New York: The Guilford Press. .

SPSS (2009). *PASW Statistics 17 for Windows*. Chicago, IL.: SPSS Inc.

Sugden, D. A., & Chambers, M. E. (2003). Intervention in children with Developmental Coordination Disorder: the role of parents and teachers. *The British Journal of Educational Psychology, 73*, 545-561.

Thomas, J. R., Nelson, J. K., & Silverman, J. (2005). *Research methods in physical activity (5th ed.)*. Champaign: IL: Human Kinetics.

Watemberg, N., Waiserberg, N., Zuk, L., & Lerman-Sagie, T. (2007). Developmental coordination disorder in children with attention-deficit-hyperactivity disorder and physical therapy intervention.
Developmental Medicine and Child Neurology, 49, 920-925.

World Health Organisation (1993). *International statistical classification of diseases and health-related problems, Tenth Revision (ICD-10)*. Geneva: Author.

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MOTORISCHE FERTIGKEITEN JUNGER ERWACHSENER MIT ASPERGER SYNDROM: EINE VERGLEICHSSTUDIE

(Resümee)

Obwohl Trainingsprogramme zur Verbesserung von körperlicher Fitness und motorischer Kompetenz sich als effektiv bei typisch entwickelten Jugendlichen erwiesen haben, liegt nur ungenügendes Datenmaterial über den Einfluss von solchen Interventionen bei Jugendlichen mit Asperger Syndrom (AS) vor. Die Absicht dieser Studie war es, die Effektivität eines Übungsprogramms für motorische Kompetenz und körperliche Fitness zu prüfen, das als Teil eines Berufsausbildungsprogramms für Jugendliche mit AS angeboten wurde. Zwanzig Jugendliche mit AS (Durchschnittsalter = 16.75 Jahre) waren an dieser Studie beteiligt. Ein quasi-experimentelles, nicht gleichwertiges Kontrollgruppen-Design mit einer Nachfolge-Messung nach einer Periode von sechs Monaten schloss daran an. Die Interventionsgruppe wurde einem 12-wöchigen Übungsprogramm unterzogen, das darauf abzielte, motorische Kompetenz und körperliche Fitness zu verbessern. Das strukturierte Bewegungsprogramm wurde an drei Tagen der Woche über eine Stunde durchgeführt. Die Datengewinnung umfasste in ihren Vor-, Nach- und Folge-Evaluierungen die Movement Assessment Battery for Children (M-ABC-II) und den EUROFIT-Physical-Fitness-Test zusammen mit Trainingstagebüchern und Kommentaren von Lehrenden und Betreuenden. Zwei 2x3 wiederholte ANOVA-Messungen ergaben verbesserte motorische Kompetenz und nachhaltige Verbesserung der körperlichen Fitness. Da dieses Trainingsprogramm erfolgreich für Jugendliche mit AS zu sein schien, wird die Implementierung ähnlicher Programme daher empfohlen.

SCHLÜSSELWÖRTER: Asperger Syndrom, Übungs-/Trainingsprogramm, Bewegung, Motorische Fertigkeiten, Körperliche Fitness, M-ABC-II, EUROFIT, Jugendliche.

LES HABILETES MOTRICES DE JEUNES ADULTES ATTEINTS DU SYNDROME D'ASPERGER : UNE ETUDE COMPARATIVE

(Résumé)

Bien que les programmes d'entraînement soient efficaces pour améliorer la condition physique et les compétences motrices chez des jeunes en développement, il n'existe pas assez de données sur l'impact de ces interventions chez des jeunes atteints du syndrome d'Asperger (AS). L'objectif de cette étude était d'examiner l'efficacité d'un programme d'activité physique inclut dans un programme de formation professionnelle sur la compétence motrice et la condition physique d'adolescents atteints d'AS. Vingt adolescents atteints d'AS (âge moyen = 16,75 ans) ont été inclus dans cette étude. Un plan quasi-expérimental avec groupe contrôle non équivalent et un suivi sur 6 mois a été mené. Le groupe intervention a bénéficié d'un programme d'activité physique de 12 semaines orienté sur l'amélioration des compétences motrices et la condition physique. Le programme structuré d'activité physique se déroulait 3 fois par semaine pour une durée d'une heure. La collecte de données incluait des évaluations pré, post et de suivi en utilisant le M-ABC-II **(**Movement Assessment Battery for Children) et le test de condition physique EUROFIT associé à un journal d'activité physique ainsi que des commentaires des parents et des tuteurs. Deux ANOVA à mesures répétées 2X ont fait ressortir une amélioration des compétences motrices et de la condition physique qui était maintenue dans le temps. Le programme d'activité physique a eu du succès auprès d'adolescents atteints d'AS. La mise en œuvre de programmes similaires est recommandée.

MOTS CLEFS: Syndrome d'Asperger, exercice, programme d'activité physique, activité physique, habiletés motrices, condition physique, M-ABC-II, EUROFIT, adolescents.

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