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Physical activity: Its implication on attention span and quality of life in children with autism spectrum disorder

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Physical Activity: Its Implication on Attention Span and Quality of Life in Children
with Autism Spectrum Disorder

Beron Tan Wei Zhong

A report submitted in Partial Fulfilment of the Requirements for the Award of Bachelor
of Science (Psychology) Honours, Faculty of Computing, Health and Science,

Edith Cowan University.

Submitted (October, 2011)

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Abstract

The current study was designed to partially extend previous research (Nicholson, Kehle, Bray, & Heest, 2011; Rosenthal-Malek & Mitchell, 1997) by examining the effects of physical activity on the 1) attention span and 2) health-related quality of life (HRQoL) of autism spectrum disorder (ASD) children in Singapore. Male participants ($N = 12$) aged 2-6 years, diagnosed with ASD were randomly assigned to either a physical activity (experimental) or non-physical activity group (control). In the physical activity group, participants were administered 8 tri-cycling sessions; together, both groups of participants were measured for their attention span, and their parents completed the HRQoL questionnaires. The results revealed that as the exercise session increases, participants in the physical activity group demonstrated increasingly longer duration of attention span compared to the control group. These results further extended the findings of Nicholson et al. (2011) and Rosenthal-Malek and Mitchell (1997) that physical activity enhances cognition of ASD children. However, the results do not support the effects of physical activity on the overall HRQoL and instead revealed the improvement on the social functioning subscale. In general, these results suggested the beneficial effects of physical activity on ASD children and its incorporation into the early intervention should be recommended.

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Physical Activity: Its Implication on Attention Span and Quality of Life in Children
with Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a range of neurodevelopmental disorders which includes Autistic disorder, Asperger's syndrome and Pervasive developmental disorder-not otherwise specified (Griffin, 2010). It impairs three broad areas which include social interaction, communication and stereotyped behaviours (Landry, Mitchell, & Burack, 2009). ASD is also most commonly co-morbid with anxiety disorder (White, Ollendick, Scahill, Oswald, & Albano, 2009) which further complicates its management.

The prevalence for ASD in the United States of America (USA) was 6.7 in 1000 children (Bertand et al., 2001) and the disorder is 4-5 times more prevalent in males than females (American Psychiatric Association, 2000). In 2005, the estimated incidence of autism and Asperger's syndrome in Australia was 2.2 per 1000 children, aging from infants up to 5 years old and was about 6.3 in 1000 children between 6 to 12 years old; the gender ratio (male:female) of about 4:1 was also reported (Williams, MacDermott, Ridley, Glasson, & Wray, 2008). Consistent with the Australian data, an epidemiological study conducted in Singapore by Bernard-Opitz, Kwook, and Sapuan (2001) reported similar gender distribution of ASD, and it was the foremost cause of disease burden among children below 14 years old (Phua, Chua, Ma, Heng, & Chew, 2009). In addition, the typical symptoms appear to remain constant throughout the lifetime (Matson & Horovitz, 2010) with poor prognosis (Poon, 2011). However, research has suggested that early intervention can reduce the symptoms of ASD but are more likely to benefit those with higher functioning and mild ASD (Matson & Horovitz, 2010). Nevertheless, early intervention is strongly advocated for better management and productive development for ASD children (Griffin, 2010). Furthermore, Poon (2011)

has also argued that despite the known poor prognosis, there should be significant effort into developing and implementing intervention programs.

The following section of this paper will be reviewing the possible aetiologies of ASD including brain structural and functional abnormalities, impaired sleep regulations and abnormal serotonin levels. The various benefits of physical activity, its effects on cognition and ASD children, and the possible physiological and psychological mechanisms of exercise and cognition relationship will be discussed. In addition, issues pertaining to the type, frequency and duration of physical activity on the overall health and the aspects of the quality of life in ASD children will also be examined. Lastly, the rationale of the research and hypotheses will be presented at the end of the section.

Aetiology of Autism Spectrum Disorder

Individuals with ASD have impairments in areas of social, communication and stereotyped behaviours (Landry et al., 2009), but its behavioural manifestation is not fully universal and has a wide variation of dysfunction that differed among individuals (Toro et al., 2010). However some of the reported behaviours but not limited to the followings are: deficits in joint attention and bonding, which may instead be shown towards inanimate items (Volkmar & Pauls, 2003); joint attention was defined by Dawson et al (2004) as a set of social skills that involve the child's ability to engage in eye contacts and behaviours that allows for social interaction with a parent/adult and an object to take place. Other reported behaviours are self-mutilation or aggressive behaviours (Folstein, 1999), sleep disturbances (Nicholas et al., 2007), stereotyped behaviours like hands-waving or flapping, physical rocking-motion and kissing or placing items in the mouth (Rosenthal-Malek & Mitchell, 1997).

The exact aetiology of ASD is not known (Skuse, 2007) due to the complexity of this range of neurodevelopmental conditions (Charles, Carpenter, Jenner, & Nicholas, 2008). However, most of the possible explanations consisted mainly of

factors from genetic and environmental influences (Ashwood et al., 2011). The most common association between ASD and other genetic conditions are Tuberous Sclerosis Complex, Fragile X and Rett Syndrome (Kumar & Christian, 2009). Each of these genetic conditions has similar manifestations of clinical symptoms as ASD, but they do not fully resemble the disorders, and are therefore suggested to have a common genetic expression rather than a common genetic causation (Moss & Howlin, 2009). In other words, though the associated genetic conditions and ASD have different aetiologies, they seem to converge along the line of similar outcomes. Due to this similar expression of symptoms, the actual causal factors for ASD is further complicated (Moss & Howlin, 2009).

Furthermore, Skuse (2007) proposed that the association itself (i.e., genetic disorders and susceptible genes to ASD) does not bring forth the clinical manifestation of ASD but the compromised intelligence related to the genetic disorders caused an insufficient compensation for cognitive development; thus making the manifestations more evident. This theory proposed that the similar symptoms displayed by the associated disorders do not necessarily suggest a common causation, but instead was attributed to the level of intelligence. However, Moss and Howlin (2009) found that intelligence deficits alone was only able to explain certain incidences of ASD associated with some genetic conditions but not all cases, especially for individuals with mild to moderate level of intelligence. It was found that these associated genetic conditions with ASD cases were approximately 10% (Faras, Ateeqi, & Tidmarsh, 2010). Even though ASD are associated with genetic factors, there is no particular gene that is fully accountable and multiple genes are believed to have contributed to ASD (Volkmar & Pauls, 2003; Kumar & Christian, 2009; Toro et al., 2010), in conjunction with other chromosomal disorders (Skuse, 2007), environmental (e.g., toxins or stressful

environment) and neurobiological factors (Levy, Mandell, & Schultz, 2009). The following section describes other factors that are associated with the disorders.

Abnormalities in Brain Anatomy and Functions

Although research has identified certain genetic contributions to the disorder, in an associated study, Wang et al. (2009) found a common class of candidate genes called cadherin 9 and 10, which may be responsible for atypical brain development and neural connectivity in the ASD population. Eigsti and Schuh (2008) found that the white matter in the brain of ASD individuals which represents the connectivity is not typical. In relation, there is evidence that the brain of the ASD children seems to enlarge significantly during the first year period of birth as measured by their head circumference (Courchesne, Carper, & Akshoomoff, 2003), which was an outcome of increased cerebral volume: overall gray and white matter (Minshew & Williams, 2007); though Friedman et al. (2006) discovered that the gray matter differences are more pronounced in ASD individuals than the white matter compared to typical developing children and those with delayed development. Overall, the abnormal growth of the brain and the ASD symptoms occurring concurrently within this time frame may signify the important changes or disruptions undergoing in the brain during this crucial period of brain development (Courchesne et al., 2003; Minshew & Williams, 2007). Imaging studies provide additional support of early brain enlargement and decreased neural connectivity (Eigsti & Schuh, 2008; Minshew & Williams, 2007).

Furthermore, it was also found that the communications/coordination among the brain hemispheres are restricted and compromised (Eigsti & Schuh, 2008; Levy et al., 2009), possibly related to the structural abnormalities of the corpus callosum (Just, Cherkassky, Keller, Kana, & Minshew, 2007). As the corpus callosum functions as a “point of communication” between the two hemispheres, abnormalities in this area may have affected the quality of the neural connectivity (Just et al., 2007). In addition, the

size of the corpus callosum among autism adults was generally smaller compared to adults without the disorder (Just et al., 2007). Therefore, both hemispheres may not be able to function optimally together for the necessary transmission of information required for higher cognitive processes to take place (Eigsti & Schuh, 2008), such as learning where both hemispheres coordination are imperative (Nicholson, Kehle, Bray, & Heest 2011). Studies have also revealed drastic decrements in the neural connectivity when ASD individuals undertake task requiring higher cognitive processes, suggesting an impaired ability to synthesise information (Minshew & Willams, 2007). The dysfunctional neural connections affect the entire brain system, in particular, the areas responsible for language and social behaviours may have similar underlying defects (Levy et al., 2009). Taken together, may have resulted in the impairments/symptoms of ASD (Wang et al., 2009) and one of the symptoms commonly experienced is sleep-related problems (Nicholas et al., 2007).

Abnormalities in Sleep regulation

Other abnormalities are also noted in individuals with ASD: one such factor is sleep patterns (Nicholas et al., 2007). As sleep-related issues are common in ASD, the clock genes: *per1* and *npas2* (Nicholas et al., 2007), melatonin metabolism (Rossignol & Frye, 2011) and ASMT gene deficiencies (Melke et al., 2008) are all suspected to be partially involved in the causation of ASD. In a review by Rossignol and Frye (2011), it was suggested that problems with or in relation to the metabolism of melatonin could lead to melatonin deficiency in certain patients with ASD, and may possibly or indirectly account for behavioural symptoms in the day that are related to sleep issues. The atypical melatonin concentration may also be due to disruptions in the circadian regulation system that caused the irregularities and two of the clock genes, *per1* and *npas2* were found to be associated with autism symptoms (Nicholas et al., 2007). In relation, Melke et al. (2008) have also found that 65% of their ASD sample had lower

levels of melatonin content which may be due to genetic mutation of ASMT gene that are important for the synthesis of melatonin. However, Melke et al. argued that abnormal ASMT gene or melatonin metabolism cannot be a causal factor for ASD given that the abnormalities are also detected in parents and relatives of ASD patients and therefore such genetic mutations/deficiencies could only suggest a risk factor.

Abnormal Serotonin Levels

Interestingly, melatonin is mainly synthesised through serotonin (Rossignol & Frye, 2011) and increased serotonin level of 25 to 50% in the blood (Belmonte et al., 2004) was consistently found in ASD individuals (Anderson et al., 2009; Cote et al., 2006). Paradoxically, increased serotonin level does not seem to increase melatonin concentration which as suggested by Rossignol and Frye that a dysfunction in the metabolism of melatonin (i.e., ASMT) may be present. The elevated serotonin concentrations found in ASD individuals may be due to the dysfunction/insufficient serotonin transporter and/or metabolism (Makkonen, Riikonen, Kokki, Airaksinen, & Kuikka, 2008) which could be caused by the consumption of food or drugs containing serotonin during embryonic development, resulting in high levels of serotonin to enter the embryonic brain and damaged the serotonin terminals (Hadjikhani, 2009). As serotonin has multiple physiological implications (Cote et al., 2006), most notably for its possible contribution to early brain development and the limbic regions which are important for emotions and social functioning (Belmonte et al., 2004), unusual levels of serotonin especially in pregnancy may be a plausible cause for atypical development of the ASD brain (Hadjikhani, 2009).

In studies of murine and serotonin, it was found that the maternal production of serotonin was critical for the brain development of the developing embryo (Cote et al., 2006; Kistner-Griffin et al., 2010). The authors further suggested that the maternal genes affect the developing embryos much more than the genetic structure of the

embryo itself, and therefore it may be possible that the maternal serotonin abnormalities may have contributed to the atypical development of the brain in ASD individuals. In contrast, Fatemi, Merz and Realmuto (2003) proposed that the serotonin anomalies in individuals with ASD could be attributed to the impaired development of neural circuits in the cerebellum which are necessary for the transmission of impulses to other brain areas. However the above studies are mostly conducted on murine and therefore should be interpreted with caution. In summary, studies seem to point towards the idea that a certain amount of serotonin during pregnancy is necessary for typical brain development and that the abnormal level of serotonin and/or dysfunction of its related pathways may have significant influence on the developing brain (Cote et al., 2006; Fatemi et al., 2003; Kistner-Griffin et al., 2010).

In general, none of the factors examined above could totally explain the aetiology of ASD but have provided valuable insights into the various factors that may place an individual susceptible to the development of the disorders. Most of the factors seem to show that there are impairments in the brain structures and/or functions and connectivity within and between the brain hemispheres, suggesting that ASD is a syndrome that involves the entire neural network rather than a specific area of brain abnormalities (Minshew & Williams, 2007). These imply a need for an intervention that is capable of targeting a wide range of impairments rather than a problem-specific solution.

Mechanism of Physical Activity

Physical activity has been viewed to have a vast positive effect on physical and mental health: affecting the central nervous system (Hennigan, O'Callaghan, & Kelly, 2007) circulatory system of the heart and the locomotor system (Ploughman, 2008), alleviating symptoms of depression (Kubesch et al., 2003) and anxiety (Paluska & Schwenk, 2000), improving psychological aspects of well-being (Fox, 1999; Biddle,

Gorely, & Stensel, 2004) and general well-being (Deslandes et al., 2009), enhancing cognition (Ding, Vaynman, Akhavan, Ying, & Gomez-Pinilla, 2006; Praag, 2009; Vaynman, Ying, & Gomez-Pinilla, 2004) particularly on aspects of acquired skills or memory abilities (Vaynman & Gomez-Pinilla, 2005) and maintenance of cognitive abilities relating to aging (Churchill et al., 2002; Podewils et al., 2005; Weuve et al., 2004). Of particular interest that has raised much research evidence in the past few decades was the effect of physical activity on the central nervous system (Vaynman & Gomez-Pinilla, 2005), specifically on cognitive processes.

An increasing focus on improving the physical level of children and youth has been in part due to the accelerating numbers of obesity in these age groups, as a result of sedentary lifestyle and the lack of physical exercise (Biddle et al., 2004). Leppo, Davis, and Crim (2000) stated that the formation of healthy lifestyles (i.e., exercise) is best formed during early childhood years where physical movements are critical milestones for the development of cognitive processes. In a meta-analytical study by Sibley and Etnier (2003), 44 research papers that examined the association between physical activity and cognitive performances in children aging from 4 to 18 years old were reviewed. The studies reviewed were based on categorisation of the research designs, publication, participants' physical and mental conditions, age ranges, types/intensities of physical activities and types of cognitive measurements. Participants ranged from early childhood to high school age with either typical development, impaired physical or mental developmental conditions, participated in short to long-term aerobic or anaerobic exercises: strength training, walking, running, treadmill, circuit training and gross-motor exercises. The participants were then tested on their cognitive performances across measurements assessing either intelligence, memory, perception, verbal and arithmetic abilities or other cognitive skills following post-exercises and compared the results with non-physical activity group or with their pre-exercises

performance. It was found that there was an overall positive association of 0.32 (i.e., effect size) between physical activity and children's cognition regardless of the disorders or developmental conditions relevant to the child. Furthermore, the authors also found that the effect was greatest for children aged 4 to 13 years, suggesting that physical activity may be most influential on the cognition of the children in this age group.

Given the importance of physical activity on typical developing children, more emphasis should be given to children with special needs (Biddle et al., 2004), especially children with learning difficulties (Sibley & Etnier, 2003). According to the DSM-IV-TR (American Psychiatric Association, 2000), ASD children have a relatively short attention span, and are not able to focus on majority of the circumstances (Folstein, 1999), which is an area of concern where early attentional impairments may affect the development of learning into adulthood as attention is an important factor for learning (Landry et al., 2009). Even though they do have an unusual level of attention on restricted interests, for example, public transport scheduled-timings (Folstein, 1999); unfortunately, it does not have associated functional values. Schneider-Garces et al. (2009) proposed that problems with attention control may also affect working memory capacity which decreases performance. In considering this research, enhancing attention span should be an area of focus in the early intervention of children with ASD.

Previous research by Rosenthal-Malek and Mitchell (1997) suggested the use of physical activity to improve overall positive behaviours and reduce negative behaviours on ASD children, which includes decreasing self-stimulatory behaviours, increased academic and work-related performance. The experimental study recruited five male teenagers, average age of 14.9 years old, with autistic disorder and an average IQ of 42.2, to examine the effects of physical activity (i.e., mild level of jogging) on their number of overt stereotypic behaviours (e.g., physically rocking, flapping of hands or

fingers, putting objects in their mouth etc.) recorded over a period of 50 seconds per participant (i.e., 5 seconds each observation randomly across participants with a total of 10 observations per participant), their performance on the arithmetic sessions (i.e., 10 questions pertaining to values of different coins) and the number of work tasks completed (e.g., transferring eggs into cartons, assembling beads or pens). All the participants were exposed to warm-up sessions and 20 minutes of jogging for 10 days (i.e., 5 days prior to arithmetic sessions and 5 days before work task sessions) and another 10 days on routine classroom lessons acting as a control condition (i.e., 5 days pre-arithmetic sessions and 5 days pre-work task sessions). The authors found that the number of stereotypic behaviours were significantly lower after the participants were exposed to jogging than compared to after control condition. The number of correct responses and work tasks completed were also found to be significantly increased following exercise compared with the control condition. However, the authors did not state how the post-exercise or post-control condition were randomised into the arithmetic and work-task sessions (e.g., the order of sequence) and in addition, the lack of a control group to allow for comparison, the actual effects of physical activity could not be substantiated. Furthermore, the increased in the arithmetic and work-task performance may be a matter of practice effect.

Another study by Nicholson et al. (2011) has also reported that physical activity increases academic involvement during classroom sessions. They examined the effects of jogging on classroom involvements measured in seconds of four primary school boys aged nine years, diagnosed with higher functioning range of the autism spectrum. The participants' classroom behaviours were measured separately according to active (e.g., reading out materials, engaging in peer discussion and etc.), passive (e.g., non-verbalised reading etc.) and total time involvements. Participants were observed 15 minutes each time over 5 sessions in 2 weeks as their baseline and subsequently first

participant will begin the jogging intervention for 12 minutes and observed for 15 minutes per trial over 3 sessions a week. An additional participant will begin their jogging session following each week until the last participants has jogged for two weeks. All the interventions were stopped for four weeks before a follow-up measurement was resumed with the same protocol as the baseline measurements. Distance covered by each participant in terms of the number of steps and laps were recorded and checked against the pedometer attached to the participants. Effect sizes were then used to analyse the results to gauge the effect of physical activity. The authors found that there was an increase in the classroom involvement time following participation of the exercise intervention (i.e., large effect sizes ranging from -0.7 to -1.5) and a positive correlation of the amount of physical activity with the level of academic involvement but the correlation coefficient was not reported. The authors also states that the durability of the effects were not consistent across the participants at the follow-up measurements. However, the authors did not use any significant value or analysis that allows the quantification of the effects seen and the lack of an equalised treatment frequency may result in biasness. In addition, there are no control group for comparison and therefore the results could not be generalised and are thus weakened.

In a correlational study, physically active elderly has also shown to have better visual attention than non-physically active elderly (Roth, Goode, Clay, & Ball, 2003). 140 elderly participants (mainly White Americans) with an average age of 74.5 years; the gender distribution of males and females were 61 and 79 respectively, participated in the study. The participants were tested on their visual cognitive abilities based on a software program that classified whether an individual will be at a higher chance of getting into road traffic accidents or other movement-related issues and were followed up with two questionnaires assessing their physical activity type, frequency, duration and intensity which were used to discriminate participants into physically active or

inactive group. There were 21 participants who were identified as physically active and had participated in at least 20 minutes of moderate and above intensity exercises three times a week. Correlations were then calculated among the questionnaire items and the visual attention test results. The authors found that the physically active group performed better in their visual cognitive abilities compared to the non-physically active group and that the active group participants were also not classified as having a higher risk of accidents whereas about 33% of the inactive group participants were at higher risk. In addition, consistent involvements in specific moderate and above intensity exercises (e.g., cycling, running, sports or exercise activities and etc.) were correlated significantly with visual attention rather than general routines of daily living. These results suggested that a more specific, regular and moderate or higher intensity exercises are more likely to be associated with better visual cognitive abilities in elderly participants. However, due to the nature of the study, the authors also cautioned against interpreting the results as causal.

Despite the limitations of the above studies, they provided valuable insights into the potential of using physical activity as a therapeutic measure in decreasing negative behaviours (e.g., stereotypic behaviours) and increasing positive behaviours associated with cognitive gains (e.g., work-task and academic improvements). In view of the vast benefits derived from physical exercises, there is a potential of incorporating the therapeutic use of physical activity as part of the focus of early intervention in children with ASD. However, an important question should be considered as to why physical activity may have a positive effect on children with ASD.

The mechanism of physical activity on learning and performance can be considered greatly under physiological aetiology (Nicholson et al., 2011). Multiple studies have explored the potential effects of exercise on cognitive functions: neurotrophins regulations (Ploughman, 2008), reactive oxygen species (Radak,

Kumagai, Talylor, Naito, & Goto, 2007), monoamine transmission and hemispheric coordination (Nicholson et al., 2011). However, Sibley and Etnier (2003) have highlighted the possibility of reduced anxiety and elevated self-esteem hypothesis in enhancing cognitive functions after physical exercise. Their meta-analysis study also revealed positive cognitive effects observed across any types of physical activities and across individuals aged 4 to 18 years and therefore the authors suggested that the mechanism underlying these seemingly universal effects may more likely to be psychological in nature. In support, other studies have also found that the cognitive gains are shown in individuals of 7 and 10 years (Elleberg & St-Louis-Deschenes, 2010), nine years (Nicholson et al., 2011) as well as 14 and 15 years old (Rosenthal-Malek & Mitchell, 1997). Thus, the beneficial effects are likely to be universal across these age groups and provided support that a psychological mechanism may be probable. In contrast, Tomporowski, Lambourne and Okumura (2011) summarises that this underlying mechanism may be partly attributed to the physiological factors occurring in the brain but could also be as a result of other psychosocial factors that contributes to this phenomenon and therefore a model that incorporates various fields of knowledge would be required to unveil the relationship between physical activity and cognitive progress.

Neurotrophins regulations

Multiple experimental studies and meta-analysis have found that physical activity enhances cognitive performances in rodents and some in humans (Ding, Vaynman, Akhavan, Ying, & Gomez-Pinilla, 2006; Praag, 2009; Vaynman & Gomez-Pinilla, 2005; Vaynman, Ying, & Gomez-Pinilla, 2004), and a possible explanation has centred on the neurotrophic mechanism, focused mainly on the brain-derived neurotrophic factor (BDNF) (Deslandes et al., 2009). Neurotrophins act as the point of regulation for the growth and survival of developing neurons and also exerted influence

on genes (Ploughman, 2008). The idea underlying neurotrophic hypothesis is that the brain is capable of modifying its structures and functions (Hennigan et al., 2007) accordingly, to the demands by the introduction of the environmental (Churchill et al., 2002) or behavioural stimuli through the development and enhancement of their connections (Cotman & Berchtold, 2002), which have been associated with aspects of learning and recollection of memory (Praag, 2008). The most evident stimulus that has the potential to trigger these changes is physical activity (Praag, 2009).

A study conducted by Vaynman et al. (2004) on rodents blocked the functions of BDNF during exercise, which is a factor found to be triggered by physical activity and are critical for the process of acquiring learning and consolidation of memory; it was found that the rodents in the exercising group that were BDNF inhibited no longer experienced the beneficial effects on cognition and had reduced cognitive performance to the level comparable to the controls. The authors thus suggested that the BDNF may be the mechanism that underlies the effects of cognitive improvement seen after physical activity. As BDNF production is particularly sensitive to physical activity, its potential beneficial functions on cognition can be easily accessed, even patients with disorders of the central nervous system can benefit by activating the brain inherent capability to generate neuronal changes towards recovery of its functions through exercising (Vaynman & Gomez-Pinilla, 2005). Similarly, children with ASD may underperform in different aspects of behaviours and/or cognition, however these do not represent the inability of the brain to function; instead the problems may be a result of untapped abilities in these areas which can be elicited if the correct stimulus is applied (Belmonte et al., 2004).

Coincidentally, the neurotrophic hypothesis seems to concur with the direction of the aetiology of ASD: the abnormal brain structure and/or impaired functions and neural connectivity within and among its structures. These may suggest that if ASD are

generally accepted as disorders related to the brain's neural network (Minschew & Williams, 2007) that are abnormal both in its neuronal connectivity and structures (Just et al., 2007), it may thus be plausible that physical activity may act as a mediating factor that has the potential to influence the brain's inherent ability to modify its molecular structures and functions through the generation and enhancement of their connectivity, and therefore may induce the integration of the entire brain system to be in a state optimal for learning to take place (Nicholas et al., 2011).

Psychosocial Theories

The relationship between physical activity and psychological well-being has been widely studied (Fox, 1999). According to the mastery hypothesis, the positive cognitive gains seen after exercise can be in part due to the feeling of obtaining a sense of competency in the physical activity and as a result increases both self-confidence and a sense of autonomy in both the physical skill as well as other areas like cognitive performance (Paluska & Schwenk, 2000). This mastery effect is also capable of transferring to other life aspects like the individual self-esteem and to a more general psychological well-being (Fox, 1999). These suggested that by acquiring a physical skill (i.e., exercise), individuals will also acquire the positive feelings associated with a sense of mastery and instead will be able to apply these mastery feelings to other areas and thus increase the likelihood of success. In addition, physical activity can also act on relieving stress and anxiety associated with social or task demands, which could also assist cognitive performances (Sibley & Etnier, 2003). In a study by Kwan and Bryan (2010) on the relationship between affective response and physical exercise, they found that the exercise could serve as a stress and mood regulator (i.e., reduced stress and improve affect) which are the benefits derived from physical activity. This may suggest that as the level of stress and mood are regulated to a positive level after exercise,

individuals may be more able or willing to focus on the task at hand, which may partially explain the associated cognitive effects seen post-exercise.

Another related theory that is more comprehensive is self-efficacy theory proposed by Bandura (1993). Self-efficacy perception affects the direction of individual's thought, emotion, motivation and behaviour, which functions as a critical factor for cognitive development. The belief in the ability to exert an effective regulation of the performance in required situation has an impact on subsequent performances in other areas of functioning. Therefore, the successful performance experience gained from one event becomes the foundation/reference of success that strengthens the level of self-efficacy, improves cognitive processes, reduces associated stress and could also improve the ability to carry out required behaviours in other settings. With higher levels of self-efficacy, thought processes are enhanced and allow the application of cognitive resources efficiently to the task at hand. Furthermore, the success gives a sense of fulfilment and motivates further attempts in trying to accomplish challenging tasks in order to achieve the satisfaction, which also builds perseverance on improving performance and develops resistance towards giving up when faced with failed attempts. This makes the individual more likely to approach task demands in the environment/settings and as a result, hones their cognitive processes which nurture task interest and focus, leading to enhancement of task performance. In summary, physical activity may represent an acquired successful skill that elevates the self-belief within the child in his/her ability and motivation to perform which act as a base reference that can be applied to other situational demands; this may be a plausible mechanism that explains the relationship between physical activity and cognition.

The Types, Durations and Intensities of Physical Activity

Though the effects of physical activity on cognition are well documented, the types, duration and intensities of the physical activity are important considerations in

the process of therapeutic implementation (Paluska & Schwenk, 2000). Based on a meta-analysis, it was found that the type of physical activity was not a significant contributor to the effects of physical activity on cognitive performances (Sibley & Etnier, 2003). In addition, past studies of exercise and cognition have reported a wide range of physical activities: jogging (Nicholas et al., 2011; Rosenthal-Malek & Mitchell, 1997), on treadmills (Medina et al., 2010), swimming, cycling, and other forms of aerobic exercises (Churchill et al., 2002). Moreover, according to the characteristics of BDNF, it is stimulated greatly by physical activities (Vaynman & Gomez-Pinilla, 2005). Taken together, it may be highly probable that the enhancement of cognitive abilities through exercise are not specific to any types of physical activities and that any form of aerobic exercises may be sufficient to derive its beneficial effects.

Due to the contribution of exercise on psychological and physical health, it has been suggested that longer duration of exercises may be better for the individuals to enjoy greater benefits (Fox, 1999). In contrast, Ploughman (2008) argued that increases in fitness level through increased exercises are not parallel to increased cognitive benefits. Moreover, longer sessions of exercises may cause the issue of excessive workouts which can have harmful consequences to both physical and psychological aspects of the individuals; for example, displaying depression-like symptoms (Peluso & Andrade, 2005; Paluska & Schwenk, 2000) and increased in stress hormones (Daly, Seegers, Rubin, Dobridge, Hackney, 2005; Ploughman, 2008). In a literature review by Peluso and Andrade (2005), 87 research articles related to the association of physical activity and mood were examined. They found that while moderate intensity level of exercises within the individual threshold are associated with mood enhancement, high intensity exercises like prolonged canoeing, running and other aerobic exercises, unfortunately resulted in its reduction, impairing both physical and psychological health: for example, depressive-symptoms resembling clinical depression like lethargic,

body aches, irritable or depressive moods, sleep disturbances and etc. (Esfandiari, Broshek, & Freeman, 2011). In relation, Daly et al. (2005) examined the blood stress hormonal levels of 22 healthy male adults of average 24.6 years of age before and after exposure to extreme treadmill exercise and also at post 30, 60, 90 minutes and 24 hours. During the treadmill exercise, participants had to reach their maximum point of fatigue before ceasing the physical activity. The authors found that the level of stress hormones were increased significantly at post-immediate to 60 minutes after high intensity exercise, with levels peaked to 203% and 475% higher at post-30 minutes compared to baseline. On the other aspect, Bakken et al. (2001) undertook a pilot study of eight weeks of low intensity aerobic exercises (e.g., walking, stepping, flexion of upper limbs and etc.) on the psychomotor performance of 10 elderly participants (i.e., five exercise and five non-exercise participants), mean age of 82.5 years with no significant physical or medical conditions that may affect their participation. The low intensity exercises were not found to significantly improve physical health (i.e., aerobic fitness) but were able to improve aspects of cognitive functioning in exercise participants (i.e., information processes). These studies may indicate that low to moderate intensity exercises are sufficient to produce both cognitive and physical benefits. Collectively, it seems likely that moderating the intensity of the exercises (Ploughman, 2008) is most beneficial to the individual's overall health.

Unfortunately, the appropriate threshold of physical activity and cognitive gains are not presently known (Ploughman, 2008). However, past research on children have utilised a range of 12 to 20 minutes of physical activity each session and had reported positive cognitive and behavioural gains (Nicholas et al., 2011; Rosenthal-Malek & Mitchell, 1997), therefore, at the minimum these research studies provided a "safe time range" as a guide for the implementation of physical activity on children. Furthermore, Leppo et al. (2000) has provided the recommendation that exercise activity should be

catered to the individual needs of the child based on their capabilities. Therefore, physical activity should be provided in ways that are appropriate for the child.

Furthermore, Strong et al. (2005) states that it is imperative for physical activity to be promoted in early childhood as there is evidence that it has increased benefits in physical and psychological well-being. However, previous research on the effects of physical activity on ASD children was based on a limited number of participants with no control group comparison which makes it difficult for future generalisation. In considering the beneficial effects of physical activity, more emphasis should be placed on examining its effects on early intervention in ASD children as well as their quality of life.

Quality of Life

Another issue of importance yet with a dearth of literature is the Health-Related Quality of Life (HRQoL) of children with ASD (Kuhlthau et al., 2010). Brewin, Renwick, and Schormans (2008) mentioned that the goal for professionals is to enhance the quality of life of children especially those with developmental disabilities. Kuhlthau et al. (2010) found that ASD children who have more negative behaviours scored lower on the quality of life and suggested future studies that focus on improving the problem behaviours should improve the HRQoL. This implies a need to develop interventions that specifically targets improving the quality of life of ASD children. A review of the literature has not identified any studies conducted to examine the effects of physical activity on HRQoL and attention span of ASD children in Singapore.

Summary

The purpose of the current study was to partly replicate previous studies by utilising an increased number of participants and a control group to examine the impact of physical activity on the attention span and HRQoL in ASD children of early intervention age (2-6 years) in Singapore. Firstly, Nicholson et al. (2011) and

Rosenthal-Malek and Mitchell (1997) found that 12 – 20 minutes of physical activity improved academic involvement and work performance. Therefore, it will be anticipated that the attention span of children diagnosed with ASD will increase following exposure to physical activity. Secondly, Kuhlthau et al. (2010) suggested that with improved problem behaviours of ASD children, their HRQoL scores should also improve and thus an increase will be expected in the HRQoL scores of children diagnosed with ASD following exposure to physical activity. Lastly, the non-physical activity group will act as a control group and will be expected to have no difference in both the attention span across trial measurements and, pre/post-HRQoL scores.

The specific hypotheses for this research are:

1. Participants in the physical activity group will display significant increment in their duration on the sustained attention span task as measured in seconds after the 8 sessions of physical activity compared with the participants in the non-physical activity group.
2. Participants in the physical activity group will demonstrate increased improvement of the attention span duration as the number of exercise session increases compared to the non-physical activity group.
3. The difference in duration of attention span in both physical activity and non-physical activity group will be dependent on the number of exercise sessions.
4. The participants in the physical activity group will demonstrate significant increase in their overall HRQoL post scores as measured by the Pediatric Quality of Life Inventory (PedsQL) after the completion of the exercise intervention in comparison with the non-physical activity group.

Method

Research Design

The current study used an experimental design to examine the effects of physical activity on two main areas: attention span and quality of life. For the attention span,

there are two independent variables: trial (0, 1, 2 and 3) and group condition (physical/non-physical activity), with the performance on the attention task (i.e., attention span) as the dependent variable. The quality of life includes the group condition (physical/non-physical activity) as the independent variable and the HRQoL scores as the dependent variable. The study randomly assigned participants equally to one of the two group conditions: physical activity and non-physical activity. The randomisation process was conducted based on coin tosses (e.g., head of the coin: participant assigned to physical activity group).

Participants

The participants in the current study were 14 children aged 2-6 years that have been previously diagnosed with ASD according to the DSM-IV-TR (American Psychiatric Association, 2000). In addition, all met the criterion of not having any physical disability, and were able to participate having had parental/guardian consent. Two of the participants were removed at the analysis stage due to one being identified as an outlier and one having missing data. Overall, 12 male participants data were retained for this study. Demographic summary of the participants are presented in Table 1.

Table 1
Summary of Participants' Demographic Information in Both Group Conditions and Overall

	Number (%)	Mean Age	SD	<i>n</i>
Physical activity		5.00	1.16	7
Race				
Chinese	^a 6 (85.71)			
Malay	1 (14.29)			
Gender				
Male	^a 7 (100.00)			
Female	0 (0.00)			
Non-physical		4.71	1.38	7
Race				
Chinese	^b 5 (71.43)			
Malay	2 (28.57)			
Gender				
Male	6 (85.71)			
Female	^b 1 (14.29)			

Overall		4.86	1.23	14
Race				
Chinese	11 (78.57)			
Malay	3 (21.43)			
Gender				
Male	13 (92.86)			
Female	1 (7.14)			

Note: In total there are only two participants removed at the early stage of analysis

^a One participant removed due to outlier ^b One participant removed due to missing data

Participants were recruited from various early intervention centres in Singapore that provided early intervention programs to ASD children aged 2-6 years. In total, 11 early intervention centre managers from eight voluntary welfare organisations and two private early intervention agencies were approached to participate in the research. Email invitations which included information letters (Appendix A and B) and research pamphlets (Appendix C) explaining the nature and rationale of the study were sent to the organisations described above. The centres were requested to assist in distributing the provided information letters and research pamphlets to the parents of ASD children aged 2-6 years of age. Out of the 13 emails sent, five centre managers from four voluntary welfare organisations agreed to participate in the research. The reasons provided by non-participating centres were: limited resources in distributing the research materials, limited time/availability, not according to organisational protocols and no reasons/responses given. From the participating centres, 246 participants were provided with information about the study and 14 (5.69%) parents volunteered to participate in the research.

Materials

Children participants were assessed with a sustained attention task measuring their attention span and the parents were given a questionnaire asking questions about their children's HRQoL.

Sustained attention span task

The attention span task included 24 cards with 12 identical pairs (Appendix F) and was designed to be similar to the card-matching task conducted by Muller, Zelazo, Hood, Leone, and Rohrer (2004) and Pailthorpe and Ralph (1998). Based on the baseline performance of the child, the number of cards could be increased to 44 with 22 pairings if the maximum limit of the initial 12 pairs was obtained. This was to allow a proper measurement in detecting possible increase in the attention span. For example, if the child obtained the maximum number of pairing (i.e., 12) on the baseline measurement, the child will then be measured based on 22 pairings which will replace the initial baseline. The task entailed finding pairs of identical cards facing down with two cards to be flipped each time for as long as possible. A simple demonstration with four cards of two pairings was shown each time to the participants before administering the sustained attention task. The attention span of the participants was measured in seconds using a stopwatch; the measurement began when the child was ready and ended when the child lost the attention on the task (e.g., looked away from the task, left the seat, messed up, threw the cards or did not continue on the task for a period of 10 seconds).

Pediatric quality of life inventory (PedsQL)

To assess the health-related quality of life (HRQoL) of ASD children, the Pediatric Quality of Life Inventory 4.0 (PedsQL), developed by Dr. James W. Varni was used (Varni, 1998). PedsQL is a 23-items questionnaire assessing the area of physical and psychosocial health (emotional, social and school/day-care functioning) in children aged 2-18 years. Each item is scored using a 5-point Likert scale ranging from (0 – Never, to 4 – Almost Always). The total scores are computed into a scale of 0-100, with higher scores representing higher quality of life. The scores were computed if at least 50% of the items are completed as recommended by Varni (1998). In addition,

only completed items in the post-administration of the PedsQL that matched the completed items in the baseline administration were compared to allow for unbiased comparisons. Due to the difficulties in communication as commonly experienced by ASD children (Kuhlthau et al., 2010), only the parent proxy-report version for toddler and young children were adopted for this study. The toddler version has 21-items while the young children version has 23-items. The parent proxy-report has an alpha value of 0.90 and has shown to differentiate between healthy children and children with developmental conditions/disorders (Varni, Seid, & Kurtin, 2001). The PedsQL is also suitable for evaluation of intervention outcomes (Varni, Seid, & Rode, 1999) which were utilised as an outcome measurement of the exercise intervention in this study.

Procedure

From the initial 14 participants that agreed to participate, the children were randomly assigned to either physical activity ($n = 7$) or non-physical activity group ($n = 7$). At the initial session, the nature of the study was explained to the parents and any questions/concerns were addressed before consent forms were given: one for their participation (Appendix D) and the other on behalf of their child (Appendix E); a brief verbal consent from the children were also collected prior to the start of the study. Participation was voluntary and any personal information was kept confidential through the assignment of alphabets and numbers. At the first session, baseline measurements were taken from both groups of child participants. This involves utilising the attention span task being given to both groups and were recorded to measure their initial attention span. In addition, the parents were asked to complete the PedsQL questionnaire. At subsequent measurements, the attention task was repeatedly measured on three different trials separately for participants in each group condition. Lastly, the parents in both groups completed the same questionnaire on their respective last sessions. In total, all participants completed four trials of measurement on the attention task and their parents

completed two copies of the PedsQL questionnaire. All the tests administration are conducted at the respective residences of the participants and the exercise intervention were carried out at the nearby open areas or national parks. Table 2 shows the overall process of the research procedure.

Table 2

Summary Table for the Process and Order of Research Procedures

	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8
Group								
Physical activity	AS PedsQL PA	PA	PA	PA AS	PA	PA AS	PA	PA AS PedsQL
Non-physical activity	AS PedsQL	AS	AS	AS PedsQL	-	-	-	-

Note: The activities/measurements are listed in order of administration.

AS – Attention span task, PedsQL – Pediatric Quality of Life Questionnaire, PA – Physical activity intervention

Physical activity group (Experimental group)

Child participants who were randomly assigned to the physical activity group participated in eight sessions of the tri-cycling intervention, completed 15 minutes at each session. During the tri-cycling intervention, the researcher accompanied the child by staying at the side of the child at all times to ensure safety. The distance and speed covered by the participants were not measured due to the differences in the cycling ability among the participants. Time and place of the administration was also not controlled due to the variations of the participants' schedule and limitation of resources. However, all participants completed the required 15 minutes of tri-cycling per session at their own pace and capabilities, therefore the intensity was mainly of low to moderate levels. After the intervention was conducted on the fourth, sixth and eighth sessions, participants were given the attention span task to measure the post-effect of the intervention.

Non-physical activity group (Control group)

Children who were randomly allocated to the non-physical activity group only participated in four separate sessions on the attention span task to measure their level of attention span across trials. No additional activities were given to the participants in the control group as Wipfli, Landers, Nagoshi, and Ringenbach (2011) suggested that an actual control group not confounded by other given activities by the researcher should be used to illustrate a clearer view on the effects of physical activity.

Ethics

This research was approved by the subcommittee of the Faculty of Computer, Health and Science, Edith Cowan University Ethics Committee. The risk assessment was carried out prior to the commencement of this research with consideration of the potential risks that may be involved in the research process. One key consideration was the risk of accidents (e.g., falls) during the administration of the exercise intervention. The researcher was trained in first-aid procedures and equipment was available during all sessions of the physical activities. During the data collection phase, there was one incident of fall that occurred during the administration of the physical exercise (i.e., abrasion on the left knee cap) and first-aid assistance was immediately rendered on-site to the child participant: the wound was cleaned with normal saline, applied antiseptic cream and completed with a simple dressing. Visual inspection and questions pertaining to any discomfort or pain felt by the child was also carried out to ensure no other injuries were sustained. As the injury was sufficiently attended with first-aid application, no further medical attention is required.

Results

Predictive Analytics Software Statistic 18 (PASW) was used for the statistical analyses for data screenings and in exploring the relationship between physical activity, attention span and quality of life. A mixed-design of repeated-measures and between

group (i.e., physical activity and non-physical activity group across trials) analysis of variance (ANOVA) was used to address the hypotheses of the effect of trial and the effect of physical activity on the attention span and their interactions. In addition, to illustrate a clearer effect of physical activity on the attention span, baseline performance on trial 0 was assigned as the covariate to reduce baseline differences in attention span abilities among participants. Lastly, the effect of physical activity on the HRQoL was analysed with a one-way analysis of covariance (ANCOVA) with the pre-intervention scores controlled as the covariate and the post-intervention scores compared between the physical activity and non-physical activity group condition. The significance level set across the analyses is $p = .05$.

Assumption Testing

Attention span

Prior to the main analyses, data were screened for mixed design ANOVA assumptions of normality, homogeneity of variance and sphericity (Field, 2009). In terms of normality, the duration on the attention task for physical activity group on trial 1, $W(6) = 0.79$, $p = .05$, and trial 2, $W(6) = 0.78$, $p = .04$; and for non-physical activity group on trial 0, $W(6) = 0.70$, $p = .01$, trial 1, $W(6) = 0.77$, $p = .03$, and trial 2, $W(6) = 0.73$, $p = .01$, were all significantly non-normal. In conjunction with the normality plots and descriptive statistics, deviations from normality were detected together with combined group skewness (i.e., lowest to highest on all trials) ranging from 1.03 ($SE = 0.64$) to 2.57 ($SE = 0.64$) and kurtosis ranging from -0.13 ($SE = 1.23$) to 7.38 ($SE = 1.23$) which confirms that the data were non-normal and highly positive skewed. In relation to the assumptions, the homogeneity of variance test shows that variances for the durations on the attention task were equal for both groups on trial 0, $F(1, 10) = 2.30$, $p = .16$, trial 1, $F(1, 10) = 3.14$, $p = .11$, and trial 2, $F(1, 10) = 3.40$, $p = .10$, however, the variances were significantly different between groups on trial 3, $F(1, 10) = 5.96$, $p =$

.04. Taken together, the initial data analyses revealed violations of the assumptions of normality and homogeneity of variances across groups. In order to perform the required analysis, a natural logarithmic transformation of the data was performed prior to the analysis, to correct for the violations (Field, 2009; Leydesdorff & Bensman, 2006; Osborne, 2002; Raban & Rabin, 2009).

After transformation, all the assumptions initially violated are met and a 2 (group) x 3 (trial) mixed design ANOVA was performed on the transformed data. The assumption of sphericity as indicated by Mauchly's test for the effects of trial was not significant, $\chi^2(2) = 0.62, p = .74$. Therefore the assumption was not violated and no correction was required. In addition, it should be noted that Trial 0 was controlled as a covariate to account for the significant differences in baseline performances among both groups of participants, $F(1, 9) = 26.34, p = .001, partial \eta^2 = .75$. This indicates that trial 0 was significantly related to the participants' performance on the attention task and therefore could be controlled as a covariate.

PedsQL

Prior to performing a one-way ANCOVA, data screening was also carried out on the PedsQL scores. Test of normality and homogeneity of variance for the PedsQL baseline and post scores of both group of participants' revealed no violation of assumption for ANCOVA. The baseline PedsQL scores which is significantly related to the post-scores, $F(1, 9) = 41.16, p = <.001, partial \eta^2 = .82$, was assigned as a covariate to reduce baseline differences between both groups of participants.

Analysis for Hypothesis 1: The Main Effect of Group/Physical Activity

To determine if participants in the physical activity group displayed significant increment in their duration on the sustained attention span task after the 8 sessions of physical activity compared with the participants in the non-physical activity group, a mixed design ANOVA was conducted to compare the main effect of group on the

duration of the attention task. Descriptive statistics revealed that the adjusted mean (i.e., attention span) of the physical activity group ($M = 4.63$, $SD = 0.48$) was higher than the mean of the non-physical activity group ($M = 3.93$, $SD = 0.48$). The result indicates a significant main effect of group/physical activity on the performance of the attention task when the effect of trial 0 was controlled, $F(1, 9) = 5.62$, $p = .04$, $r = .62$. This indicates that after controlling for the effect of trial 0, participants in the physical activity and non-physical activity group performed significantly different on the attention span task when the main effect of trial was not included.

Analysis for Hypothesis 2: The Main Effect of Trial

To determine if participants in the physical activity group demonstrated increased improvement of the attention span duration as the number of exercise session increases compared to the non-physical activity group, a mixed ANOVA was conducted to analyse the main effect of trial on the attention span. There was a significant main effect of trial on the performance of the attention task after the effect of trial 0 was controlled, $F(2, 18) = 4.40$, $p = .03$, *partial* $\eta^2 = .33$. This indicates that by controlling for the effect of trial 0, the effect of trial significantly affected the performance of the participants on the attention task when the main effect of physical activity/group was not considered. Planned contrast indicated that on trial 3, participants' duration on the attention task was significantly higher than on trial 1, $F(1, 9) = 11.26$, $p = .008$, $r = .75$, but was not significantly different on trial 2 compared to trial 1, $F(1, 9) = 2.14$, $p = .18$, $r = .44$.

Analysis for Hypothesis 3: The Interaction Effect of Trial and Group

To examine if the difference in duration of attention span in both physical activity and non-physical activity group were dependent on the number of exercise sessions, mixed ANOVA was used to analyse the interaction effect of trial as a function of group/physical activity on the attention span. There was a significant interaction

effect between the number of trials and the group type when the effect of trial 0 was accounted, $F(2, 18) = 4.10, p = .03, \text{partial } \eta^2 = .31$. This indicates that the number of trials had different effect on the individual's performance depending upon which group they belong. To further understand this interaction, planned contrasts were performed comparing performance on each trial across participants in the physical activity and non-physical activity group. Contrasts revealed that the performance of trial 2 and trial 1 between both groups of participants, the interaction was not significant, $F(1, 9) = 4.75, p = .06, r = .59$, but when compared between trial 3 and trial 1, there was a significant interaction, $F(1, 9) = 8.17, p = .02, r = .69$. According to Figure 1, participants in the physical activity and non-physical activity group performed similar at trial 1. However, as the number of trial increases, the individuals in the physical activity group had increasingly higher scores on the attention span task with the highest performance on trial 3; while individuals in the non-physical activity group seem to have decreasing performance scores on trial 2; although there was a slight improvement on trial 3 but was still lower compared to their trial 1 performance. Overall, the increased duration was more pronounced for the physical activity group than non-physical activity group. In general, this interaction suggests that the number of trials affected the increase in the duration on the attention span task of the participants in the physical activity group more than the participants in the non-physical activity group. Descriptive statistics and ANOVA summary table are presented in Table 3 and 4.

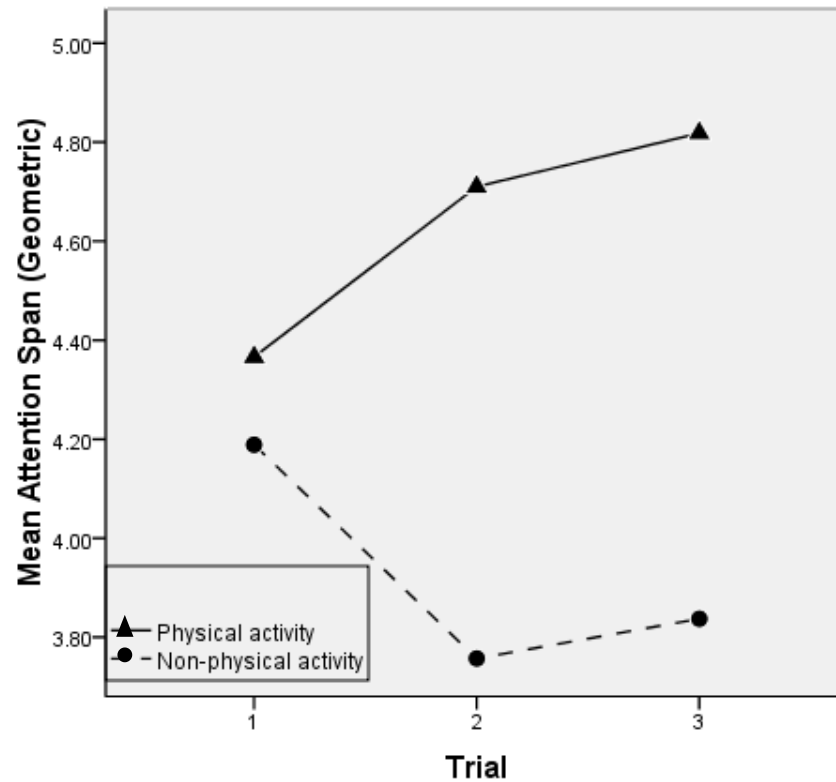


Figure 1. Mean performance on the attention span task across trials for both physical and non-physical activity group. Note that the values are in geometric units (transformed data).

Table 3

Unadjusted and Adjusted Means (geometric), and Standard Deviations for Group Conditions as a Function of Trials with Trial 0 as a covariate

Group	Trials					
	1		2		3	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Unadjusted means						
Physical activity	4.86	1.17	5.07	0.92	5.08	0.73
Non-physical	3.70	1.05	3.40	0.84	3.57	0.60
Adjusted means						
Physical activity	4.37	0.61	4.71	0.60	4.82	0.48
Non-physical	4.19	0.61	3.76	0.60	3.84	0.48

Note: $n = 6$ for each group. The above means are presented in geometric units (transformed data).

Table 4

Summary Table for Mixed Analysis of Variance of the Effects of Trial and Group Conditions on the Overall Attention Span (Transformed), with Trial 0 as Covariate

Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>	Partial η^2
Covariate	1	5.32	5.32	26.34	.001*	.75
Trial	2	1.02	0.51	4.40	.03*	.33
Trial (Error)	18	2.09	0.12			
Group	1	1.13	1.13	5.62	.04*	.38
Trial x Group	2	0.95	0.48	4.10	.03*	.31
Error	9	1.82	0.20			

Note: The Mixed ANOVA was conducted based on transformed data.

* $p < .05$.

Analysis for Hypothesis 4: The Effect of Physical Activity on overall HRQoL

To explore whether the participants in the physical activity group demonstrated a significant increase in their overall HRQoL post scores after the completion of the exercise intervention in comparison with the non-physical activity group, a one-way ANCOVA was carried out to compare the post-PedsQL scores between the groups. There was no effect of group/physical activity after controlling for the effect of baseline PedsQL scores, $F(1, 9) = 0.73$, $p = .42$, $r = .27$. This suggests that the post-PedsQL scores were not significantly different among participants in both groups after controlling for their baseline differences. As the overall PedsQL were constructed based on physical and psychosocial indexes, further analyses (i.e., ANCOVA) were conducted to examine the effects of physical activity on the individual indexes.

The effect of physical activity on the physical functioning index

Further analysis was performed on the physical functioning index post-scores to determine if there is any effect of group differences. The covariate, pre-physical index scores, were significantly related to the scores on the post-physical index of the PedsQL, $F(1, 9) = 46.52$, $p < .001$, *partial* $\eta^2 = .84$. However, there was no significant group effect on the post-physical index, $F(1, 9) = 0.05$, $p = .82$, $r = .08$, indicating that

the scores of the post-physical index were similar for both groups of participants after controlling for the effect of their pre-physical index scores.

The effect of physical activity on the psychosocial functioning index

To further analyse the effect of physical activity on the psychosocial functioning, the post-psychosocial scores were compared between both groups of participants. The pre-psychosocial index scores, controlled as the covariate significantly affected the post-psychosocial index scores on the PedsQL, $F(1, 9) = 27.07, p = .001, partial \eta^2 = .75$, but the effect of group was not significant, $F(1, 9) = 0.78, p = .40, r = .28$. This result suggested that when the effect of pre-psychosocial scores was controlled, the post-psychosocial scores did not differ significantly between the two groups of participants. However, as the psychosocial index is comprised of emotional, social and school subscales, further ANCOVAs were carried out individually for the subscales to examine any possible effect of physical activity on the subscale level.

The emotional and school post subscales scores after controlling for their individual pre-subscale scores were not significantly different among the groups (Refer to Table 6). In contrast, with the pre-social subscale scores as a covariate, $F(1, 9) = 72.13, p < .001, partial \eta^2 = .89$, a significant group effect was detected on the post-social scores, $F(1, 9) = 8.36, p = .02, r = .69$. These results indicate that the scores on the post-social subscale were significantly different for participants in the physical activity and non-physical activity group. Descriptive statistics (Table 5) shows that the participants in the physical activity group have higher post-social scores ($M = 56.39, SD = 5.60$) than participants in the non-physical activity group ($M = 46.95, SD = 5.60$) after the effect of their pre-social scores are controlled for.

Table 5

Unadjusted and Adjusted Post-Quality of Life Score Means for the Groups in PedsQL Overall, Indexes and Subscales

Group	Unadjusted Means		Adjusted Means	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Overall PedsQL				
Physical activity	64.83	13.21	64.46	2.15
Non-physical	61.50	10.11	61.87	2.15
Physical Index				
Physical activity	74.83	12.69	74.28	2.20
Non-physical	73.00	12.70	73.56	2.20
Psychosocial Index				
Physical activity	59.50	16.61	59.07	2.93
Non-physical	55.00	9.72	55.43	2.93
Emotional Subscale				
Physical activity	56.67	15.06	57.56	5.00
Non-physical	61.67	17.22	60.78	5.00
Social Subscale				
Physical activity	59.17	21.31	56.39	2.29
Non-physical	44.17	6.65	46.95	2.29
School Subscale				
Physical activity	64.33	19.21	65.01	5.42
Non-physical	60.00	16.60	59.32	5.42

Note: $n = 6$ for each group.

Table 6

Analysis of Covariance of Post Quality of Life Scores as a Function of Physical Activity with individual Pre-scores as Covariates

Source	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>p</i>	Partial η^2
Overall PedsQL						
Pre-score (Covariate)	1	1135.97	1135.97	41.16	< .001*	.82
Groups	1	20.14	20.14	0.73	.42	.08
Error	9	248.37	27.60			
Total	12	49298.00				
Physical Index						
Pre-score (Covariate)	1	1349.72	1349.72	46.52	<.001*	.84
Groups	1	1.55	1.55	0.05	.82	.01
Error	9	261.12	29.01			
Total	12	67185.00				
Psychosocial Index						
Pre-score (Covariate)	1	1389.57	1389.57	27.07	.001*	.75
Groups	1	39.84	39.84	0.78	.40	.08
Error	9	461.93	51.33			
Total	12	41243.00				
Emotional Subscale						
Pre-score (Covariate)	1	1269.99	1269.99	8.49	.02*	.49
Groups	1	30.87	30.87	0.21	.66	.02
Error	9	1346.67	149.63			
Total	12	44700.00				
Social Subscale						
Pre-score (Covariate)	1	2215.26	2215.26	72.13	<.001*	.89
Groups	1	256.58	256.58	8.36	.02*	.48
Error	9	276.41	30.71			
Total	12	35200.00				
School Subscale						
Pre-score (Covariate)	1	1642.32	1642.32	9.35	.01*	.51
Groups	1	96.84	96.84	0.55	.48	.06
Error	9	1581.01	175.67			
Total	12	49656.00				

* $p < .05$.

Discussion

The purpose of this study was to investigate the potential effects of physical activity on the attention span and quality of life of children with ASD. There are two central focuses: attention span and overall HRQoL. Four hypotheses are used to examine their relationships: hypotheses 1, 2 and 3 addresses the effects of physical activity on attention span, while the last hypothesis is on the effects of physical activity on the overall HRQoL. The results of this study supported the hypotheses for physical activity and attention span but only partially supported the last hypothesis (i.e., HRQoL). The following section will discuss the relevance of the current study together with existing literature and implications to ASD population; the limitations and future directions will also be reviewed.

Hypotheses 1, 2 and 3: Physical Activity on Attention Span

Over the past few decades, physical activity has been consistently shown to have a positive impact on cognition (Ding et al., 2006; Praag, 2009; Vaynman & Gomez-Pinilla, 2005; Vaynman et al., 2004). In particular to ASD population, studies have also demonstrated improvements of academic and work-task performance (Rosenthal-Malek & Mitchell, 1997), and classroom involvement time (Nicholson et al., 2011) after participants were administered exercise interventions. In consistent with the above cited studies, the current results found that participants exposed to physical activity shown longer duration of their attention span on the attention task as the number of exercise session increases. This study indicates that with continuing exercise interventions, participants were able to demonstrate improvement on the duration of their attention span. In addition, the comparison to a control group not exposed to any activities given by the researcher further elucidated the effects of physical activity on children with ASD.

Past studies have indicated that activity that requires high focus would trigger the brain system in enhancing the ability to learn or perform (Goard & Dan, 2009; Mitchell, Sundberg, & Reynolds, 2007; Sarter, Gehring, & Kozak, 2006; Kozak, Bruno, & Sarter, 2005). Collectively, it may suggest that there could be other tasks that may have a similar effect but are perhaps difficult to get the child to engage or stay on the task (i.e., the child can choose to ignore). Conversely, physical activity (e.g., tri-cycling) may have indirectly “forced” the child to maintain focus on the task which may have triggered the system and therefore are more likely to be effective (i.e., in enhancing cognitive functions) compared to non-physical activities. In support, the observation by Sibley and Etnier (2003) that any types of physical activity demonstrated a positive association with cognitive progress further strengthens the above notion. Furthermore, according to the neurotrophic hypothesis, the brain system is modifiable (Hennigan et al., 2007) through behavioural stimulus (Cotman & Berchtold, 2002). Taken together, may account for the improvement in attention span observed in the current study.

However, Sarter et al. (2006) argued that participant’s motivation is also an important factor in activating the enhanced brain system in response to underperformed situations. According to self-efficacy theory (Bandura, 1993), a successful performance provides a sense of fulfilment and further seeks accomplishment of challenging task in order to gain task satisfaction, which fosters perseverance. This was indeed indicated by the longer duration on the sustained attention task as the number of exercise session increases, which may reflect enhanced persistence (i.e., motivation) in task performance. In contrast, it may also be possible that despite randomisation efforts, participants with better attention span are in the physical activity group whilst participants with poorer attention span are in the non-physical activity group which may have given rise to the difference observed in this study. However, it is unlikely that individual attentional abilities played a significant influence in this difference as the

participants in the physical activity group continued to display significant improvement on their attention span duration after their baseline differences are controlled for.

In general, given the current findings in the context of previous studies, it is plausible to suggest that physical activities are beneficial to the improvement of cognitive performance (i.e., attention span) in children with ASD.

Hypothesis 4: Physical Activity on HRQoL

Apart from of the cognitive benefits derived from physical activity, Rosenthal-Malek and Mitchell (1997) have also found the reduction of stereotyped behaviours in participants with ASD following exercise interventions. Hence, the authors suggested the use of physical activity in decreasing the problem behaviours of ASD individuals. In relation, Kuhlthau et al. (2010) proposed that intervention that aims to improve the problem behaviours of ASD children would likewise increases their HRQoL. Contrary to previous research and expectation, this proposition was not supported by the results of the current study where the overall HRQoL of the physical activity group was not significantly improved after the administration of exercise intervention compared to the control participants. However, these results are consistent with the findings of Bakken et al (2001) where short-term physical activity (i.e., eight weeks) was not able to derive the improvement on the physical health of elderly participants. Indeed, this was indicated by the non-significant differences observed between both groups of participants on the physical index of the PedsQL. Alternatively, it may be probable that the number of exercise sessions in this study was too short to adequately show the effects of improving the physical aspect (i.e., as measured by physical index of PedsQL) and hence the overall HRQoL.

Interestingly, although the overall HRQoL of ASD children did not improve following the exercise intervention as expected, the social functioning subscale of the PedsQL was higher in physical activity group participants. Albeit speculative, this result

may possibly reflect the improvement of the social functioning aspect of the ASD participants after exposing to exercise interventions. Though surprising, this result are consistent with a finding by Bass, Duchowny and Llabre (2009) that ASD children aged 5 to 10 years demonstrated improvement in their social functioning after 12 weeks of horseback riding.

The current observation may be related to the opportunity for social engagement that existed in these exercise settings (Biddle et al., 2004; Fox, 1999). Even though it was not known how the social interaction may have occurred, it is evident that the amount of time spent with participants in the exercise group was longer in comparison to the control group and may thus allow for more opportunity in building of rapport between the researcher and the participants. However, participating in social opportunity settings does not naturally facilitate the improvement of social relationships (Robert, Pratt, & Leach, 1990). In addition, such opportunity also existed in early intervention settings (Terpstra & Tamura, 2008) which the current participants are attending. Therefore, social opportunity alone cannot totally account for the observation, and suggested some other mechanism may be involved in this process.

As social functioning skills are needed to be developed through learning, intervention that facilitates this aspect would be necessary for individuals to gain benefit from social settings (Terpstra & Tamura, 2008). This concept suggested that some form of learning might have occurred during the process of the exercise intervention which was noted by the improvement of the social functioning scores in the physical activity group participants. It is widely recognised that ASD individuals has brain neural network abnormalities which may have resulted in the inability to synthesise information (Minshew & Willams, 2007) between both hemispheres, where their coordination are imperative for learning to occur (Nicholas et al., 2011). Furthermore, there is evidence to suggest that physical activity is capable of triggering the brain's

ability to change (Praag, 2009) through the enhancement of their coordination which may prime the brain to be in a state optimal for learning (Nicholas et al., 2011). Taken together, it is conceivable that participants exposed to physical activity may have experienced certain physiological changes in the brain that allowed for optimised learning to occur which may have accounted for the social improvement seen in this study. Whilst it may be possible that physiological changes may have occurred, it may also be that the participants experienced the positive post-exercise effect of reduced stress and anxiety (Sibley & Etnier, 2003), and improvement of mood (Kwan & Bryan, 2010) and thus are more able and willing to engage in the social interaction; resulting in the improvement of their social functioning.

Overall, impaired social functioning is a core aspect of ASD individuals (Landry et al, 2009); improvement in this area may indicate the possibility of physical activity as a potential therapeutic intervention that is beneficial to children with ASD. However, it is noteworthy that this interpretation would require further investigation as the current measurement is a subscale of the PedsQL which consisted of limited number of questions pertaining to social functioning and thus may not be a good indicator of the overall level of social functioning.

Implications to early intervention focus of ASD

Despite being an important and interesting question to examine whether the positive effects of physical activity was attributed to physiological and/or psychological factors, more crucial question lies in whether physical activity can be an important intervention that are critical to be incorporated into the early intervention of ASD children. From the results of this study, ASD participants were able to improve their attention span and aspects of social functioning indicated that they have the potential to improve their learning provided that the right stimulus is applied to elicit this effect (Belmonte et al., 2004). Although not being able to be shown in this study (i.e., changes

occurring in the brain), physical activity may have improved the neural connectivity of the bilateral hemispheres, making the brain more receptive to learning (Nicholas et al., 2011). This suggested a “golden hour” period where the brain is optimised towards learning after physical activity. Following this notion, when the child undertakes learning during this period, in a long term perspective, the child might still be able to improve and utilise the information/skills that was acquired even after the positive associated effects subsided. Based on this assumption, a brief form of physical activity prior to any form of learning may perhaps be an effective stimulus in enhancing the child’s ability to benefit better from early intervention/educational services where certain form of learning is required (Terpstra & Tamura, 2008).

Previous study by Bass et al. (2009) reported similar findings that improvement in social functioning of ASD children were seen after participating in horse-riding activity and the authors suggested that horse-riding may be recommended to ASD individuals. However, given that cognitive improvement are seen after various types of physical activities/conditions (Churchill et al., 2002; Medina et al., 2010; Nicholas et al., 2011; Rosenthal-Malek & Mitchell, 1997), suggested that the causal factor for the effects seen cannot possibly be attributed to any specific activity. In view of the current study and the above cited research, it is perhaps reasonable to suggest that the common underlying trigger among the observed phenomena is physical activity. This interpretation is crucial to ASD population as any types of physical activity that requires attention will be beneficial to the child; provides the flexibility of utilising any form of physical activity that are suitable to the child’s needs, capability and interest, and the availability of time/cost-effective resources and simple administration by the provider (e.g., parents/teachers/guardians). Nevertheless, it is important to note that this study do not suggest that physical activity alone is sufficient as a therapeutic measure for ASD

children but instead the incorporation of such activity may complement and/or enhance the effectiveness of other early interventions or learning strategies.

Limitations

Although the current study has extended previous research by improving the methodology with an increased sample size and utilised a control group, there are important limitations to consider while interpreting the results. Firstly, despite incorporating a larger sample size compared to previous studies (Nicholson et al., 2011; Rosenthal-Malek & Mitchell, 1997), the current sample is still limited and thus must be considered as a pilot study. Secondly, the unequal treatment time between the experimental and control group may have introduced certain biasness to the nature of the results. Thirdly, the confirmation of the ASD diagnosis was not carried out on the participants due to the limitation of resources, even though it may be assumed that the participants in this study had received some form of assessment/diagnosis of ASD by a healthcare provider as they are receiving early intervention for ASD. In relation, the type and severity of the ASD participants were not known, which may have influenced the outcome of this study and its interpretation as to whether physical activity is equally effective across the ASD genre or only towards a particular disorder type or severity. However, considering the results of this study together with previous studies (Nicholson et al., 2011; Rosenthal-Malek & Mitchell, 1997) that uses high and low functioning ASD children, the positive effects associated with physical activity are likely to be applicable to the entire spectrum. Nevertheless, it is necessary to further evaluate this proposition and also to investigate if application of physical activity is also beneficial towards other clinical population, such as children with specific learning difficulties.

Furthermore, the distance and intensity of the exercise intervention were not controlled; therefore it is not possible to understand under what conditions are necessary for the ASD children to benefit from the intervention. However, as participants were

able to display increased in attention span and social functioning may suggest that perhaps it is not necessary to restrict or pressure the child in reaching a certain level of physical skills and that a pace that the child is comfortable with is sufficient in deriving the cognitive and social benefits associated with physical activity. These results further supported the concepts shared by Leppo et al. (2000) and Ploughman (2008) that physical activity should be moderated and catered in ways that are appropriate for the child.

Future studies/directions

In view of the above limitations: larger sample size, equalisation of treatment time between experimental and control groups, confirmation of ASD diagnosis and the types and severity, and the application of physical activity towards other clinical populations can be considered in extending of the current research. Alternately, case studies can be useful in determining the appropriate type of physical activity for ASD individuals (i.e., individual differences). Furthermore, future studies can also consider utilising a measuring tool specific towards measuring the social functioning of ASD children following post-exercise intervention to further examine their relationships. In addition, higher number of exercise sessions can be used to detect the maximum level of improvement (i.e., ceiling effect) and the durability of the positive effects of exercise on attention span and overall HRQoL. Lastly, it may be worth to evaluate whether the effects of physical activity prior to any forms of therapy, early intervention or learning sessions could increase the learning/therapeutic outcome (i.e., golden hour) of children with ASD and perhaps even to other clinical disorders.

Conclusions

The current study further demonstrated the positive effects of physical activity on cognition in children with ASD, extending the previous research conducted by Nicholson et al. (2011) and Rosenthal-Malek and Mitchell (1997). The methodology

used in this study provided a clearer illustration of the post-effect of physical activity in improving the attention span and aspects of social functioning of ASD children.

Notwithstanding its limitations, the current study in conjunction with existing literature raised the possibility that the observed phenomena are unlikely to be activity-specific and instead may be a function of high focus activities where any form of physical activity that are likely to cause the child to engage on task are likely to be successful in triggering the brain system to be receptive towards learning. In addition, individuals' differences, motivation, self-efficacy, mood, level of stress and anxiety are possible contributory factors towards the relationship between physical activity and cognition.

While the mechanism underlying this relationship remains controversial, the benefits of physical activity on cognition appear to be unequivocal; particularly to ASD children, its implication towards early intervention are likely to be beneficial and thus its inclusion should be encouraged. Further considerations in extending this research towards other clinical populations are an area that warrants attention.

References

- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders fourth edition text revision*. Washington, D.C.: Author.
- Anderson, B. M., Schnetz-Boutaud, N. C., Bartlett, J., Wotawa, A. M., Wright, H. H., Abramson, R. K., . . . Haines, J. L. (2009). Examination of association of genes in the serotonin system to autism. *Neurogenetics, 10*, 209-216.
doi:10.1007/s10048-009-0171-7
- Ashwood, P., Corbett, B. A., Kantor, A., Schulman, H., Van de Water, J., & Amaral, D. G. (2011). In search of cellular immunophenotypes in the blood of children with autism. *Public Library of Science, 6*(5), 1-9. doi:10.1371/journal.pone.0019299
- Bakken, R. C., Carey, J. R., Di Fabio, R. P., Erlandson, T. J., Hake, J. L., & Intihar, T. W. (2001). Effect of aerobic exercise on tracking performance in elderly people: A pilot study. *Physical Therapy, 81*(12), 1870-1879.
- Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*(2), 117-148.
- Bass, M. M., Duchowny, C. A., & Llabre, M. M. (2009). The effect of therapeutic horseback riding on social functioning in children with autism. *Journal of Autism and Developmental Disorders, 39*, 1261-1267. doi:10.1007/s10803-009-0734-3
- Belmonte, M. K., Cook, E. H., Jr., Anderson, G. M., Rubenstein, J. L. R., Greenough, W. T., Beckel-Mitchener, A., . . . Tierney, E. (2004). Autism as a disorder of neural information processing: Directions for research and targets for therapy. *Molecular Psychiatry, 9*, 646-663. doi:10.1038/sj.mp.4001499
- Bernard-Opitz, V., Kwook, K. W., & Sapuan, S. (2001). Epidemiology of autism in Singapore: Findings of first autism survey. *International Journal of Rehabilitation Research, 24*(1), 1-6.
- Bertrand, J., Mars, A., Boyle, C., Bove, F., Yeargin-Allsopp, M., & Decoufle, P. (2001).

- Prevalence of autism in a United States population: The brick township, New Jersey, investigation. *Pediatrics*, *108*(5), 1155-1161.
- Biddle, S. J. H., Gorely, T., & Stensel, D. J. (2004). Health-enhancing physical activity and sedentary behaviour in children and adolescents. *Journal of Sports Sciences*, *22*(8), 679-701. doi:10.1080/02640410410001712412
- Brewin, B. J., Renwick, R., & Schormans, A. F. (2008). Parental perspectives of the quality of life in school environments for children with asperger syndrome. *Focus on Autism and Other Developmental Disabilities*, *23*(4), 242-252. doi:10.1177/1088357608322997
- Charles, J. M., Carpenter, L. A., Jenner, W., & Nicholas, J. S. (2008). Recent advances in autism spectrum disorders. *International Journal of Psychiatry in Medicine*, *38*(2), 133-140.
- Churchill, J. D., Galvez, R., Colcombe, S., Swain, R. A., Kramer, A. F., & Greenough, W. T. (2002). Exercise, experience and the aging brain. *Neurobiology of Aging*, *23*, 941-955.
- Cote, F., Fligny, C., Bayard, E., Launay, J.-M., Gershon, M. D., & Mallet, J. (2007). Maternal serotonin is crucial for murine embryonic development. *Proceedings of the National Academy of Sciences*, *104*(1), 329-334. doi:10.1073/pnas.0606722104
- Cotman, C. W., & Berchtold, N. C. (2002). Exercise: A behavioural intervention to enhance brain health and plasticity. *Trends in Neurosciences*, *25*(6), 295-301.
- Courchesne, E., Carper, R., & Akshoomoff, N. (2003). Evidence of brain overgrowth in the first year of life in autism. *Journal of American Medical Association*, *290*(3), 337-344.
- Daly, W., Seegers, C. A., Rubin, D. A., Dobridge, J. D., & Hackney, A. C. (2005). Relationship between stress hormones and testosterone with prolonged

endurance exercise. *European Journal of Applied Physiology*, *93*, 375-380.

doi:10.1007/s00421-004-1223-1

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J.

(2004). Early social attention impairments in autism: Social orienting, joint

attention, and attention to distress. *Developmental Psychology*, *40*(2), 271-283.

doi: 10.1037/0012-1649.40.2.271

Deslandes, A., Moraes, H., Ferreira, C., Veiga, H., Silveira, H., Mouta, R., . . . Laks, J.

(2009). Exercise and mental health: Many reasons to move.

Neuropsychobiology, *59*, 191-198. doi:10.1159/000223730

Ding, Q., Vaynman, S., Akhavan, M., Ying, Z., & Gomez-Pinilla, F. (2006). Insulin-

like growth factor I interfaces with brain-derived neurotrophic factor-mediated

synaptic plasticity to modulate aspects of exercise-induced cognitive function.

Neuroscience, *140*, 823-833. doi: 10.1016/j.neuroscience.2006.02.084

Eigsti, I.-M., & Schuh, J. M. (2008). Neurobiological underpinnings of language in

autism spectrum disorders. *Annual Review of Applied Linguistics*, *28*, 128-149.

doi:10.1017/S0267190508080021

Elleberg, D., & St-Louis-Deschenes, M. (2010). The effect of acute physical exercise

on cognitive function during development. *Psychology of Sport and Exercise*,

11, 122-126. doi:10.1016/j.psychsport.2009.09.006

Esfandiari, A., Broshek, D. K., & Freeman, J. R. (2011). Psychiatric and

neuropsychological issues in sports medicine. *Clinical Journal of Sport*

Medicine, *30*, 611-627. doi:10.1016/j.csm.2011.03.002

Folstein, S. (1999). Autism. *International Review of Psychiatry*, *11*, 269-277.

Faras, H., Ateeqi, N. A., & Tidmarsh, L. (2010). Autism spectrum disorders.

Annals of Saudi Medicine, *30*(4), 295-300. doi:10.4103/0256-4947.65261

Fatemi, S. H., Merz, A., & Realmuto, G. R. (2003). The roles of reelin, Bcl2, and

- serotonin in cerebellar pathology in autism. *Journal of Developmental and Physical Disabilities*, 15(1), 1-22.
- Field, A. (2009). *Discovering statistics using spss* (3rd ed.). London, England: Sage.
- Fox, K. R. (1999). The influence of physical activity on mental well-being. *Public Health Nutrition*, 2(3a), 411-418.
- Friedman, S. D., Shaw, D. W. W., Artru, A. A., Dawson, G., Petropoulos, H., & Dager, S. R. (2006). Gray and white matter brain chemistry in young children with autism. *Archives of General Psychiatry*, 63, 786-794. Retrieved from <http://archpsyc.ama-assn.org/>
- Goard, M., & Dan, Y. (2009). Basal forebrain activation enhances cortical coding of natural scenes. *Nature Neuroscience*, 12(11), 1440-1447. doi:10.1038/nn.2402
- Griffin, S. M. (2010). *Autism spectrum disorders* (Course No. 3219). Sacramento, CA: Continuing Medical Resource.
- Hadjikhani, N. (2009). Serotonin, pregnancy and increased autism prevalence: Is there a link?. *Medical Hypotheses*, 1-4. doi:10.1016/j.mehy.2009.11.015
- Hennigan, A., O'Callaghan, R. M., & Kelly, A. M. (2007). Neurotrophins and their receptors: Roles in plasticity, neurodegeneration and neuroprotection. *Biochemical Society Transactions*, 35(2), 424-427.
- Just, M. A., Cherkassky, V. L., Keller, T. A., Kana, R. K., & Minshew, N. J. (2007). Functional and anatomical cortical underconnectivity in autism: Evidence from an fMRI study of an executive function task and corpus callosum morphometry. *Cerebral Cortex*, 17, 951-961. doi:10.1093/cercor/bhl006
- Kistner-Griffin, E., Brune, C. W., Davis, L. K., Sutcliffe, J. S., Cox, N. J., & Cook, E. H., Jr. (2010). Parent-of-origin effects of the serotonin transporter gene associated with autism. *American Journal of Medical Genetics*, 156, 139-144. doi:10.1002/ajmg.b.31146

- Kozak, R., Bruno, J. P., & Sarter, M. (2006). Augmented prefrontal acetylcholine release during challenged attentional performance. *Cerebral Cortex, 16*, 9-17. doi:10.1093/cercor/bhi079
- Kubesch, S., Bretschneider, V., Freudenmann, R., Weidenhammer, N., Lehmann, M., Spitzer, M., & Gron, G. (2003). Aerobic endurance exercise improves executive functions in depressed patients. *Journal of Clinical Psychiatry, 64*(9), 1005-1012.
- Kuhlthau, K., Orlich, F., Hall, T. A., Sikora, D., Kovacs, E. A., Delahaye, J., & Clemons, T. E. (2010). Health-related quality of life in children with autism spectrum disorders: Results from the autism treatment network. *Journal of Autism and Developmental Disorders, 40*, 721-729. doi:10.1007/s10803-009-0921-2
- Kumar, R. A., & Christian, S. L. (2009). Genetics of autism spectrum disorders. *Current Neurology and Neuroscience Reports, 9*, 188-197.
- Kwan, B. M., & Bryan, A. (2010). In-task and post-task affective response to exercise: Translating exercise intentions into behaviour. *British Journal of Health Psychology, 15*, 115-131. doi:10.1348/135910709X433267
- Landry, O., Mitchell, P. L., & Burack, J. A. (2009). Orienting of visual attention among persons with autism spectrum disorders: reading versus responding to symbolic cues. *Journal of Child Psychology and Psychiatry, 50*(7), 862-870. doi:10.1111/j.1469-7610.2008.02049.x
- Leppo, M. L., Davis, D., & Crim, B. (2000). The basics of exercise the mind and body. *Childhood Education, 142*-147.
- Levy, S. E., Mandell, D. S., & Schultz, R. T. (2009). Autism. *The Lancet, 374*, 1627-1638. doi:10.1016/S0140-6736(09)61376-3
- Leydesdorff, L., & Bensman, S. (2006). Classification and powerlaws: The logarithmic

transformation. *Journal of the American Society for Information Science and Technology*, 57(11), 1470-1486. doi:10.1002/asi.20467

Makkonen, I., Riikonen, R., Kokki, H., Airaksinen, M. M., & Kuikka, J. T. (2008).

Serotonin and dopamine transporter binding in children with autism determined by SPECT. *Developmental Medicine and Child Neurology*, 50, 593-597. doi:10.1111/j.1469-8749.2008.03027.x

Matson, J. L., & Horovitz, M. (2010). Stability of autism spectrum disorders symptoms over time. *Journal of Developmental and Physical Disabilities*, 22, 331-342. doi:10.1007/s10882-010-9188-y

Medina, J. A., Netto, T. L. B., Muszkat, M., Medina, A. C., Botter, D., Orbetelli, R., . . . Miranda, M. C. (2010). Exercise impact on sustained attention of ADHD children, methylphenidate effects. *Attention Deficit and Hyperactivity Disorders*, 2, 49-58. doi:10.1007/s12402-009-0018-y

Melke, J., Botros, H. G., Chaste, P., Betancur, C., Nygren, G., Anckarsater, H., . . . Paris Autism Research International Sibpair [PARIS] study. (2008). Abnormal melatonin synthesis in autism spectrum disorders. *Molecular Psychiatry*, 13, 90-98.

Minschew, N. J., & Williams, D. L. (2007). The new neurobiology of autism. *Archives of Neurology*, 64(7), 945-950. Retrieved from <http://www.archneurol.com/>

Mitchell, J. F., Sundberg, K. A., & Reynolds, J. H. (2007). Differential attention-dependent response modulation across cell classes in macaque visual area v4. *Neurons*, 55, 131-141. doi:10.1016/j.neuron.2007.06.018

Moss, J., & Howlin, P. (2009). Autism spectrum disorders in genetic syndromes: Implications for diagnosis, intervention and understanding the wider autism spectrum disorder population. *Journal of Intellectual Disability Research*, 53(10), 852-873. doi:10.1111/j.1365-2788.2009.01197.x

- Muller, U., Zelazo, P. D., Hood, S., Leone, T., & Rohrer, L. (2004). Interference control in a new rule task: Age-related changes, labeling, and attention. *Child Development, 75*(5), 1594-1609.
- Nicholas, B., Rudrasingham, V., Nash, S., Kirov, G., Owen, M. J., & Wimpory, D. C. (2007). Association of per1 and npas2 with autistic disorder: Support for the clock genes/social timing hypothesis. *Molecular Psychiatry, 12*, 581-592.
- Nicholson, H., Kehle, T. J., Bray, M. A., & Heest, J. V. (2011). The effects of antecedent physical activity on the academic engagement of children with autism spectrum disorder. *Psychology in the Schools, 48*(2), 198-213.
doi:10.1002/pits.20537
- Osborne, J. W. (2002). Notes on the use of data transformations. *Practical Assessment, Research and Evaluation, 8*(6), 1-8. Retrieved from <http://PAREonline.net/getvn.asp?v=8&n=6>
- Pailthorpe, W. K., & Ralph, A. (1998). Time-out as a means of shaping whole-task completion as a precursor to establishing rule-following behaviour with a severely noncompliance preschool child. *Behaviour Change, 15*(1), 50-61.
- Paluska, S. A., & Schwenk, T. L. (2000). Physical activity and mental health. *Sports Medicine, 29*(3), 167-180.
- Peluso, M. A. M., & Andrade, L. H. S. G. D. (2005). Physical activity and mental health: The association between exercise and mood. *Clinics, 60*(1), 61-70.
- Phua, H. P., Chua, A. V. L., Ma, S., Heng, D., & Chew, S. K. (2009). Singapore's burden of disease and injury 2004. *Singapore Medical Journal, 50*(5), 468-478.
- Ploughman, M. (2008). Exercise is brain food: The effects of physical activity on cognitive function. *Developmental Neurorehabilitation, 11*(3), 236-240.
doi:10.1080/17518420801997007
- Podewils, L. J., Guallar, E., Kuller, L. H., Fried, L. P., Lopez, O. L., Carlson, M., &

- Lyketsos, C. G. (2005). Physical activity, APOE genotype, and dementia risk: Findings from the cardiovascular health cognition study. *American Journal of Epidemiology*, *161*(7), 639-651. doi:10.1093/aje/kwi092
- Poon, K. K. (2011). The activities and participation of adolescents with autism spectrum disorders in Singapore: Findings from an ICF-based instrument. *Journal of Intellectual Disability Research*, 1-11. doi:10.1111/j.1365-2788.2011.01397.x
- Praag, H. V. (2008). Neurogenesis and exercise: Past and future directions. *Neuromolecular Medicine*, 1-13. doi:10.1007/s12017-008-8028-z
- Praag, H. V. (2009). Exercise and the brain: Something to chew on. *Trends Neuroscience*, *32*(5), 283-290. doi:10.1016/j.tins.2008.12.007
- Raban, D. R., & Rabin, E. (2009). Statistical inference from power law distributed web-based social interactions. *Internet Research*, *19*(3), 266-278. doi:10.1108/10662240910965342
- Radak, Z., Kumagai, S., Taylor, A. W., Naito, H., & Goto, S. (2007). Effects of exercise on brain function: Role of free radicals. *Applied Physiology, Nutrition and Metabolism*, *32*, 942-947. doi:10.1139/H07-081
- Roberts, C., Pratt, C., & Leach, D. (1990). Classroom and playground interaction of students with and without disabilities. *Exceptional Children*, *57*(3), 212-224.
- Rossignol, D. A., & Frye, R. E. (2011). Melatonin in autism spectrum disorders: A systemic review and meta-analysis. *Developmental Medicine and Child Neurology*, *53*, 783-792. doi:10.1111/j.1469-8749.2011.03980.x
- Roth, D. L., Goode, K. T., Clay, O. J., & Ball, K. K. (2003). Association of physical activity and visual attention in older adults. *Journal of Aging and Health*, *15*(3), 534-547. doi:10.1177/0898264303253512
- Rosenthal-Malek, A., & Mitchell, S. (1997). Brief report: The effects of exercise on the self-stimulatory behaviours and positive responding of adolescents with autism.

Journal of Autism and Developmental Disorders, 27(2), 193-202.

Sarter, M., Gehring, W. J., & Kozak, R. (2006). More attention must be paid: The neurobiology of attentional effort. *Brain Research Reviews*, 51, 145-160.

doi:10.1016/j.brainresrev.2005.11.002

Schneider-Garces, N. J., Gordon, B. A., Brumback-Peltz, C. R., Shin, E., Lee, Y., Sutton, B. P., . . . Fabiani, M. (2009). Span, CRUNCH, and beyond: Working memory capacity and the aging brain. *Journal of Cognitive Neuroscience*, 22(4), 655-669.

Sibley, B. A., & Etnier, J. L. (2003). The relationship between physical activity and cognition in children: A meta-analysis. *Pediatric Exercise Science*, 15, 243-256.

Skuse, D. H. (2007). Rethinking the nature of genetic vulnerability to autistic spectrum disorders. *Trends in Genetics*, 23(8), 387-395. doi:10.1016/j.tig.2007.06.003

Strong, W. B., Malina, R. M., Blimkie, C. J. R., Daniels, S. R., Dishman, R. K., Gutin, B. G., . . . Trudeau, F. (2005). Evidence based physical activity for school-age youth. *Journal of Pediatrics*, 146, 732-737.

Terpstra, J. E., & Tamura, R. (2008). Effective social interaction strategies for inclusive settings. *Early Childhood Education Journal*, 35, 405-411. doi:10.1007/s10643-007-0225-0

Tomporowski, P. D., Lambourne, K., & Okumura, M. S. (2011). Physical activity interventions and children's mental function: An introduction and overview. *Preventive Medicine*, 52, S3-S9. doi:10.1016/j.ypmed.2011.01.028

Toro, R., Konyukh, M., Delorme, R., Leblond, C., Chaste, P., Fauchereau, F., . . . Bourgeron, T. (2010). Key role for gene dosage and synaptic homeostasis in autism spectrum disorders. *Trends in Genetics*, 26, 363-372.

doi:10.1016/j.tig.2010.05.007

Varni, J. W. (1998). *Pediatric quality of life inventory version 4.0*. Lyon, France: Mapi

Research Institute.

Varni, J. W., Seid, M., & Kurtin, P. (2001). PedsQL (TM) 4.0: Reliability and Validity of the pediatric quality of life inventory (TM) version 4.0 generic core scales in healthy and patient populations. *Medical Care*, 39(8), 800-812.

Varni, J. W., Seid, M., & Rode, C. (1999). The PedsQL(TM): Measurement model for the pediatric quality of life inventory. *Medical Care*, 37(2), 126-139.

Vaynman, S., & Gomez-Pinilla, F. (2005). License to run: Exercise impacts functional plasticity in the intact and injured central nervous system by using neurotrophins. *Neurorehabilitation and Neural Repair*, 19, 283-295.
doi:10.1177/1545968305280753

Vaynman, S., Ying, Z., & Gomez-Pinilla, F. (2004). Hippocampal BDNF mediates the efficacy of exercise on synaptic plasticity and cognition. *European Journal of Neuroscience*, 20, 2580-2590. doi:10.1111/j.1460-9568.2004.03720.x

Volkmar, F. R., & Pauls, D. (2003). Autism. *The Lancet*, 362, 1133-1141. Retrieved from <http://thelancet.com/>

Wang, K., Zhang, H., Ma, D., Bucan, M., Glessner, J. T., Abrahams, B. S., . . .

Hakonarson, H. (2009). Common genetic variants on 5p14.1 associate with autism spectrum disorders. *Nature*, 459(7246), 528-533.

doi:10.1038/nature07999.

Weuve, J., Kang, J. H., Manson, J. E., Breteler, M. M. B., Ware, J. H., & Grodstein, F.

(2004). Physical activity, including walking, and cognitive function in older women. *Journal of American Medical Association*, 292(2), 1454-1461.

Retrieved from <http://jama.ama-assn.org/>

White, S. W., Ollendick, T., Scahill, L., Oswald, D., & Albano, A. M. (2009).

Preliminary efficacy of a cognitive-behavioural treatment program for anxious youth with autism spectrum disorders. *Journal of Autism and Developmental*

Disorders, 39, 1652-1662. doi:10.1007/s10803-009-0801-9

Wipfli, B., Landers, D., Nagoshi, C., & Ringenbach, S. (2011). An examination of serotonin and psychological variables in the relationship between exercise and mental health. *Scandinavian Journal of Medicine and Science in Sports*, 21, 474-481. doi:10.1111/j.1600-0838.2009.01049.x

Williams, K., MacDermott, S., Ridley, G., Glasson, E. J., & Wray, J. A. (2008). The prevalence of autism in australia. Can it be established from existing data?. *Journal of Paediatrics and Child Health*, 44, 504-510. doi:10.1111/j.1440-1754.2008.01331.x



Appendix A

Dear Manager,

My name is Beron Tan Wei Zhong and I am currently undertaking my Bachelor of Science in Psychology (Honours) at Edith Cowan University. As part of my course, I am required to carry out a research project. The ECU Human Research Ethics Committee has approved this research. I am interested in examining the impact of physical activity on the attention span and the quality of life of children with Autism Spectrum Disorder (ASD).

I seek your assistance in distributing the information letters to the parents in your centre. The study will require children (2-6 years old) diagnosed with ASD to participate in either 8 sessions of physical activity (i.e., tri-cycling) for 15 minutes each time and/or an attention task at the residence and convenience of the parents/guardians. The parent/guardian will also be required to complete a questionnaire on the first and the last session, which will take approximately 5 minutes. The study will be conducted in the month of July this year and all the tests and procedures will be administered personally by the researcher. If you agree to assist in the research, I will forward information letters and pamphlets for you to pass on to the potential participants.

If you require any further information or would like to discuss the research further, we can arrange for a phone conversation to clarify any questions or issues about the research. Please do not hesitate to contact me at (65) 8401 7640 or by email at: wng10@our.ecu.edu.au. Alternatively, you may contact my supervisors Professor Lynne Cohen at (61) 8 6304 5575 or l.cohen@ecu.edu.au and Associate Professor Julie Ann Pooley at (61) 8 6304 5591 or j.pooley@ecu.edu.au. If you have any concerns or complaints about the research project and wish to talk to an independent person, you may contact:

Research Ethics Officer

Edith Cowan University

270 Joondalup Drive

JOONDALUP WA 6027

Phone: (08) 6304 2170

Email: research.ethics@ecu.edu.au

Thank you for your kind attention and I look forward to hear from you.

Kind regards

Beron Tan



Appendix B

Information Letter

Dear Parent/Guardian,

My name is Beron Tan Wei Zhong and I am currently undertaking my Bachelor of Science in Psychology (Honours) at Edith Cowan University. As part of my degree, I am required to undertake a research project. The ECU Human Research Ethics Committee has approved this research. I am interested in examining the impact of physical activity on the attention span and the quality of life of children with Autism Spectrum Disorder (ASD).

If you are interested in allowing your child to participate in the research, your child may be required to participate in a physical activity (i.e., tri-cycling) for 15 minutes each time at your residence and convenience for 8 sessions in the month of July 2011. First-aid assistance will also be on-site to attend to your child if required. In between the sessions, your child will also be required to carry out an attention task not more than 15 minutes to monitor his/her performance. In addition, the study will require you to complete a short questionnaire asking about your child's well-being on the first and the last session. The questionnaire will take approximately 5 minutes to complete. Participation in the study is entirely voluntary and any personal identification/information will be kept confidential. You and/or your child may withdraw from the study at any point of the research without any penalty.

If you have any questions or concerns and/or are interested/willing to allow your child to participate, please do not hesitate to contact me at (65) 8401 7640 or via email at wng10@our.ecu.edu.au. Alternatively, you may contact my supervisors Professor Lynne Cohen at (61) 8 6304 5575 and Associate Professor Julie Ann Pooley at (61) 8 6304 5591. If you have any concerns or complaints about the research project and wish to talk to an independent person, you may contact:

Research Ethics Officer

Edith Cowan University

270 Joondalup Drive

JOONDALUP WA 6027

Phone: (08) 6304 2170

Email: research.ethics@ecu.edu.au

Thank you for considering to be part of the study and I look forward to your participation.

Kind regards

Beron Tan

Appendix C



Research Project
School of Psychology and Social
Science



Physical Activity: Its Implication on the Attention Span and Quality of Life in Children with Autism Spectrum Disorder



Purpose?

To examine the potential beneficial effects of physical activity on the attention span and quality of life in children with Autism Spectrum Disorder



Benefits?

- ✓ Fun-activities for your child
- ✓ Promote their learning and quality of life
- ✓ Promote physically active lifestyle



What do my child and I need to do?

Your child

- 15 mins of tri-cycling
- Sustained attention span activity

Parent/guardian

- fill in a short questionnaire



Can my child and I participate?

YES~!! If your child:

- I. 2 – 6 years old
- II. autism spectrum disorder
- III. does not have movement difficulties
- IV. able to participate in physical activity

Who do I contact?

Beron Tan Wei Zhong
(65) 8401 7640
wng10@our.ecu.edu.au



Appendix D

Informed Consent (For Parents/Guardians)Physical Activity: Its Implication on Attention Span and Quality of Life in Children
with Autism Spectrum Disorder

I have read and understood:

- The outline and nature of the research study via the information letter provided to me.
- I have the opportunity and the right to clarify any doubts to my satisfaction about the study through the contacts of the research team provided in the information letter.
- I am required to complete a questionnaire on the first and the last session of the research study.
- My personal identification/information will be kept confidential and will not be disclosed without my consent.
- The data collected for the purpose of this research study may be used in future research purposes provided that my name and any identifying information are removed.
- I have the right to withdraw at any point of the study without incurring any penalty and no explanation is required.

I have read and fully understood all of the above information provided to me and I agree to participate in this research study at my own will.

Participant's name/signature/date

Witness's name/signature/date



Appendix E

Informed Consent (On behalf of the child)Physical Activity: Its Implication on Attention Span and Quality of Life in Children
with Autism Spectrum Disorder

I have read and understood:

- The outline and nature of the research study via the information letter provided to me.
- I have the opportunity and the right to clarify any doubts to my satisfaction about the study through the contacts of the research team provided in the information letter.
- My child may be required to participate in the physical activity (i.e., tri-cycle) and/or an attention task at my residence and convenience in the month of July 2011.
- My child's personal identification/information will be kept confidential and will not be disclosed without my consent.
- The data collected for the purpose of this research study may be used in future research purposes provided that my child's name and any identifying information are removed.
- My child and/or I (on his/her behalf) have the right to withdraw from participating in this study at any point of the research without incurring any penalty and no explanation is required.
- I understand that there may be a risk involved for my child in participating in this research study and I trust that the researcher(s) will ensure risk is kept to the minimal.

I have read and fully understood all of the above information provided to me and I agree to allow my child to participate in this research study at my own will.

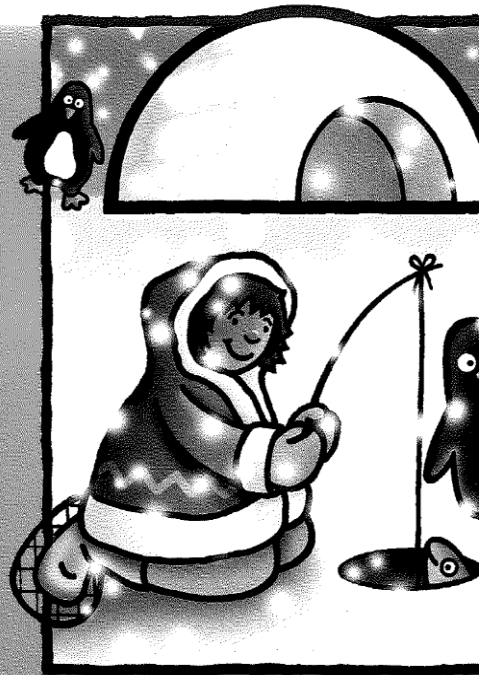
Parent/guardian's name/signature/date

Witness's name/signature/date

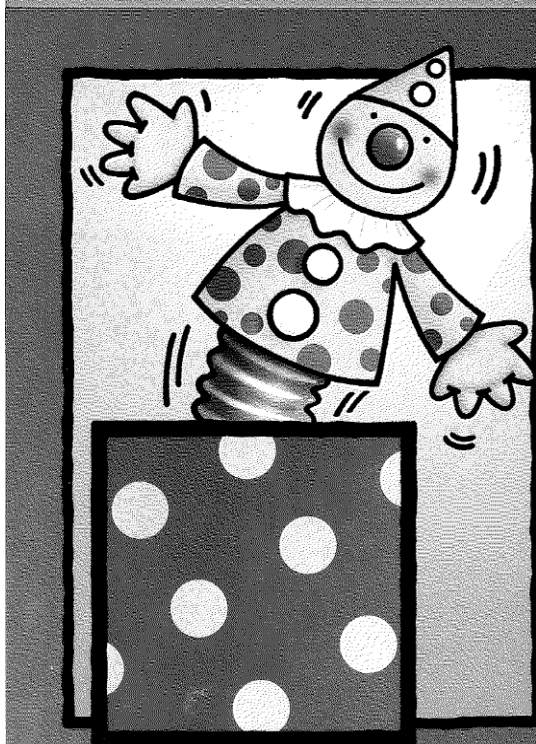
Appendix F



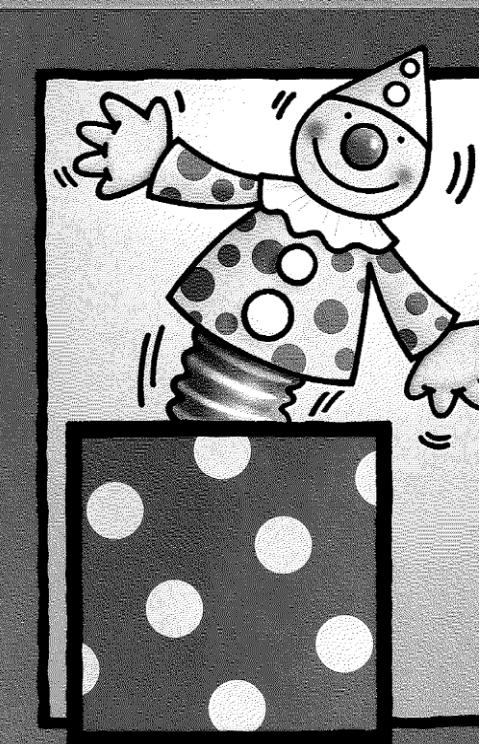
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