The impact of a computer-based activity programme upon the social functioning of children with Autistic Spectrum Disorder.

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Consenting Process
The ethical elements of the research, including the consenting process, was approved by Northumbria University Ethical Committee, and the ethical committees of Newcastle upon Tyne City Council, North Tyneside Borough Council, and Gateshead City Council.

Abstract

Problems with social functioning are a major area of difficulty for children with autism. Such problems have the potential to exert a negative influence on several aspects of the children's functioning, including their ability to access education. *Objective.* This study looked to examine if a computer-based activity programme could improve the social functioning of these children. *Materials and Methods.* Using a pooled subject design, 100 children with autistic spectrum disorder were randomly allocated, controlling where possible for age and gender, to either an intervention or a control group. The children in the intervention group were encouraged to use the Nintendo Wii and the software package "Mario and Sonics at the Olympics" in addition to their routine school physical education classes over a nine month period. The control group attended only the routine physical education classes. *Results.* After one year, analysis of the changes in the scores of teacher-completed measures of social functioning showed that boys in the intervention group had made statistically significant improvement in their functioning when compared to controls. The number of girls in the study was too small for any change to reach statistical significance. *Conclusion.* This type of intervention appears to have potential as a mechanism to produce improvement in the social functioning, at least of boys, as part of a physical education programme.

Introduction

Being able to function positively in a social network is a basic human need, and having difficulty in doing so handicaps the individual at a most fundamental level. It is for this reason that difficulties with social interaction are viewed as perhaps the most handicapping of the triad of impairments that make up autistic spectrum disorder (ASD)[1, 2]. As the child with ASD matures these social deficits often become even more prominent [3], with the socialising demands of adolescence proving particularly difficult. The area where children learn and refine their social skills is primarily in school, and therefore programmes to improve the social functioning of these children is an important part of their educational provision.

In order to assess the potential impact of interventions to improve social functioning it is first necessary to identify which aspect of social functioning is being targetted. While correcting maladaptive social interaction is important, the focus for children with ASD is often the strengthening of positive social behaviour, and increasing the children's interest in social interaction. Programmes to improve this aspect of social functioning have tended to be those that have proved useful with typically developing children. Most commonly these are social skills training programmes, which have generally been shown to be effective [4-7], especially in less severe forms of ASD [8, 9]. The meta-analysis of Reichow and colleagues [10] found that such programmes produced a clinically significant increase in the children's social skills, and the authors estimated that this type of intervention increased the average Vineland social score from 123 to 147. However not all children with ASD are willing, or able, to participate in such programmes, and considerable skill is required to lead such groups.

The rapid development of computer technology and the way children with ASD are often drawn to electronic media [11, 12] have combined to encourage an increasing number of studies to look at the use of computers to assist children with ASD. This type of intervention can be particularly useful for children with ASD because they do not cope well with new or unpredictable social environments, struggle with regulating sensory input, and find it very difficult to regulate attention effectively [13]. However they often have relatively strong visual processing skills [14], and find the computer's context-free environment very acceptable [15]. In addition, computer based activities tend to lessen resistance to academic

demands, increase task engagement and reduce the incidence of challenging behaviour [15, 16].

In one of the earliest reviews of computer-based interventions, Marion Panyan [17] found that although the published studies were small scale, they did suggest that the approach could be valuable, and she concluded that the selection of appropriate software and integrating computer instruction within the classroom environment was the way forward. In their more recent review of published literature, Ramdoss and colleagues [15] found that studies still tended to be small in scale and very variable in quality. They examined 11 studies, in 8 of which the subjects were children, but only 4 of these had more than 8 subjects, and only one had controls which were children with ASD. The studies had used a variety of measures but the ones which focussed upon social skills related outcomes were consistently positive, although the degree of improvement was quite variable. Other measures, such as facial processing, and recognising emotional expressions, were not consistently found to have benefitted. The authors concluded that this type of intervention showed promise as an intervention that could improve social functioning. In their review of the literature Wainer & Ingersoll [14] drew more positive conclusions, suggesting that computer-based interventions had shown evidence of efficacy for improving positive social behaviours.

Although the interventions reported to date appear to have a positive impact upon social functioning, they have tended to use specialised equipment, and would not be easily incorporated into routine classroom structures. We were interested in whether commercial interactive computer games, which are a cheaper and more accessible way to use computer technology [18], could offer a more practical way of improving the social functioning of children with ASD. Also, the project would have a sample size larger than any previously reported, offering the opportunity to significantly add to this area of study. In Britain, with very few exceptions, health provision for children with ASD is from the National Health Service (NHS), with the children's educational provision being provided by local councils. As part of a wider project it was possible to explore whether playing a computer-based activity game would strengthen the positive social functioning of children with ASD. The study used a pooled subject design, with the children randomly allocated to either intervention or control, controlling where possible for age and gender. This allocation could only be partially achieved because of the relatively small number of potential participants,

and the low number of girls. Selection was completed when 50 families had been allocated to each group.

Materials and Methods

Settings and Participants. Having obtained ethical approval from academic bodies, educational gatekeepers and parents, the study was carried out over the period of one academic year. The study was carried out in the three schools which had the specialist classes for children with marked ASD in the region. The children had been diagnosed, and continued to be monitored, by the regional specialist children's autism service. Participant criteria also required the children to be aged between 7 and 16 years of age. All the children had either a moderate or severe learning disability because this was a requirement for admission to one of the units, and this was determined by formal assessments undertaken by the educational service psychologists.

None of the children had any physical illness or disability that would adversely influence their ability to use the computer game. All the children were receiving the standard support from health and education services, and none of them had comorbid mental health problems of sufficient severity to justify treatment with psychoactive medication.

The families of the children were given a detailed description of the study prior to obtaining their agreement to participate. Background demographic information was also collected from the family concerning family make-up, employment of parents etc.

Social Functioning Assessment. The social functioning of the primary aged children was assessed using the Staff Questionnaire: Social Behaviour at School [19]. This is a questionnaire for the assessment of children age 5-10 years. It consists of a list of 42 social behaviours drawn from the List of Social Situation Problems [19] which the teacher has to identify as significantly present or not. The list consists of questions such as "Is the child bullied frequently", "Does the child become embarrassed easily", "Does the child interrupt inappropriately", and "Does the child talk too loudly". It has an $\alpha = 0.86$, and a test-retest for the elements of $r = 0.71$ to 0.81. The adolescent questionnaire, the Staff Questionnaire Social Behaviour (adolescents) [19] consists of 24 questions, and uses a likert rating of 1-5 to explore three main areas; peer relationships (with questions such as "Joins in activities with peers"), relationship with staff (with questions like "Approaches staff appropriately with

requests or questions"), and general social behaviour (with questions such as "Fidgets and fiddles with hands during conversations"). Its reliability has been found to be 0.65, and the standard error of measurement associated with the total scale scores was 5.64 [20]. The scales were designed to identify areas for improvement in response to social skills training programmes (Spence 2014 – private communication), and have been shown to be of value in this regard [20, 21].

The Computer-based Activity. The Nintendo Wii™ was chosen for the study because it is widely available. It offers a range of activity based programmes which give the user a strong connection with the software, and allows the activity to be carried out safely while encouraging the player to further explore the virtual environment [22]. The games are intended to be fun and interactive, and use a wide variety of elements, such as music, playback and bonuses. For the purposes of this study the *Mario & Sonic at the Olympic Games*™ was chosen. This is a collection of twenty-four events based on the Olympic Games. The games use the motion sensor capabilities of the Wii Remote and Nunchuck attachment to control the actions of the on-screen character. The children taking part in the intervention arm of this study used the single match mode for up to 4 players. The children had a free choice of any of the activities on the game disc that allowed for up to 4 players to play simultaneously. This limited the games to athletics, aquatics, fencing and table tennis. Table tennis allowed for two player use and the other events used a turn taking format.

Procedure. Each class had a teacher and up to three assistants, depending on the level of support the children required. The children's class teachers were asked to complete the relevant social questionnaire prior to commencement of the study. The children allocated to the control group had the standard school physical education programme. The children in the intervention group, in addition to these standard lessons, had sessions in which they used the activity game in groups of 2 to 4, under supervision, for a period of 15 minutes per day, three times per week over a nine month period. The most popular activities were the running events in the athletics and the swimming events in the aquatics activities. The teachers and their assistants had flexibility over the time of day the intervention would occur. Wherever possible, each school carried out their intervention at the same time each day so as not to significantly disrupt the children's routine. The sessions were conducted in the space used for the timetabled physical education lessons. Written instructions were provided on how to set

the Wii up on the classroom interactive white board and the staff's ability to use the Wii was confirmed before the study commenced. Random visits were made to the participating schools to monitor the intervention delivery.

Additional Assessment. It is known that a child's level of social activity is strongly influenced by family issues such as parental expectations and support [23]. To offer some insight into the dynamics of the families in each of the study groups, the general family functioning of the two groups was compared by asking the children's mother to complete the Family Adaptation and Cohesion Evaluation Scales (FACES IV) [24]. This is a self-report measure which gives two scales, one measuring family cohesion (the degree of emotional attachment between family members) and the other flexibility (the ability to change structure, roles and relationships in response to situational and developmental stress). Using these scales, problematic family functioning is associated with extreme scores (i.e. < 15 or > 85). Reliability of the FACES IV scales has been found to be acceptable for research and clinical purposes, with Cronbach's α values for the scales and subscales being; Cohesion = 0.89, Flexibility = 0.84, Rigid = 0.82, Enmeshed = 0.77, Disengaged = 0.87, and chaotic = 0.86 [25].

Sample Make-up. The selection by age and gender (within the limits of the population available to the study) resulted in there being 33/34 children under the age of eleven years in the intervention/control groups, and the groups contained 39/40 boys respectively (see table 1). All the children had moderate to severe intellectual difficulties, and 35/40 were living with both parents. There was a difference between the groups when identifying those that were the only children in the family (9/25). In terms of parental employment, 7/9 came from families where both parents were working, and 13/12 came from families where both parents were unemployed.

All statistical analyses were conducted with IBM-SPSS version 22.0. Student *t* tests were used for comparisons of parametric data. The social data was assessed for normalcy using the Shapiro-Wilk test [26], and the results indicated that non-parametric reporting would be more reliable. Thus, the Mann Whitney U test was used for comparison of this data, and the impact of the intervention was assessed by analysis of covariance (ANCOVA).

Results

The results from the FACES IV questionnaire showed no significant difference in family functioning between the two groups, with the control group mean for cohesion being 57.82 (std dev 12.77), and for the intervention group 60.54 (std dev 11. 65, $t = 1.11$, 98 df). For flexibility of family functioning the mean score for the control group families was 51.3 (std dev 11.71) and the intervention group 50.16 (std dev 10.03, $t = 0.52$, 98 df).

Differences in Initial Parameters.

The data was analysed by age group and then further divided by gender because there is a well-established understanding that the social functioning of girls varies significantly from boys, especially in adolescence [27, 28]. There is no evidence ASD would erode these differences. In addition, girls with ASD tend to have a different symptom pattern (for example, showing less repetitive behaviours than males [29, 30]), and of specific relevance to this study is the gender difference reported in the degree of social problems [31, 32]. Although this study would produce a small subset of girls, the potential differences between the sexes were considered worthy of exploration.

Table 1 shows the summary of the initial social scores between the two groups. (The coefficient of variance was calculated as the interquartile range divided by the median.) When the initial scores for the junior children were compared, the Mann Whitney U was 6.70 (giving a significance of 0.56 – i.e. not significant). The scores for the adolescents showed a trend towards a difference, but this did not reach statistical significance (Mann Whitney U 20.5; significance of 0.09).

Differences after the Intervention. Table 2 shows the changes to the summary scores of the two groups after the intervention had been completed. This reveals that the median scores in the control group did not change appreciably over the period of the study (primary before $\bar{x}$= 32, $\sigma = 0.22$; after $\bar{x}$= 32, $\sigma = 0.19$; secondary before $\bar{x}$ = 46, $\sigma = 0.15$; after $\bar{x}$= 46, $\sigma = 0.14$). By contrast, there was a marked difference in the median score of the children in the intervention group (primary before $\bar{x}$= 26, $\sigma = 0.15$; after $\bar{x}$ = 36, $\sigma = 0.15$; secondary before $\bar{x}$ = 69, $\sigma = 0.36$; after $\bar{x}$ = 82, $\sigma = 0.24$). When the degree of change seen in control and intervention groups over the time of the study are compared using an ANCOVA (table 3) it reveals that in the younger boys there was a very significant improvement in the functioning of those boys using the Wii, when compared to controls ($F = 44.99$, $p < 0.001$) . The scores

from the girls however did not show a statistically significant change ($F = 0.56$, *NS*). The adolescent group was small, but again the boys using the Wii showed gains that were statistically significant ($F = 4.46$, $p < 0.05$), but this was not evident in the girls ($F = 0.26$, *NS*).

Discussion

To our knowledge, this is the first attempt to explore whether a widely available recreational computer-based activity game has an impact on the social functioning of children with ASD. The results of the study suggest this type of activity has the potential to improve the social functioning of children with ASD, especially boys. This is interesting because boys with ASD are generally reported to have greater difficulties with social functioning than girls [32], and so if confirmed this would make it a useful addition to the curriculum for these children. The lack of improvement shown by the girls is probably because the number of girls in the study was small. However it may also have been influenced by the way boys generally are much more engaged in computer games than girls [33, 34], although once engaged girls do tend to out-perform the boys [35]. Alternatively, it could be another example of the differences in symptom patterns seen between boys and girls [29-31], differences which may contribute to the relative under diagnosis of ASD in females [36].

The aim of the project was to try to bring about positive change in social functioning not only while playing the game but more generally; a good measure of how successful any such programme has been. The programme chosen was a commercial product designed for entertainment, and to promote physical activity. These types of programmes are fun and interactive, and by their nature, they tend to encourage people to play. It has been recognised that they also tend to motivate players to improve their performance [37], as well as increasing the players desire to compete [38]. The use of a programme aimed at improving social functioning which generates a degree of self-motivation would clearly have benefits for these children. The programme chosen also encouraged multiple player use, and research suggests that for children with ASD generalisation is best achieved by interventions that involve peers and encourages interaction between them [39-42]. This intervention encourages both physical and social interaction with peers, making it a good candidate to improve social functioning.

It is important, however, to recognise that this study was limited in scope and rigour, so caution needs to be exercised over the conclusions that are drawn. The children in the study lived in a circumscribed urban area in the North of England, and so the results may not represent fully the impact upon children with autism in more diverse areas. Also, although efforts were made to match the two groups, the relatively small population meant the matching process could only use a limited number of parameters, and this was also only partially successful. Using a pooled sample from three schools gave rise to a potential contamination between control and intervention children, but it was decided to proceed with this method because it gave a degree of control of wider school issues, and reduced the extra sessions that the staff in each school had to undertake. It was also recognised that the schools participation in the research project may have prompted some change in the content of the routine PE sessions. However, the fact that both control and intervention children were sharing these routine lessons meant any such change would have minimal impact.

The small pool from which the sample was drawn limited the degree of randomisation and matching that could be achieved. This introduced the potential for differences in initial levels of social functioning between the groups, but in the event they proved to be quite similar. Also, given the nature of the sample, non-parametric statistical analyses were preferred when assessing the degree of change in scores to avoid the presumption of normally distributed data. The assessment of the social functioning was by teacher questionnaire, and although there is no formal psychometric data available for the Spence questionnaires that would permit comparison to other scales, they have proved sensitive to change in functions in previous studies [19, 21]. Assessing change following intervention was the purpose for which these scales were designed, and not a formal measure of absolute social skills (Spence 2014 – *private communication)*, although this is the first time they have been used with children with ASD. Using a measure of change meant the teachers did not need to compare their pupils to norms of social functioning in typically developing children. This was thought significant, since the teachers involved in the study were exclusively teaching children with ASD, and would not have ready access to such knowledge.

The small staff complement meant that the assessors of the children's social function could not be blinded to the children's study status. There was no data gathered from sources other than the teacher completed social questionnaires, and this obviously weakens the robustness

of the results. In addition, although change was evident at the end of the study, without a follow-up it is not possible to be explicit about its persistence over time.

Finally, it is possible the children's social skills could have been influenced by other factors during the time of the project. For instance, it is known that a child's level of social activity is strongly influenced by such factors as parental expectations and support, the modelling of siblings, and the opportunities that exist within their community to participate in social activities [43-45]. In this study resources did not permit these specific issues to be explored in any detail, but there were only a small number of children with out-of-school activities, and most of these were in the control group. It is thus unlikely that such activities have exerted a negative effect on the overall results.

Conclusion

Although various computer-based interventions have been explored to improve the social functioning of children with ASD, the use of a computer game which was developed as an entertaining, physical activity is a novel approach. The results show that, at least in boys, such a programme has the potential to produce positive change to social functioning. Further research in this area is needed before positive recommendations can be made, but, if the impact is confirmed, the ready availability, and modest cost, of such programmes makes them a practical option for schools and families to consider as part of an individual child's programme of intervention.

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References

1. Rogers S: **Interventions that Facilitate Socialization in Children with Autism.** *J Autism Dev Disord* 2000, **30**:399 - 408.

2. Laushey KM, Heflin LJ: **Enhancing social skills of kindergarten children with autism through the training of multiple peers as tutors.** *J Autism Dev Disord* 2000, **30**:183 - 193.
3. Tantam D: **The challenge of adolescents and adults with Asperger syndrome.** *Child Adolesc Psychiatr Clin N Am* 2003, **12**:143 - 163.
4. Chang Y-C, Laugeson EA, Gantman A, Ellingsen R, Frankel F, Dillon AR: **Predicting treatment success in social skills training for adolescents with autism spectrum disorders: The UCLA Program for the Education and Enrichment of Relational Skills.** *Autism* 2014, **18**:467 - 470.
5. Simpson A, Langone J, Ayres KM: **Embedded video and computer based instruction to improve social skills for students with autism.** *Ed Train Dev Disabil* 2004, **39**:240 - 252.
6. Lacava PG, Rankin A, Mahlios E, Cook K, Simpson RL: **A single case design evaluation of a software and tutor intervention addressing emotion recognition and social interaction in four boys with ASD.** *Autism* 2010, **14**:161 - 178.
7. Bernard-Opitz V, Sriram N, Nakhoda-Sapuan S: **Enhancing social problem solving in children with autism and normal children through computer-assisted instruction.** *J Autism Dev Disord* 2001, **31**:377- 384.
8. Beaumont R, Sofronoff K: **A multi-component social skills intervention for children with Asperger syndrome: the Junior Detective Training Program.** *J Child Psychol Psychiat* 2008, **49**:743 - 753.
9. Solomon M, Goodlin-Jones BL, Anders TF: **A social adjustment enhancement intervention for high functioning autism, Asperger's syndrome, and pervasive developmental disorder NOS.** *J Autism Dev Disord* 2004, **34**:649 - 668.
10. Reichow B, Steiner AM, Volkmar FR: **Social skills groups for people aged 6 to 21 with autism spectrum disorders (ASD).** *Evid Based Child Hlth* 2012 **8**:266 - 315.
11. Mazurek MO, Wenstrup C: **Television, Video Game and Social Media Use Among Children with ASD and Typically Developing Siblings.** *J Autism Dev Disord* 2013, **43**:1258 - 1271.
12. MacMullin JA, Lunsky Y, Weiss JA: **Plugged in: Electronics use in youth and young adults with autism spectrum disorder.** *Autism* 2015, **early view**.
13. Behrmann M, Minshew NJ: **Sensory Processing in Autism**. In: *Autism Spectrum Disorders Phenotypes, Mechanisms and Treatments. Volume 180*, edn. Edited by Leboyer M, Chaste P. Basel: Karger; 2015: 54 - 67.
14. Wainer AL, Ingersoll BR: **The use of innovative computer technology for teaching social communication to individuals with autism spectrum disorders.** *Res Autism Spectr Disord* 2011, **5**:96 - 107.
15. Ramdoss S, Machalicek W, Rispoli M, Mulloy A, Lang R, O'Reilly M: **Computer-based interventions to improve social and emotional skills in individuals with autism spectrum disorders: A systematic review.** *Dev Neurorehab* 2012, **15**:119 - 135.
16. Williams C, Wright B, Callaghan G, Coughlan B: **Do children with autism learn to read more readily by computer assisted instruction or traditional book methods? A pilot study.** *Autism* 2002, **6**:71 - 91.
17. Panyan MV: **Computer-technology for autistic students.** *J Autism Dev Disord* 1984, **14**:375 - 382.
18. Ackerman PL, Kanfer R, Calderwood C: **Use it or lose it? Wii brain exercise practice and reading for domain knowledge.***Psychol Aging* 2010, **25**:753 - 766.
19. Spence SH: **Social skills training with children and adolescent.** Oxford: NFER-NELSON Publishing Company Ltd.; 1979.

20. Spence SH, Marzillier JS: **Social skills training with adolescent male offenders: I. Short-term effects.** *Behav Res Ther* 1979, **17**:7 - 16.
21. Spence SH, Marzillier JS: **Social skills training with adolescent male offenders: II. Short—term, long-term, and generalized effects.** *Behav Res Ther* 1981, **19**:349 - 368.
22. Joo LY, Yin TS, Xu D, Thia E, Chia PF, Kuah CWK, He KK: **A feasibility study using interactive commercial off-the-shelf computer gaming in upper limb rehabilitation in patients after stroke.** *J Rehabil Med* 2010, **42**:437 - 441.
23. McGillicuddy-De Lisi AV: **Parents' Beliefs and Children's Personal-Social Development**. In: *Parental Belief Systems: The Psychological Consequences for Children (Second Edition).* edn. Edited by Sigel IE, McGillicuddy-De Lisi AV, Goodnow JJ. London: Psychological Press; 2014: 115 - 142.
24. Olson DH, Gorall DM, Tiesel J: **FACES-IV package: administration.** Minneapolis, Minnesota.: Life Innovations, Inc.; 2006.
25. Olson DH: **FACES IV and the Circumplex Model: Validation Study.** *J Marit Fam Ther* 2011, **3**:64 - 80.
26. Shapiro SS, Wilk MB: **An analysis of variance test for normality (complete samples).** *Biometrika* 1965, **52**:591 - 611.
27. Bell D, Foster SL, Mash EJ: **Handbook of Behavioral and Emotional Problems in Girls**. London: Springer Science & Business Media; 2006.
28. Eagly AH: **Sex Differences in Social Behavior: A Social-role interpretation**. London: Psychology Press; 2013.
29. Hartley SL, Sikora DM: **Sex Differences in Autism Spectrum Disorder: An Examination of Developmental Functioning, Autistic Symptoms, and Coexisting Behavior Problems in Toddlers.** *J Autism Dev Disord* 2009, **39**:1715 - 1722.
30. Mandy W, R. C, Chowdhury U, Salter G, Seigal A, Skuse D: **Sex differences in autism spectrum disorder: evidence from a large sample of children and adolescents**. *J Autism Dev Disord* 2012, **42**:1304 - 1313.
31. Holtmann M, Bolte S, Poustka F: **Autism spectrum disorders: Sex differences in autistic behavior in autistic behavior domains and coexisting psychopathology.** . *Dev Med Child Neurol* 2007, **49**:361 - 366.
32. Head AM, McGillivray JA, Stokes MA: **Gender differences in emotionality and sociability in children with autism spectrum disorders**. *Mol Autism* 2014, **5**:19.
33. Hartmann T, Klimmt C: **Gender and Computer Games: Exploring Females' Dislikes**. *J Comp Mediat Comm* 2006, **11**:910 - 931.
34. Connolly TM, Boyle EA, MacArthur E, Hainey T, Boyle JM: **A systematic literature review of empirical evidence on computer games and serious games.** *Comp Educ* 2012, **59**:661 - 686.
35. Robertson J: **Making games in the classroom: Benefits and gender concerns**. *Comp Educ* 2012, **59**:385 - 398.
36. Halladay AK, Bishop S, Constantino JN, Daniels AM, Koenig K, Palmer K, Messinger D, Pelphrey K, Sanders SJ, Singer AT *et al*: **Sex and gender differences in autism spectrum disorder: summarizing evidence gaps and identifying emerging areas of priority**. *Mol Autism* 2015, **6**:36.
37. Anderson F, Annett M, Bischof WF: **Lean on Wii: Physical rehabilitation with virtual reality Wii peripherals.** *Stud Hlth Tech Inform* 2010, **154**:229 - 234.
38. Sandlund M, Waterworth EL, Häger C: **Using motion interactive games to promote physical activity and enhance motor performance in children with cerebral palsy.** *Dev Neurorehab* 2011, **14**:15 - 21.

39. Watkins L, O'Reilly M, Kuhn M, Gevarter C, Lancioni GE, Sigafoos J, Lang R: **A review of peer-mediated social interaction interventions for students with autism in inclusive settings.** *J Autism Dev Disord* 2015, **45**:1070 - 1083.
40. McFadden B, Kamps D, Heitzman-Powell L: **Social Communication Effects of Peer-Mediated Recess Intervention for Children with Autism**. *Res Autism Spectr Disord* 2014, **8**:1699 - 1712.
41. Mason R, Kamps D, Turcotte A, Cox S, Feldmiller S, Miller T: **Peer Mediation to Increase Communication and Interaction at Recess for Students with Autism Spectrum Disorders.** *Res Autism Spectr Disord* 2014, **8**:334 - 344.
42. Prendeville JA, Prelock PA, Unwin G: **Peer play interventions to support the social competence of children with autism spectrum disorders**. *Seminars Speech Lang* 2006, **27**:32 - 46.
43. Wilson KS: **Predicting parental social influences: The role of physical activity variability**. *Psychol Sport Exerc* 2012, **13**:1 - 9.
44. Maitland C, Stratton G, Foster S, Braham R, Rosenberg M: **The Dynamic Family Home: a qualitative exploration of physical environmental influences on children's sedentary behaviour and physical activity within the home space**. *Intl J Behav Nutr Phys Act* 2014, **11**:157 - 169.
45. Hamilton K, White KM: **Social Influences and the Physical Activity Intentions of Parents of Young-Children Families: An Extended Theory of Planned Behavior Approach**. *J Fam Issues* 2012, **33**:1351 - 1372.

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