



BISHOP
GROSSETESTE
UNIVERSITY

[BG Research Online](#)

Dimolareva, M. and Dunn, T.J. (2020) *Animal-Assisted interventions for school-aged children with autism spectrum disorder: a meta-analysis*. Journal of Autism and Developmental Disorders. ISSN 1573-3432

This is an Accepted Manuscript published by Springer in its final form on 29th September 2020 at <https://doi.org/10.1007/s10803-020-04715-w>

This version may differ slightly from the final published version.

Copyright is retained by the author/s and/or other copyright holders.

End users generally may reproduce, display or distribute single copies of content held within BG Research Online, in any format or medium, for personal research & study or for educational or other not-for-profit purposes provided that:

- The full bibliographic details and a hyperlink to (or the URL of) the item's record in BG Research Online are clearly displayed;
- No part of the content or metadata is further copied, reproduced, distributed, displayed or published, in any format or medium;
- The content and/or metadata is not used for commercial purposes;
- The content is not altered or adapted without written permission from the rights owner/s, unless expressly permitted by licence.

For enquiries about BG Research Online email bgro@bishopg.ac.uk.

Animal-Assisted Interventions for school-aged children with Autism Spectrum Disorder: a meta-analysis

Mirena Dimolareva^{1*} & Thomas J. Dunn¹

1. Psychology Division, Bishop Grosseteste University, Lincoln.

*Correspondence: Mirena Dimolareva, Psychology Division, Bishop Grosseteste University, Lincoln, LN1 3DY.

Tel: 01522 583770

Email – mirena.dimolareva@bishopg.ac.uk

Abstract

Research has indicated beneficial effects of Animal-Assisted Interventions (AAIs) for children with Autism. However, there is a dearth of meta-analyses and the findings are often contradictory. The current meta-analysis assesses the effectiveness of AAIs on social interaction, communication and global Autism symptoms. A total of 1447 studies were returned, of which 16 ($n = 489$) met the inclusion criteria. The meta-analyses indicated small effect sizes related to improvements in social interaction and communication and reduction in ASD symptoms. Additionally, there was little evidence for a relationship between dosage and effect size. In conclusion, AAIs appear to offer small improvements in social interaction and communication for children with Autism, which may be comparable to activities used in active control conditions.

Key Words: Animal-Assisted Interventions, Autism, Children, School-Age

1 **Animal-Assisted Interventions for school-aged children with Autism Spectrum Disorder: a**
2 **meta-analysis**

3
4
5 Abstract

6
7 Research has indicated beneficial effects of Animal-Assisted Interventions (AAIs) for children
8 with Autism. However, there is a dearth of meta-analyses and the findings are often
9 contradictory. The current meta-analysis assesses the effectiveness of AAIs on social interaction,
10 communication and global Autism symptoms. A total of 1447 studies were returned, of which 16
11 (*n* = 489) met the inclusion criteria. The meta-analyses indicated small effect sizes related to
12 improvements in social interaction and communication and reduction in ASD symptoms.
13 Additionally, there was little evidence for a relationship between dosage and effect size. In
14 conclusion, AAIs appear to offer small improvements in social interaction and communication
15 for children with Autism, which may be comparable to activities used in active control
16 conditions.
17
18

19 *Key Words:* Animal-Assisted Interventions, Autism, Children, School-Age
20
21
22
23
24
25

26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1 Recently there has been an upsurge in research concerning the therapeutic benefits of Animal-
2 Assisted Interventions (AAIs). AAIs are sessions with therapeutic, health and/or wellbeing goals
3 which involve the presence of an animal (SCAS, 2013). There are different types of AAIs such as
4 Animal-Assisted Therapy (e.g. Animal-Assisted Play Therapy), Animal-Assisted Activities (e.g.
5 therapy animal visits to nursing homes), Animal-Assisted Education (i.e. completing tasks with
6 therapy animals to improve educational outcomes). AAIs can vary in duration and length, for
7 example, from weekly, 1-hour sessions for 6- months (Kern et al., 2011), to weekly 1-hour
8 sessions for 10 weeks (Gabriels et al., 2012) or twice weekly, 20-minute sessions for 8 weeks
9 (O’Haire, McKenzie, McCune & Slaughter, 2014). AAI sessions can include structured (e.g. how
10 to lead and care for a horse) as well as unstructured components (e.g., free play time with the
11 animals) (e.g. Gabriels et al., 2012; O’Haire et al., 2014). AAI research also differs in terms of
12 design, where some studies use a randomised and/or controlled design (e.g. Becker, Rogers &
13 Burrows, 2017; Gabriels et al., 2012) compared to others who employ pre-post designs with no
14 control group (e.g. Anderson & Meints, 2016).

15
16
17
18
19
20
21
22
23
24
25
26 In general, the literature points to positive effects of interacting and engaging with animals, across
27 a range of disorders (e.g., Schuck, Emmerson, Fine & Lakes, 2015; Friedmann, Katcher, Thomas,
28 Lynch & Massent, 1983; Stefanini, Martino, Bacci & Tani, 2016). However, assessing AAIs’ ‘true’
29 impact for children with Autism Spectrum Disorder (ASD) has somewhat lagged behind the
30 volume of single-study publications. The evidence from systematic literature reviews focusing on
31 single case studies is promising (O’Haire, 2013; O’Haire, 2017; Brelsford, Meints, Gee & Pfeffer,
32 2017; Mapes & Rosén, 2016) and highlight beneficial effects of AAIs for school-aged children
33 with ASD (Brelsford et al., 2017; Davis et al., 2015; O’Haire, 2013; O’Haire, 2017; Mapes &
34 Rosén, 2016). More specifically, children who participate in AAIs show a reduction in global ASD
35 behavioural symptoms and maladaptive behaviours as well as improvement in empathetic
36 behaviours, classroom participation, self-regulation, and social interaction with others (Anderson
37 & Meints, 2016; Anderson & Olson, 2006; Kern et al., 2011; O’Haire, 2013; O’Haire, 2017;
38 Ajzenman, Standeven & Shurtleff, 2013; Mapes & Rosén, 2016). Research shows that autistic
39 children seek interaction with animals more often than with humans and inanimate objects
40 (Prothmann, Ettrich & Prothmann, 2009), thus it is proposed that interacting with animals may act
41 as a facilitator for human interaction (McNicholas & Collis, 2000). Furthermore, some researchers
42 argue animals communicate their intentions non-verbally through body language, which might be
43 easier to understand by individuals with ASD (Prothmann et al., 2009). In line with this, research
44 demonstrates that after participating in an AAI, children with ASD produce more meaningful
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1 utterances (Stevenson, Jarred, Hinchcliffe & Roberts, 2015) and show improvements in motor
2 action such as posture and non-verbal communication (Ajzenman et al., 2013; Borgi et al., 2016;
3 Gabriels et al., 2015). Although findings are generally consistent and point to a benefit of AAI for
4 children with ASD, some studies have only found non-significant trends towards improvement in
5 children's behaviour, language ability and communication (Gabriels et al., 2012; Anderson &
6 Meints, 2016; Jenkins & DiGennaro, 2013) and rely on reporting anecdotal parent perception of
7 AAI benefits (Jenkins & DiGennaro, 2013).
8
9

10
11
12
13 To the current authors' knowledge, there are only two meta-analyses related to the effects of
14 AAI, both of which were published over twelve years ago. Taken together, these two meta-
15 analyses indicate that AAI may offer small to moderate beneficial effects for depression as well
16 as general well-being, medical and behavioral indicators (Souter & Miller, 2007; Nimer &
17 Lundahl, 2007). One meta-analysis showed positive effects of Animal-Assisted Therapy (AAT)
18 for children with ASD ($d = 0.72$, $k = 4$) (Nimer & Lundahl, 2007), however this was limited to
19 four studies and excluded research involving general Animal-Assisted Activities (i.e., studies
20 where animal interaction was goal-directed but not accompanied by some other form of therapy
21 such as Animal-Assisted Education) (Fine, 2015). Given the practical implications of providing a
22 therapeutic intervention to an increasing population of children with special educational needs
23 (Department of Education, 2018), and more specifically school-age children with ASD, it is
24 important to include instances where the isolated impact of AAI on ASD is assessed (Mapes &
25 Rosén, 2016) Additionally, previous research (including one meta-analysis) have failed to
26 account for the impact of dosage (e.g., time engaged in AAI) on outcome. Although intervention
27 dose is an essential condition of drug development, it is somewhat neglected in behavioral
28 interventions. Retrospective data analyses (such as meta-analysis) are one way of examining the
29 dose-response relationship (i.e., intervention efficacy).
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44

45 AAI are becoming increasingly popular in schools, despite the lack of clarity relating to the
46 effectiveness of the evidence (Brelsford et al., 2017). Given the growth in AAI research over the
47 last decade, it is crucial to gauge the current state of knowledge relating to the impact of AAI for
48 children with ASD. Therefore, the objective of the current meta-analysis is to specifically
49 investigate the effect of any Animal-Assisted Interventions on children's ASD symptoms and most
50 common deficits, namely social interaction and communication (Redefer & Goodman, 1989). This
51 meta-analysis extends previous publications in four ways: 1) it employs a broad and comprehensive
52 range of search terms and databases (see supplementary material); 2) it seeks to capture all Animal-
53
54
55
56
57
58
59
60
61
62
63
64
65

1 Assisted Interventions regardless of animal type; 3) it utilises meta-regression techniques and
2 subgroup analysis to account for possible sources of heterogeneity and compare effect sizes across
3 study design; 4) it undertakes a comprehensive Risk of Bias Assessment.

4
5
6 The current meta-analysis aims to:

- 7
8
9 i. Conduct an up-to-date meta-analysis of studies examining the effect of AAI on children
10 with ASD.
11
12 ii. Estimate the effect of AAI on two core components of ASD (social interaction &
13 communication) as well as global ASD scores.
14
15
16 iii. Provide an assessment as to the quality of AAI studies in the field.
17
18 iv. Explore the role of dosage in AAI's effect on ASD symptoms.
19
20

21 Methods

22 Eligibility criteria

23
24
25 Studies investigating the effect of AAIs on social, communication and diagnostic symptoms of
26 school-aged children with ASD were selected for this meta-analysis. PRISMA Guidelines were
27 followed (Liberati et al., 2009). The following criteria was set for inclusion: (1) article must be
28 written in English (2) participating children had a formal diagnosis of ASD (3) participants were
29 of school-age (4) research included a measure of social interaction and/or communication and/or
30 ASD symptoms (5) only published, peer-reviewed studies were included to maintain a set quality
31 of research. In reference to point (3), articles including only children of school age were included
32 as Animal-Assisted Interventions are becoming increasingly popular in schools and the
33 effectiveness of these interventions should be quantitatively assessed to establish their suitability
34 for school-aged children and shape decisions around organising and implementing AAIs. Articles
35 were excluded from the analysis if: (1) the interventions were not with children of school-age (4-
36 18 years) (2) there were no measures of ASD global score, communication and/or social
37 interaction as an outcome variable (3) the article status was 'unpublished' (4) the article was not
38 peer-reviewed as part of the publication process.
39
40
41
42
43
44
45
46
47
48
49
50

51 Databases

52
53
54 Seven databases were searched from their start date until present. The searches were completed
55 on 01.03.2020. The databases searched were: Academic Search Complete, Anthrozoöes, Autism
56 Data, PsychArticles, PsychInfo, Science Direct, Web of Science.
57
58
59
60
61
62
63
64
65

Search

The search terms were pre-determined. The following terms were used to ensure all aspects of AAI were included in the search as Animal-Assisted Interventions in this case was used as an umbrella term to include more specific interventions: “Animal-Assisted Intervention”, “Animal-Assisted Activities”, “Animal-Assisted Therapy”, “Canine-Assisted Intervention”, “Canine-Assisted Activities”, “Canine-Assisted Therapy”, “Dog-Assisted Intervention”, “Dog-Assisted Activities”, “Dog-Assisted Therapy”, “Equine-Assisted Intervention”, “Equine-Assisted Activities”, “Equine-Assisted Therapy” were paired with “special needs”, “learning difficulties”, “developmental delay”, “special educational needs”, “Autism Spectrum Disorder”, “Attention Deficit Hyperactivity Disorder”, “language delay”, “language disorder”. These search terms were chosen to widen the search and ensure inclusivity of research articles as ASD is often diagnosed with other comorbid conditions.

Selection process

All searches were conducted by the first author. Selection of articles was completed by both authors, ensuring participants had a formal diagnosis of ASD and had appropriate measures for social interaction and/or communication and/or ASD symptoms. The second author contacted researchers when data clarifications were required.

Data items

The meta-analysis was set out by outcome measure and design type. The following data were extracted from each study: (1) Participant Information (diagnosis, N, age etc.); (2) Measures (communication, social interaction, ASD symptoms); (3) Design (pre-post, control group, single group, active control, follow-up, case-study); (4) Statistics (*Mean*, *SD*, *Effect size*).

Data collection process

A spreadsheet was developed by the second author who also extracted the data required for the meta-analysis calculations. The participant information and design data were extracted by both authors separately to reduce likelihood of bias.

Risk of bias within individual studies

A risk of bias summary was constructed based on the Cochrane collaboration tool for assessing risk of bias (Higgins & Green, 2014). This evaluates potential areas of bias including selection bias, performance bias, attrition bias, detection bias, and reporting bias. To supplement this,

1 additional AAI-specific risk of bias criteria were included (ASD diagnostic tool, ASD
2 diagnostician, intervention instructor, outcome measure, rater consistency).
3

4 For Cochrane derived risk of bias items, the review protocol was that as set out in the Cochrane
5 handbook (Higgins & Green, 2014). The coding protocol for AAI-specific items was as follows:
6 ASD diagnostic tool (validated/reliable diagnostic tool = Low, non-previously established
7 diagnostic tool = High, unclear = Unclear); ASD diagnostician (clinician = Low, non-clinician =
8 High, unclear = Unclear); Intervention instructor (experienced = Low, inexperienced = High,
9 unclear = Unclear); Assessment tool (reliable = Low, unreliable = High, unclear = Unclear);
10 Rater-consistency (same pre/post = Low, different pre/post = High, unclear = Unclear).
11
12
13
14
15
16
17

18 Controlled and single-group pre-post studies were included in the same risk of bias assessment.
19 In order to capture the increased risk of bias for single-group studies (compared to those with a
20 control), a 'design' criterion was included (where single-group studies were classified as 'High
21 risk' and controlled studies as 'Low risk'). For all criteria specifically relating to controlled
22 studies (e.g., allocation concealment), single-group studies were automatically coded as 'High
23 risk'. The quality of the control condition (from lowest to highest) was assessed by categorising it
24 as either no treatment, minimal treatment, non-specific active control, active control, and
25 evidence-based treatment (EBT) (where EBT was defined as there being at least one prior
26 published study demonstrating a significant medium-sized effect). Risk of bias was assessed by
27 two raters independently, based on the above criteria. Any coding discrepancies were discussed
28 with reference to the relevant study until a consensus was reached.
29
30
31
32
33
34
35
36
37
38

39 Summary measures

40
41 The primary effect size measure was the standardised mean change (Cohen's *d*). In line with
42 Becker (1988) and Morris (2008), the standardised mean change was calculated for the
43 intervention and control groups separately, which meant the difference between effect sizes of
44 each condition could be calculated along with the sum of sampling variances, giving an overall
45 effect size for control group pre/post studies (CGPP). For single group pre/post studies (SGPP),
46 the standardised mean change for the intervention group was calculated (Morris, & DeShon,
47 2002). Where correlation coefficients between pre and post were not available, a recommended
48 conservative estimate ($r = .7$) was used (Rosenthal, 1993). All effect sizes were calculated from
49 means and SDs, which were either extracted from the articles directly or obtained by way of
50 contacting the authors. In instances where studies had more than one rater using the same scale
51 (e.g., parent and teacher), raw scores were averaged, and effects sizes calculated. Where multiple
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1 time points were available, only end-of-treatment (EoT) was included in any effect size
2 calculation. This was mainly due to reasons of consistency as nearly all studies made
3 measurements at only two time points.
4
5

6 Synthesis of results 7

8
9 All meta-analyses were conducted using the *metafor* package in R (Viechtbauer, 2010). A meta-
10 analysis was carried out for each area of interest (Social, Communication & ASD), and included
11 a separate sub-group analysis as defined by study design (SGPP, CGPP, ACPP). The
12 standardised mean change, its 95% confidence interval (95% CI), and corresponding z and p
13 values were estimated. All meta-analyses were specified as random-effects models, which allows
14 for an adjustment in effect estimates, dependent on the extent of variation across different studies.
15
16 Heterogeneity was assessed across studies in each group and sub-group using the I^2 and the Q -
17 statistic (Higgins & Thompson 2002, Higgins, Thompson, Deeks & Altman, 2003). I^2 is
18 particularly useful as it provides a percentage of effect size variability due to heterogeneity rather
19 than sampling error. A rough guide for I^2 interpretation is as follows: 0% to 40%: might not be
20 important; 30% to 60%: may represent moderate heterogeneity; 50% to 90%: may represent
21 substantial heterogeneity; 75% to 100%: considerable heterogeneity (Higgins et al., 2003). The
22 Q -statistic (based on χ^2) provides a test of significance of between-study heterogeneity.
23
24 Subgroup analyses were carried out to investigate whether study design (e.g. SGPP vs CGPP vs
25 ACPP) accounted for a proportion of the heterogeneity present. A random-effects model was
26 used to estimate heterogeneity variance (I^2 and the Q -test).
27
28
29
30
31
32
33
34
35
36
37
38

39 Risk of bias across studies 40

41 Publication bias was assessed through visual inspection of funnel plots, where asymmetry of the
42 distribution of effect size to standard error is suggestive of publication bias (Viechtbauer, 2010).
43 Egger's test was used to assess the significance of asymmetry (Sterne & Egger, 2001). The trim-
44 and-fill method was applied to any identified instances of asymmetry and effect sizes recalculated
45 (Duval & Tweedie, 2000a; Duval & Tweedie, 200b). This technique estimates potentially
46 missing studies due to publication bias, based on the assumption that the more extreme effect
47 sizes are suppressed. These potentially suppressed studies (with corresponding effect sizes) can
48 then be included in further meta-analysis re-calculations in order to gauge their impact (Shi &
49 Lin, 2019).
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

Additional analyses

In line with the objectives of this meta-analysis, meta-regression was used to examine the relationship between dosage (moderator) and effect sizes of all treatment outcomes (Social, Communication, global ASD). Dosage was calculated by multiplying session length in minutes by frequency per week and overall treatment length. For studies that reported session time as a range, the mean of the range was used (e.g., a 30-40-minute session would be coded as 35 minutes). A random-effects models was used to estimate the model coefficients, providing corresponding z and p values, while the Q -statistic was used as the omnibus test of the model coefficients.

Results

Study selection

The search returns from all databases (N=1447) were assessed at title and abstract level for their suitability in terms of the inclusion criteria for this meta-analysis. As the abstract for some papers did not have the details to assess suitability of the research, the full text was assessed for eligibility. The selection process is presented in Figure 1.

(Insert Figure 1 here)

Study characteristics

The study characteristics along with Mean, Standard Deviation and Effect Size are presented in Table 1. The table is in alphabetical order by first author and includes the 16 studies included in this meta-analysis. The total number of participants was 489.

Single group pre- post (SGPP) design accounted for 4 studies, while 9 studies adopted no-treatment pre-post (CGPP) and 3 studies had active control pre- post (ACPP) design. All studies had measured either Social Interaction, Communication, Global ASD or a combination of measures. Studies have used a variety of validated and standardized measures.

(Insert Table 1 here)

Risk of bias within individual studies

The studies included in this meta-analysis were a combination of SGPP (25%), CGPP (56.2%) and ACPP (18.8%) designs. In general, the reporting of blinding procedures was low (i.e., resulting in a potential high risk of bias). Specifically, whether the outcome assessors and personnel were blind to the study hypotheses was unclear. Rater consistency was reported in 56% of the studies. The potential of bias in the quality of ASD diagnostician and diagnostic tool was low to moderate, with 56% deemed qualified diagnosticians (e.g., clinical/educational psychologist) and 69% employed reliable tools (e.g., previously validated). Outcome measures were considered to be low risk of bias, given that 100% of studies used established standardized measures.

(Insert Figure 2 here)

(Insert Figure 3 here)

Results of individual studies

A meta-analysis for each outcome (Social, Communication, Global ASD) along with sub-group comparisons are reported below. Means and SDs at all relevant measurement points along with standardized mean change effect sizes can be seen in Table 1.

Synthesis of results

Effect on social interaction

The results of the social interaction meta-analysis across nine studies ($n = 360$) can be seen in Figure 4. Overall, the results show a small statistically significant improvement in terms of social interaction (as estimated using *SMC*) as a consequence of AAIIs ($SMC = .21$, $SE = .07$, $z = 2.86$, $p < .01$, $CI [.07, .35]$). Heterogeneity was low across all studies ($I^2 = 0\%$, $Q = 6.73$). The effect size for SGPP studies was small but statistically non-significant ($SMC = .22$, $SE = .14$, $z = 1.56$, $p = .12$, $CI [-.06, .50]$), for CGPP studies it was small and statistically significant ($SMC = .24$, $SE = .11$, $z = 2.18$, $p = .03$, $CI [.03, .45]$), and for ACPP studies it was small and statistically non-significant ($SMC = .12$, $SE = .16$, $z = .73$, $p = .47$, $CI [-.19, .44]$). There was no statistically significant difference across subgroups ($I^2 = 0\%$, $p = .83$).

(Insert Figure 4 here)

Effect on communication

The results for the communication meta-analysis across nine studies ($n = 285$) can be seen in Figure 5. Overall, the results show a small statistically significant improvement in terms of communication (as estimated using *SMC*) from AAIIs ($SMC = .26$, $SE = .09$, $z = 2.85$, $p < .01$, $CI [.08, .44]$). Heterogeneity was moderate across all studies ($I^2 = 30.1\%$, $Q = 11.02$). The effect size for SGPP studies was small but statistically non-significant ($SMC = .22$, $SE = .12$, $z = 1.84$, $p = .07$, $CI [-.02, .45]$), for CGPP studies it was moderate and statistically significant ($SMC = .34$, $SE = .17$, $z = 1.98$, $p = .05$, $CI [.00, .68]$), and for ACPP studies it was small and statistically non-significant ($SMC = .23$, $SE = .22$, $z = 1.05$, $p = .29$, $CI [-.19, .66]$). There was no statistically significant difference across design-type ($I^2 = 0\%$, $p = .84$).

(Insert Figure 5 here)

Effect on global measures of ASD

The results for the ASD meta-analysis across seven studies ($n = 148$) can be seen in Figure 6. Overall, the results show a small non-statistically significant reduction in terms of ASD symptoms (as estimated using *SMC*) because of AAIIs ($SMC = -.19$, $SE = .11$, $z = -1.80$, $p = .07$, $CI [-.39, .02]$). Heterogeneity was low across all studies ($I^2 = 0\%$, $Q = 13.48$). The effect size for SGPP studies was small and statistically non-significant ($SMC = -.25$, $SE = .14$, $z = -1.78$, $p = .07$, $CI [-.52, .02]$), for CGPP studies it was small and statistically non-significant ($SMC = -.17$, $SE = .19$, $z = -.87$, $p = .38$, $CI [-.54, .21]$), and for ACPP studies it was large and statistically significant in favour of the control group ($SMC = 2.63$, $SE = .98$, $z = 2.67$, $p < .01$, $CI [.70, 4.56]$). There was a significant difference across study-type (SGPP vs CGPP vs ACPP) in terms of heterogeneity variance ($I^2 = 96.7\%$, $p = .02$).

(Insert Figure 6 here)

Risk of bias across studies

Inspection of funnel plots (see Figure 7) suggests symmetry for Social and Communication outcomes but not for the ASD outcome (Viechtbauer, 2010). This was confirmed using Egger's test, where the distribution of effect sizes to standard error did not significantly deviate from symmetry for Social ($z = 1.09$, $p = 0.28$) or Communication ($z = 0.68$, $p = 0.48$), but did for ASD ($z = 2.84$, $p < .01$). In light of this, the trim-and-fill method was used to estimate the effect sizes of

1 potentially suppressed studies for the ASD outcome and then the ASD meta-analysis was
 2 recalculated (Duval & Tweedie, 2000a; Duval & Tweedie, 200b). Using this technique, the
 3 results showed a marginal increase in ASD overall effect size (from -.19 to -.25 [SE =0.45, z = -
 4 0.56, p=.57]) but a decrease in significance. This is to be expected given that the estimated
 5 missing studies represent those with greater error (see Figure 7). Combined, these analyses
 6 suggest that the effect size estimates for Social and Communication were robust and not likely
 7 impacted by publication bias, whereas the estimate for ASD could potentially be biased.

8 (Insert Figure 7 here)

15 *Additional analyses*

18 *Meta-regression results (dosage)*

19 The meta-regression results showed no significant relationship between dosage (approximate
 20 mins of therapy time) and improvement in social interaction ($\beta = .00$, $SE = .00$, $z = .68$, $Q = .47$, p
 21 $= .49$), communication ($\beta = .00$, $SE = .00$, $z = .11$, $Q = .01$, $p = .91$), or Global ASD symptoms (β
 22 $= -.00$, $SE = .00$, $z = -.42$, $Q = .17$, $p = .67$). However, it should be noted that plots (see Figure 8)
 23 demonstrated a tentative trend towards expected relationships (e.g., improvement in social skills
 24 and reduction in ASD symptoms). Given that only one of the three outcomes achieved the
 25 minimum number of studies per moderator (i.e., 10) (Borenstein, Hedges, Higgins & Rothstein,
 26 2009), the above findings should be taken with caution and require further investigation.

27 (Insert Figure 8 here)

34 Discussion

35 Meta-analytic methods allowed us to inspect the potential therapeutic value of Animal-Assisted
 36 Interventions (AAIs) for children with Autism Spectrum Disorder (ASD). This analysis examined
 37 sixteen unique AAI studies with a total of 489 ASD-diagnosed participants. Two core
 38 components of ASD symptomology thought to benefit from AAIs (social interaction and
 39 communication) as well as global ASD scores were examined.

40 The results showed a small effect (i.e., improvement) in a child's social interaction when all study
 41 types were combined (SGPP;CGPP;ACPP). However, only a small effect size for studies that
 42 included a non-active control group was statistically significant. The one study that included an
 43 active control (barn activity with no horses) showed no significant improvement in terms of
 44 social interaction (Gabriels et al., 2015). These results suggest that compared to passive activities

1 such as waitlist (e.g. Borgi et al., 2016; Gabriels et al., 2012), AAI may marginally improve
2 social interaction for children with ASD. However, compared to an activity involving a related
3 task (but without an animal) AAI demonstrates no improvement in social interaction. This
4 suggests the role of the animal in improving social interaction for children with ASD may be
5 limited.
6
7
8
9

10 The effect of AAI on communication was small and only statistically significant when all study
11 types were combined. For studies using a passive control comparison (Borgi et al., 2016; Gabriels
12 et al., 2012; Pan, Granger, Guérin, Shoffner & Gabriels, 2019), analysis showed a moderate
13 improvement in communication as a result of AAI. However, this effect disappeared when
14 comparing AAI to active controls (Gabriels et al., 2012- barn activity with no horses; Kwon et al.,
15 2019- conventional therapy). This suggests AAI may have limited impact on improving
16 communication for children with ASD above alternative interventions.
17
18
19
20
21
22

23 AAI also appeared to show little reduction in terms of global ASD scores (i.e., those thought to
24 capture multiple domains core to ASD). Specifically, the effect sizes for studies employing a
25 passive control (Harris & Williams, 2017; Jenkins & DiGennare Reed, 2013; Kern et al., 2011) or
26 those employing no control (Anderson & Meints, 2016; Holm et al., 2014; Ward et al., 2013)
27 were both non-significant. The only study to employ an active control (dance) showed a
28 significant and moderate effect size in favour of the control condition (Souza-Santos, dos Santos,
29 Azevedo-Santos & Teixeira-Machado, 2018). Although only one study, it does suggest that
30 alternative interventions may offer similar or greater reduction in global ASD symptoms
31 compared to AAI.
32
33
34
35
36
37
38
39
40

41 The results from meta-regression analyses showed non-significant relationships between dosage
42 and effect size. However, it should be noted that the sample size of studies was close to the
43 minimum required for reliable analysis (Borenstein, Hedges, Higgins & Rothstein, 2009) and the
44 direction of relationships were in line with that expected.
45
46
47
48

49 *Recommendations for the field*

50 *Risk of Bias*

51 When assessing the risk of bias within studies, it was evident that valuable information was often
52 missing or unclear (e.g., only 56% of studies indicated whether it was the same rater at baseline
53 and end of treatment). In order to reduce potential for bias, it is recommended that future research
54 should report rater consistency [i.e., at baseline and end-of-treatment]; report the allocation
55
56
57
58
59
60
61
62
63
64
65

1 process for participants (e.g., randomized); report the level of assessor blinding; provide clear
2 information relating to the ASD diagnostician; be clear as to how incomplete data were dealt
3 with; and to ensure correct and thorough reporting of data. If implemented, these will
4 undoubtedly increase the reliability of study findings and enhance future meta-analyses. In terms
5 of bias across studies, the results generally showed low levels of heterogeneity, suggesting
6 methodological (e.g., study design) and clinical (e.g., participants) differences had little impact on
7 the meta-analysis results.
8
9

10 *Future enquiry*

11
12
13
14
15
16 As well as reporting factors that may impact risk of bias, it is also proposed that the field would
17 benefit from improved study design. Out of the total number of unique studies included in this
18 meta-analysis, 29% were single group pre-post designs, 53% used a passive control group, 18%
19 included an active control condition and only 11% offered any type of follow-up assessment.
20 Therefore, it would be beneficial for future studies to employ an active control design and seek to
21 establish the potential long-term changes in AAI effects over greater time periods. It is also
22 important that evidence-based active controls are selected in order to assess the cost-benefit of
23 AAI. In other words, it is crucial to compare the benefit of AAI for children with ASD, whilst
24 considering its financial and practical costs, relative to alternative interventions.
25
26

27
28
29
30
31
32
33 Overall, the findings of the current meta-analysis indicate that the effect of AAI for children with
34 ASD is small. However, whether AAI's effectiveness varies dependent on currently untested
35 factors is yet to be established. In future, the measuring and reporting of moderators such as age,
36 dosage, extent of ASD symptoms, and sub-group characteristics could lead to targeted
37 applications of AAI. This, combined with the use of evidence-based control comparisons, will
38 surely provide a better understanding of AAI potential therapeutic use and AAI-specific
39 mechanisms of change.
40
41
42
43
44
45

46 *Limitations*

47
48
49 Owing to the statistical nature of meta-analyses, observational and single-case-study research was
50 excluded. However, combined with the current meta-analysis may provide a more complete
51 picture as to AAIs effectiveness. The current meta-analysis, focusing on social interaction and
52 communication, did not assess the entirety of symptoms associated with ASD (e.g., repetitive
53 motor behavior). Only a limited number of studies provided sufficient data to conduct robust
54 meta-regressions related to dosage. The studies included in the meta-analysis were rated to have
55
56
57
58
59
60
61
62
63
64
65

1 moderate risk of bias with some factors such as ‘random sequence generation’ and ‘allocation of
 2 concealment’ often being rated as high risk of bias. In addition, criteria such as ‘blinding outcome
 3 personnel and assessors’ were often rated as unclear, also suggesting a potential source of bias.
 4 However, results indicate low to moderate risk of bias for the meta-analysis findings themselves
 5 based on the fact there was little evidence of publication bias and estimates of heterogeneity were
 6 generally low.
 7
 8
 9
 10

11 Conclusion

12 The current meta-analysis examines the effect of AAIs on core behaviours related to children
 13 diagnosed with ASD. It also uniquely considers the role of dosage in terms of AAI efficacy.
 14 Overall, the findings show AAI offers small improvements in terms of social interaction and
 15 communication but no real reduction of global ASD symptoms. Based on the current analysis,
 16 there appears to be little evidence that dosage plays a role in the magnitude of AAI effect,
 17 however more data are needed to establish this concretely. This study also contributes several
 18 recommendations to the field regarding risk of bias reporting, study design, and potential avenues
 19 for future enquiry.
 20
 21
 22
 23
 24
 25
 26
 27
 28
 29
 30

31 Reference List

32
 33
 34
 35 Ajzenman, H.F., Standeven, J.W., & Shurtleff, T.L. (2013). Effect of hippotherapy on motor
 36 control, adaptive behaviors, and participation in children with autism spectrum disorder: a pilot
 37 study. *American Journal of Occupational Therapy*, 67(7), 653-663, DOI:
 38 10.5014/ajot.2013.008383
 39
 40
 41

42
 43 All Party Parliamentary Group on Autism (2018). Autism Diagnosis Crisis. Retrieved on:
 44 10.3.2020. Retrieved from: [https://www.autism.org.uk/get-involved/media-centre/news/2018-07-
 45 18-autism-diagnosis-postcode-lottery-exposed.aspx](https://www.autism.org.uk/get-involved/media-centre/news/2018-07-18-autism-diagnosis-postcode-lottery-exposed.aspx)
 46
 47

48
 49 Anderson, K. L., & Olson, M. R. (2006). The value of a dog in a classroom of children with
 50 severe emotional disorders. *Anthrozoös*, 19(1): 35-49. DOI: [10.2752/089279306785593919](https://doi.org/10.2752/089279306785593919)
 51
 52

53
 54 Anderson, S. & Meints, K. (2016). Brief Report: The Effects of Equine-Assisted Activities on the
 55 Social Functioning in Children and Adolescents with Autism Spectrum Disorder. *Journal of
 56 Autism and Developmental Disorders*, 46(10), 3344-3352. DOI: 10.1007/s10803-016-2869-3
 57
 58
 59
 60
 61
 62
 63
 64
 65

1 Becker, B. J. (1988). Synthesizing standardized mean-change measures. *British Journal of*
 2 *Mathematical and Statistical Psychology*, 41(2), 257–278. doi:10.1111/j.2044-
 3 8317.1988.tb00901.x
 4

5
 6 Becker, J.L., Rogers, E.C.& Burrows, B (2017). Animal-assisted Social Skills Training for
 7 Children with Autism Spectrum Disorders. *Anthrozoös*, 30(2), 307-326
 8
 9 DOI: [10.1080/08927936.2017.1311055](https://doi.org/10.1080/08927936.2017.1311055)
 10

11
 12 Borenstein, M., Hedges, L., Higgins, J., & Rothstein, H. (2009). *Introduction to meta-analysis*.
 13 Chichester, West Sussex: John Wiley & Sons.
 14

15
 16 Borgi, M., Loliva, D., Cerino, S., Chiarotti, F., Venerosi, A., Bramini, M., et al., (2016).
 17 Effectiveness of a Standardized Equine-Assisted Therapy Program for Children with Autism
 18 Spectrum Disorder. *Journal of Autism and Developmental Disorders*, 46(1), 1-9. DOI:
 19 10.1007/s10803-015-2530-6
 20
 21

22
 23 Brelsford, V.L., Meints, K., Gee, N. R., & Pfeffer, K. (2017). Animal-Assisted Interventions in
 24 the Classroom- A Systematic Review. *International Journal of Environmental Research and*
 25 *Public Health*, 14, 669. DOI: 10.3390/ijerph14070669.
 26
 27

28
 29 Davis, T.N.; Scalzo, R.; Butler, E.; Stauffer, M.; Farah, Y.N.; Perez, S.; Coviello, L. (2015).
 30 Animal-assisted interventions for children with autism spectrum disorder: A systematic review.
 31 *Education and Training in Autism and Developmental Disabilities*, 50, 316–329.
 32

33
 34 Department of Education (2018). Special educational needs in England: January 2018. Retrieved
 35 on: 10.03.2020. Retrieved from:
 36 [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729208/SEN_2018_Text.pdf)
 37 [/729208/SEN_2018_Text.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729208/SEN_2018_Text.pdf)
 38
 39

40
 41 Duval, S., & Tweedie, R. (2000a). Trim and Fill: A Simple Funnel-Plot-Based Method of Testing
 42 and Adjusting for Publication Bias in Meta-Analysis. *Biometrics*, 56(2), 455–463.
 43 doi:10.1111/j.0006-341x.2000.00455.x
 44

45
 46 Duval, S., & Tweedie, R. (2000b). A Nonparametric “Trim and Fill” Method of Accounting for
 47 Publication Bias in Meta-Analysis. *Journal of the American Statistical Association*, 95(449), 89–
 48 98. doi:10.1080/01621459.2000.10473905
 49
 50

51
 52 Fine, A. H. (Ed) (2015). *Animal-assisted Therapy: Foundations and guidelines for animal-*
 53 *assisted interventions* 4th ed. Elsevier, London, UK.
 54
 55
 56
 57
 58
 59
 60
 61
 62
 63
 64
 65

- 1 Friedmann, E., Katcher, A. H., Thomas, S. A., Lynch, J. J., & Messent, P. R. (1983). Social
2 interaction and blood pressure: Influence of animal companions. *Journal of Nervous and Mental*
3 *Disease, 171*(8), 461-465. DOI:10.1097/00005053-198308000-00002
4
5
6 Gabriels, R. L., Agnew, J. A., Holt, K. D., Shoffner, A., Zhaoxing, P., Ruzzano, S., et al., (2012).
7 Pilot study measuring the effects of therapeutic horseback riding on school-age children and
8 adolescents with autism spectrum disorders. *Research in Autism Spectrum Disorders, 6*, 578-588.
9 DOI: 10.1016/j.rasd.2011.09.007
10
11
12 Gabriels, R. L., Pan, Z., Dechant, B., Agnew, J. A., Brim, N., & Mesibov, G. (2015).
13 Randomized Controlled Trial of Therapeutic Horseback Riding in Children and Adolescents with
14 Autism Spectrum Disorder. *Journal of the American Academy of Child and Adolescent*
15 *Psychiatry, 54*(7), 541–549. DOI:10.1016/j.jaac.2015.04.007
16
17
18 García-Gómez, A., Risco, M.L., Rubio, J.C., Guerrero, E., & García-Peña, I.M. (2013). Effects of
19 a Program of Adapted Therapeutic Horse-Riding in a Group of Autism Spectrum Disorder
20 Children. *Electronic Journal of Research in Educational Psychology, 12*(1), 107-128. DOI:
21 10.14204/ejrep.32.13115
22
23
24 Harris, A., & Williams, J.M. (2017). The Impact of a Horse Riding Intervention on the Social
25 Functioning of Children with Autism Spectrum Disorder. *International Journal of Environmental*
26 *Research and Public Health, 14*(7), 776. DOI: 10.3390/ijerph14070776
27
28
29 Higgins, P.T.J. & Green, S. (2014). *Cochrane handbook for systematic reviews of interventions*.
30 John Wiley & Sons Ltd, West Sussex, England.
31
32
33 Higgins, J. P. T., Thompson, S. G., Deeks, J. J. & Altman, D. G. (2003). Measuring inconsistency
34 in meta-analyses, *BMJ, 327*:557. DOI: [10.1136/bmj.327.7414.557](https://doi.org/10.1136/bmj.327.7414.557)
35
36
37 Higgins J.P.T & Thompson S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics*
38 *in Medicine, 21*, 1539–1558.
39
40
41 Holm, M. B., Baird, J. M., Kim, Y. J., Rajora, K. B., D'Silva, D., Podolinsky, L., et al. (2014).
42 Therapeutic horseback riding outcomes of parent-identified goals for children with autism
43 spectrum disorder: an ABA' multiple case design examining dosing and generalization to the
44 home and community. *Journal of autism and developmental disorders, 44*(4), 937–947. DOI:
45 10.1007/s10803-013-1949-x
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1 Jenkins, S.R. & DiGennaro Reed, F.D. (2013). An experimental analysis of the effects of
2 therapeutic horseback riding on the behavior of children with autism. *Research in Autism*
3 *Spectrum Disorders*, 7, 721-740. DOI: 10.1016/j.rasd.2013.02.008
4
5

6 Kern, J. K., Fletcher, C. L., Garver, C. R., Mehta, J. A., Grannemann, B. D., & Knox, K. R.
7 (2011). Prospective trial of equine-assisted activities in autism spectrum disorder. *Alternative*
8 *Therapies in Health and Medicine*, 17(3), 14–20
9
10

11 Kwon, S., Sung, I.Y., KO, E.J. & Kim, H.S. (2019). Effects of Therapeutic Horseback Riding on
12 Cognition and Language in Children with Autism Spectrum Disorder or Intellectual Disability: A
13 Preliminary Study. *Annals of Rehabilitation Medicine*, 43(3), 279-288. DOI:
14 [10.5535/arm.2019.43.3.279](https://doi.org/10.5535/arm.2019.43.3.279)
15
16
17
18
19

20 Lanning, B. A., Baier, M. E., Ivey-Hatz, J., Krenek, N. & Tubbs, J. D. (2014). Effects of equine
21 assisted activities on autism spectrum disorder. *Journal of Autism and Developmental Disorders*,
22 44(8), 1897–1907.
23
24
25

26 Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P., Clarke, M.,
27 Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting
28 systematic reviews and meta-analyses of studies that evaluate health care interventions:
29 explanation and elaboration. *PLoS medicine*, 6(7), e1000100.
30
31
32
33
34 <https://doi.org/10.1371/journal.pmed.1000100>
35

36 Mapes, A.R., & Rosén, L. A. (2016). Equine-Assisted Therapy for Children with Autism
37 Spectrum Disorder: A Comprehensive Literature Review. *Review Journal of Autism and*
38 *Developmental Disorders*, 3, 377-386. DOI: 10.1007/s40489-016-0090-0
39
40
41

42 McNicholas, J. & Collis, G.M. (2000). Dogs as catalysts for social interactions: Robustness of the
43 effect. *British Journal of Psychology*. 91: 61–70. DOI: 10.1348/000712600161673
44
45
46

47 Morris, S. B. (2007). Estimating Effect Sizes From Pretest-Posttest-Control Group Designs.
48 *Organizational Research Methods*, 11(2), 364–386. doi:10.1177/1094428106291059
49
50

51 Morris, S. B., & DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with
52 repeated measures and independent-groups designs. *Psychological Methods*, 7, 105–125.
53
54
55

56 Nimer, J. & Lundahl, B. (2007). Animal-Assisted Therapy: A Meta-Analysis. *Anthrozoös*, 20(3),
57 225-238. DOI: 10.2752/089279307X224773
58
59
60
61
62
63
64
65

1 O’Haire, M. E. (2013). Animal-Assisted Intervention for Atism Spectrum Disorder: A Systematic
2 Literature Review. *Journal of Autism and Developmental Disorders*, 43, 1606-1622. DOI:
3
4 10.1007/s10803-012-1707-5
5

6 O’Haire, M. E. (2017). Research on animal-assisted intervention and autism spectrum disorder,
7 2012–2015. *Applied Developmental Science*, 31(3), 200-216, DOI:
8
9 10.1080/10888691.2016.1243988
10

11 O’Haire, M. E., McKenzie, S. J., McCune, S. & Slaughter, V. (2014). Effects of classroom
12 animal-assisted activities on social functioning in children with Autism Spectrum Disorder.
13
14 *Anthrozoös*, 20(3), 162-168. DOI: 10.1089/acm.2013.0165
15
16
17

18 Pan, Z., Granger, D.A., Guérin, N.A., Shoffner, A. & Gabriels, R. L. (2019). Replication Pilot
19 Trial of Therapeutic Horseback Riding and Cortisol Collection With Children on the Autism
20 Spectrum. *Frontiers in Veterinary Science*, 5:312. DOI: 10.3389/fvets.2018.00312
21
22
23

24 Prothmann, A., Ettrich, C., & Prothmann, S. (2009). Preference for, and responsiveness to,
25 people, dogs and objects in children with autism. *Anthrozoös*, 22(2), 161–171.
26
27
28

29 Redefer, L. A., & Goodman, J. F. (1989). Brief report: Pet-facilitated therapy with autistic
30 children. *Journal of Autism and Developmental Disorders*, 19(3), 461–467.
31
32 doi:10.1007/bf02212943
33
34

35 Rosenthal, R. (1993). *Meta-analytic procedures for social research*. Newbury Park: Sage
36 Publications.
37
38
39

40 Schuck, S. E., Emmerson, N. A., Fine, A. H., & Lakes, K. D. (2015). Canine-assisted therapy for
41 children with ADHD: preliminary findings from the positive assertive cooperative kids study.
42
43 *Journal of attention disorders*, 19(2), 125–137. DOI:10.1177/1087054713502080
44
45

46 Shi, L., & Lin, L. (2019). The trim-and-fill method for publication bias: practical guidelines and
47 recommendations based on a large database of meta-analyses. *Medicine*, 98(23), e15987.
48
49 <https://doi.org/10.1097/MD.00000000000015987>
50
51

52 Society for Companion Animal Studies (2013). Animal-Assisted Intervention Terminology.
53 Retrieved on: 10.08.20. Retrieved from: [http://www.scas.org.uk/animal-assisted-](http://www.scas.org.uk/animal-assisted-interventions/174-2/)
54 [interventions/174-2/](http://www.scas.org.uk/animal-assisted-interventions/174-2/)
55
56
57
58
59
60
61
62
63
64
65

1 Souter, M. A. & Miller, M. D. (2007). Do Animal-Assisted Activities Effectively Treat
2 Depression? A Meta-Analysis. *Anthrozoös*, 20(2), 167-180. DOI: 10.2752/175303707X207954
3

4 Souza-Santos, C., dos Santos, J. F., Azevedo-Santos, I. & Teixeira-Machado, L. (2018). Dance
5 and equine-assisted therapy in autism spectrum disorder: Crossover randomized clinical
6 trial. *Clinical Neuropsychiatry: Journal of Treatment Evaluation*, 15(5), 284–290.
7
8
9

10 Stefanini, M.C., Martino, A., Bacci, B. & Tani, F. (2016). The effect of animal-assisted therapy
11 on emotional behavioural symptoms in children and adolescents hospitalized for acute mental
12 disorders. *European Journal of Integrative Medicine*, 8(2), 81-88. DOI:
13 10.1016/j.eujim.2016.03.001
14
15
16
17

18 Sterne, J. A. C., & Egger, M. (2001). Funnel plots for detecting bias in meta-analysis: Guidelines
19 on choice of axis. *Journal of Clinical Epidemiology*, 54(10), 1046–1055
20
21
22

23 Stevenson, K., Jarred, S., Hinchcliffe, V., & Roberts, K. (2015). Can a dog be used as a motivator
24 to develop social interaction and engagement with teachers for students with autism? *Support for
25 Learning*, 30(4), 341–363. DOI: 10.1111/1467-9604.12105.
26
27
28

29 Viechtbauer, W. (2010). Conducting meta-analyses in R with the *metafor* package. *Journal of
30 Statistical Software*, 36(3), 1-48. <http://www.jstatsoft.org/v36/i03/>.
31
32
33

34 Ward, S.C., Whalon, K., Rusnak, K., Wendell, K., & Paschall, N. (2013). The association
35 between therapeutic horseback riding and the social communication and sensory reactions of
36 children with Autism. *Journal of Autism and Developmental Disorders*, 43, 2190-2198.
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

Figure Captions

Fig 1 Flow Diagram of the Study Selection Process

Fig 2 Risk of bias for all individual studies organized by risk of bias criteria

Fig 3 Risk of bias table for each study across all criteria

Fig 4 Meta-analysis of AAI effect sizes for social interaction

Fig 5 Meta-analysis of AAI effect sizes for communication

Fig 6 Meta-analysis of AAI effect sizes for global ASD scores

Fig 7 Funnel plots for Social, Communication and ASD scores (left to right) with pseudo 95% CIs

Fig 8 Meta-regression plots showing the relationship between AAI dosage (mins of animal contact) and standardized mean change effect size

Figure 1 top

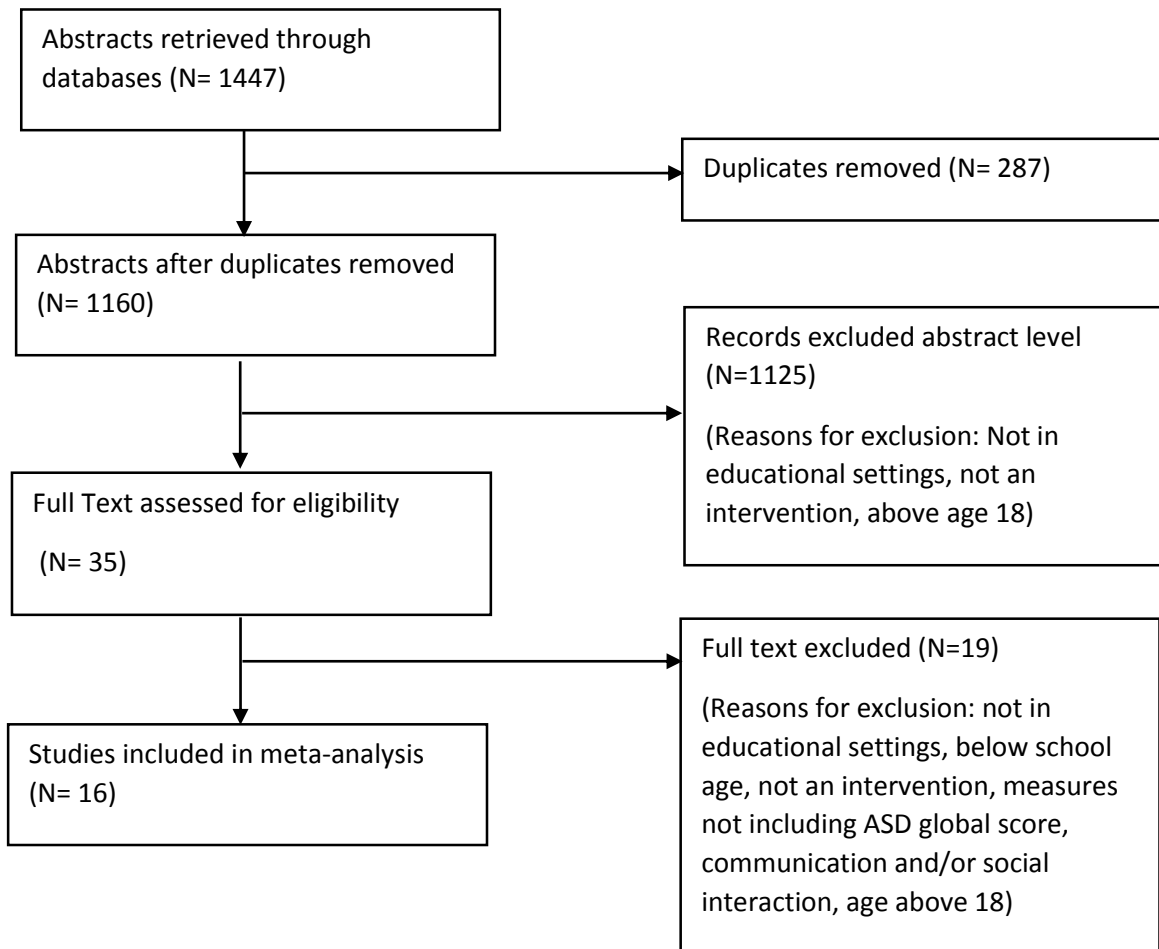


Figure 2 top

Program used to create figure: R, Metafor package

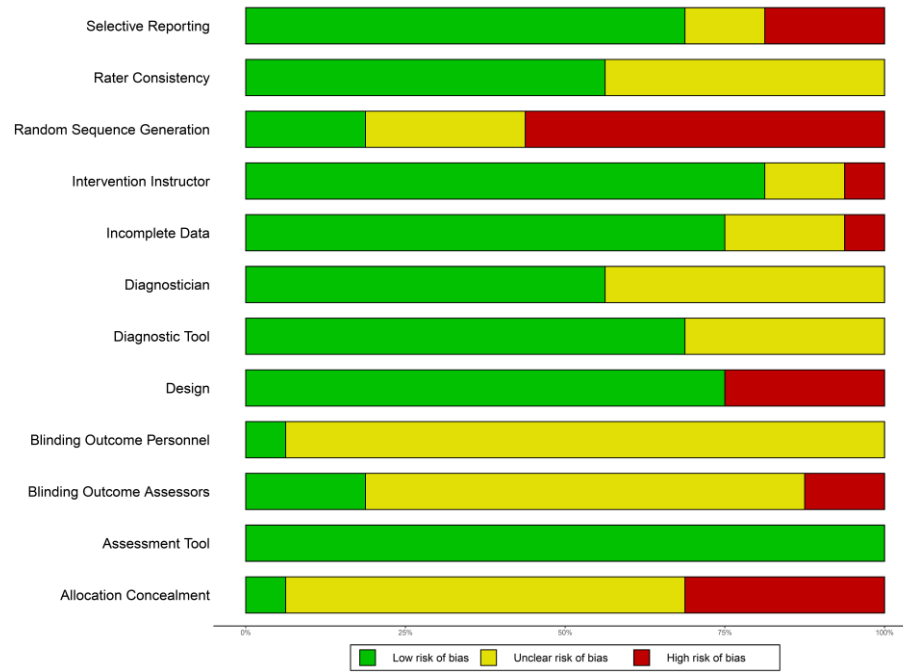


Figure 3 top

Program used to create figure: R, Metafor package

	Ajzenman (2013)	Anderson (2016)	Borgi (2016)	Gabriels (2012)	Gabriels (2015)	García-Gomez (2013)	Harris (2017)	Holm (2014)	Jenkins (2013)	Kern (2011)	Kwon (2019)	Lanning (2014)	O'Haire (2014)	Pan (2019)	Souza-Santos (2018)	Ward (2013)
Selective Reporting	+	+	-	-	+	?	+	+	-	+	+	+	+	+	?	+
Rater Consistency	+	+	+	+	+	+	?	?	?	+	?	?	?	+	+	?
Random Sequence Generation	-	-	-	?	+	-	-	-	?	?	?	-	-	+	+	-
Intervention Instructor	+	+	+	+	+	+	+	+	+	?	+	+	-	+	?	+
Incomplete Data	+	?	+	?	+	-	+	+	+	+	+	+	?	+	+	+
Diagnostician	?	+	+	+	?	?	+	+	+	+	?	+	?	?	+	?
Diagnostic Tool	+	+	+	+	+	?	+	+	?	+	?	?	?	+	+	+
Design	-	-	+	+	+	+	+	-	+	+	+	+	+	+	+	-
Blinding Outcome Personnel	?	?	?	?	?	?	?	?	?	+	?	?	?	?	?	?
Blinding Outcome Assessors	?	+	+	?	-	?	-	?	?	+	?	?	?	?	?	?
Assessment Tool	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Allocation Concealment	-	-	?	?	?	?	?	-	?	-	?	+	?	?	?	-

Figure 4 top

Program used to create figure: R, Metafor package

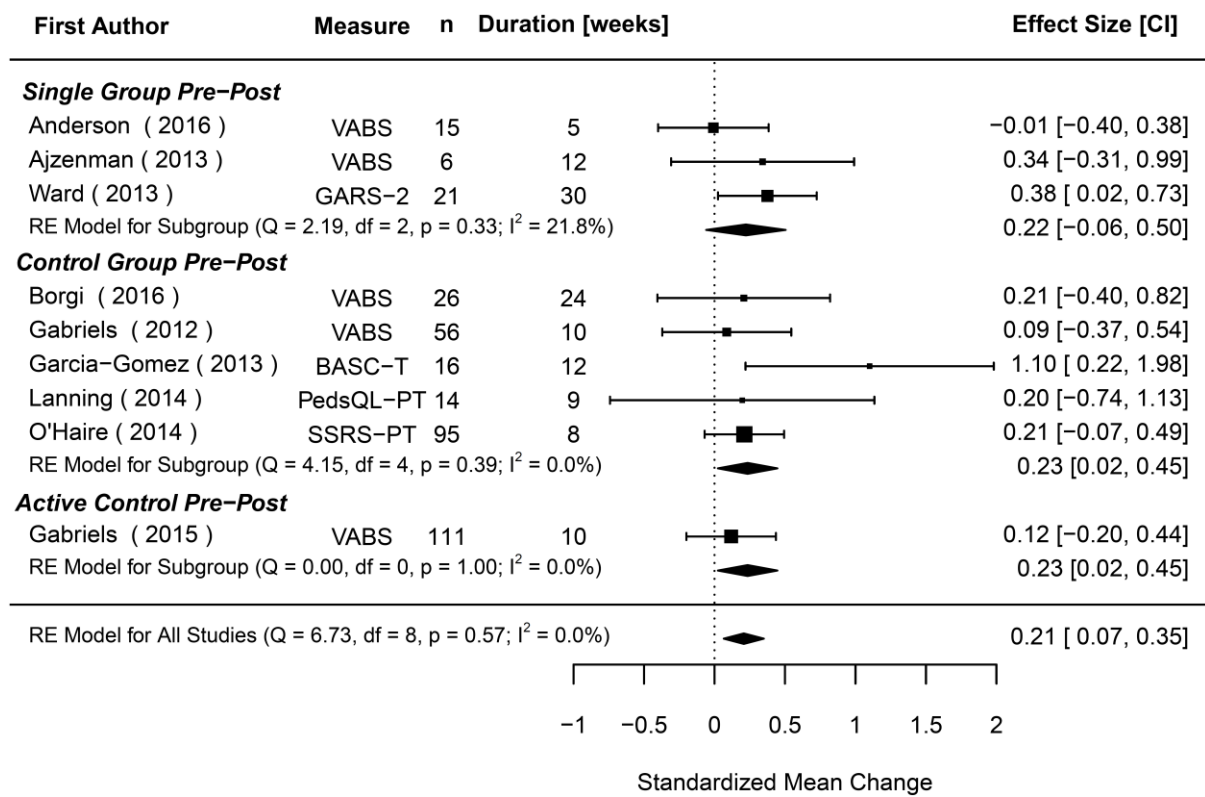


Figure 5 top

Program used to create figure: R, Metafor package

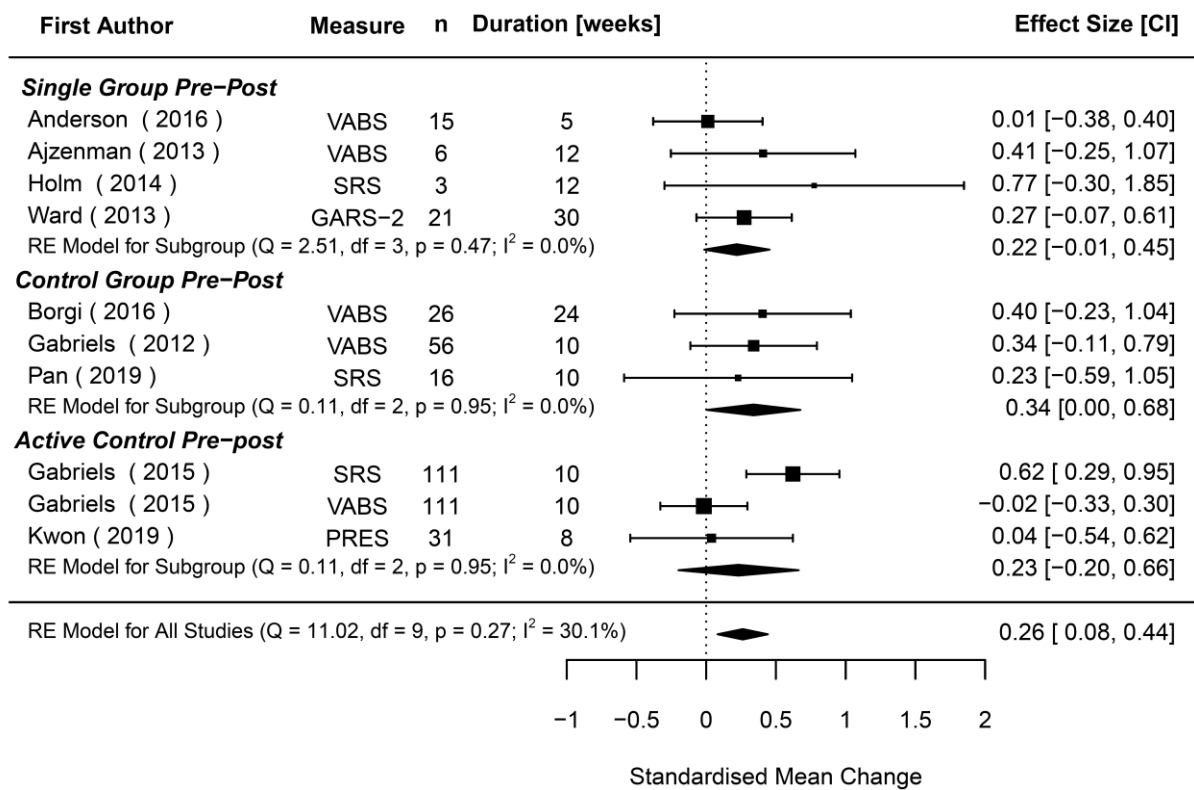


Figure 6 top

Program used to create figure: R, Metafor package

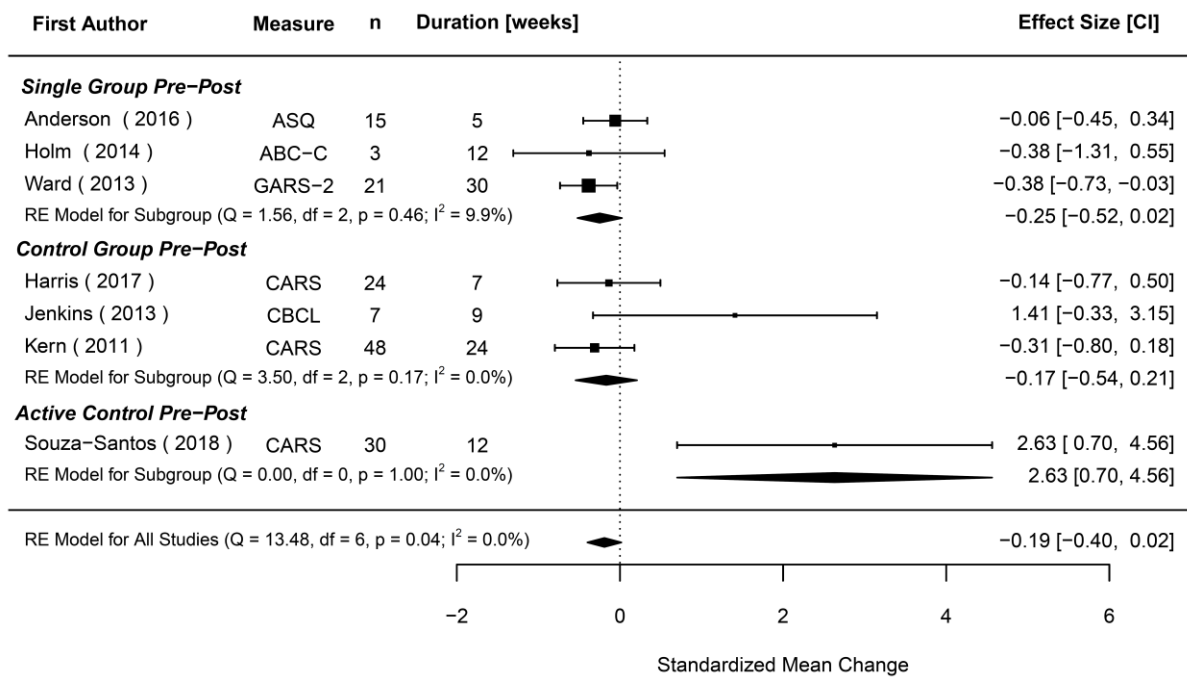
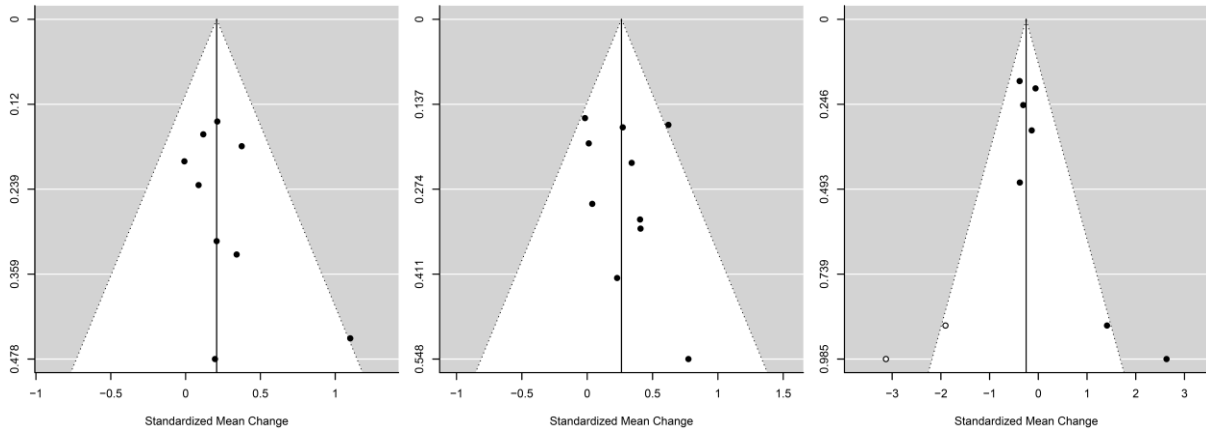


Figure 7 top

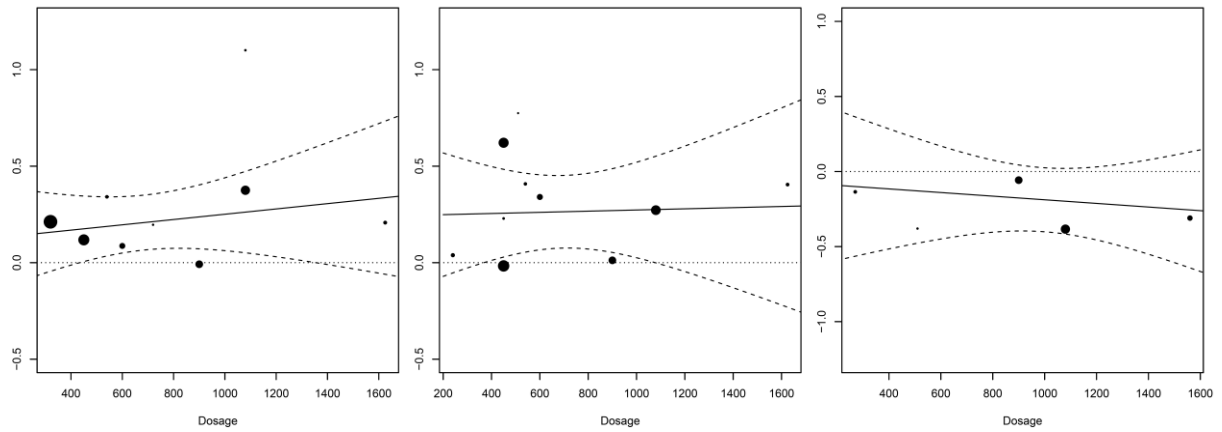
Program used to create figure: R, Metafor package



Note: estimated missing studies are represented with hollow circles

Figure 8 top

Program used to create figure: R, Metafor package



Note: some data points may not be visible in the plots for purposes of ease of visualization, but have been included in all necessary calculations

Tables

Table 1

Characteristics of all studies included in the meta-analysis

Study (First Author, Year)	Participant Information			Tx (n)	Comparison (n) (Control/ Waitlist/ Active)	AAI Tx (duration, frequency)	Measures (social, com., ASD)	Intervention		Comparison		<i>Effect Size</i>
	Diagn osis (N)	Age (yrs)	Sex					Pre: Mean (SD)	Post: Mean (SD)	Pre: Mean (SD)	Post: Mean (SD)	
Ajzenma n 2013	ASD (N= 7)	5-12	M= 4 F= 3	Hippo- therapy (n= 7)	-	1x45 min/wk 12 wks	Social: VABS Com: VABS	61.11 (17.67) 65 (18.54)	68.17 (21.52) 74 (19.52)	- - -	- - -	0.34 0.41
Anderso n 2016	ASD (N=15)	5-16	M= 11 F= 4	THR (n= 15)	-	1x3 hrs/wk 5 wks	Social: VABS Com: VABS ASD: ASQ	45.27 (23.21) 44.2 (31.19) 62.13 (24.2)	45.07 (22.48) 44.6 (30.39) 60.66 (24.19)	- - -	- - -	-0.01 0.01 -0.06
Borgi 2016	ASD (N=28)	6-12	M= 28	EAT (n= 13)	Waitlist (n= 15)	1x60- 70mins/wk 25 wks	Social: VABS Com: VABS	5.2 (2.3) 7.5 (2)	5.9 (2.1) 18.6 (2)	7.1 (2.3) 8.3 (2.4)	7.3 (2.8) 8.6 (2.2)	0.21 0.40
Gabriels 2012	ASD (N=42)	6-16	M= 36 F= 6	THR (n= 42)	Waitlist pre-start (n= 16)	1x1hr/wk 10wks	Social: VABS Com: VABS	104.9 (29.9) 143.6 (24.9)	113.2 (27.4) 149 (24.8)	104.25 (30.08) 147.69 (31.58)	110.13 (33.35) 143.44 (32.85)	0.09 0.34
Gabriels 2015	ASD (N=12 7)	6-16	M= 101 F= 15	THR (n= 63)	Barn Activities (n= 64)	1x45 min/wk 10wks	Social: VABS Com: SRS Com: VABS	95.4 (35.53) -36.8 (10.04) 135.4 (33.75)	107 (37.6) -30.2 (8.75) 140.9 (36.93)	102.9 (28.55) -33.9 (11.38) 133.3 (34.95)	108.8 (30.78) -33.6 (11.38) 139.6 (31.87)	0.12 0.62 -0.02

Garcia-Gomez 2013	ASD (N=32)	7-14	M=13 F=3	THR (n=8)	Control (n=8)	2x45 min/wk 12 wks	Social: BASC-T	6.17 (5.49)	7.5 (9.40)	12 (3.26)	8.75 (3.09)	1.10
Harris 2017	ASD (N=26)	6-9	M=22 F=4	THR (n=10)	Waitlist (n=14)	5-7x45 min each	ASD: CARS	40.95 (6.07)	40.05 (5.57)	42.61 (7.52)	42.61 (7.52)	-0.14
Holm 2014	ASD (N=3)	5-13	M=3	THR (n=3)	-	1,3or5 sessions/ wk 4wks	Com: SRS ASD: ABC-C	-81.67 (1.69)	-79.33 (4.49)	- -	- -	0.77 -0.38
Jenkins 2013	ASD (N=7)	6-14	M=6 F=1	THR (n=4)	Waitlist (n=3)	1x60 min/wk 9 wks	ASD: CBCL	59.88 (3.57)	58.88 (6.47)	62.5 (0.41)	61.33 (6.20)	1.41
Kern 2011	ASD (N=41)	3-12	M=18 F=6	EAA (n=20)	Waitlist pre-start (n=24)	1x60 min/wk 24 wks	ASD: CARS	36.68 (4.73)	34.24 (4.32)	37.74 (5.54)	36.68 (4.73)	-0.31
Kwon 2019	ASD (N=31)	6-13	M=16 F=13	THR (n=18)	Active: Conventional Therapy (n=11)	1x30min/wk 8wks	Com: PRES	15.58 (13.13)	17.17 (14.1)	10.88 (10.44)	11.75 (10.08)	0.04
Lanning 2014	ASD (N=25)	4-15	M=21 F=4	EAA (n=13)	Active: Social Circles (n=12)	1x60 min/wk 12 wks	Social: PedsQL-PT	49.90 (25.54)	71.20 (26.51)	57.82 (20.24)	70.14 (21.07)	0.20
O'Haire 2014	ASD (N=64)	5-12	M=50 F=14	AAI (n=27)	Waitlist (n=37)	2x20 min/wk (16 sessions) 8wks	Social: SSRS-PT	80.3 (35.53)	84.55 (15.7)	79.5 (14.95)	80.3 (15.85)	0.21
Pan 2019	ASD (N=16)	6-16	M=13 F=3	THR (n=8)	Active: Barn Activities	1x45 min/wk 10 wks	Com: SRS	-37.4 (13.41)	-34.57 (3.95)	-30.75 (10)	-31.29 (10.98)	0.23

(n=8)

Souza-Santos 2018	ASD (N=45)	5-12	M= 36 F= 9	EAT (n=15)	Active: Dance (n=15) EAT & Dance (n=15)	2x60min/wk 12 wks for EACH INTERV.	ASD: CARS	36.6 (1.76)	32.7 (1.64)	39.8 (1.7)	31.3 (3.71)	2.63
Ward 2013	ASD (N=21)	8 (mean)	M= 15 F= 6	THR (n=21)	-	1x 1hr/wk 18 wks	Social: GARS-2 Com: GARS-2 ASD: GARS-2	-7.9 (3.59)	-6.5 (4.08)	-	-	0.38
								-9.6 (3.89)	-8.5 (4.19)	-	-	0.27
								90.5 (19.8)	82.6 (27.03)	-	-	-0.38

Author Note

Both authors' (Dr. Mirena Dimolareva and Dr. Thomas J. Dunn) affiliation at the time of completing this paper was Bishop Grosseteste University (Psychology division), Lincoln, Lincolnshire, UK.

Both authors remain at the same institution.

Correspondence concerning this article should be addressed to Dr. Mirena Dimolareva
Psychology Division, Bishop Grosseteste University, Lincoln, LN1 3DY. Tel: 01522 583770
Email – mirena.dimolareva@bishopg.ac.uk



[Click here to access/download](#)

Supplementary Material

[Author contributions AAI and ASD meta analysis.docx](#)

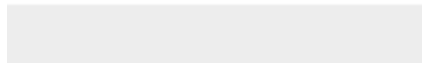


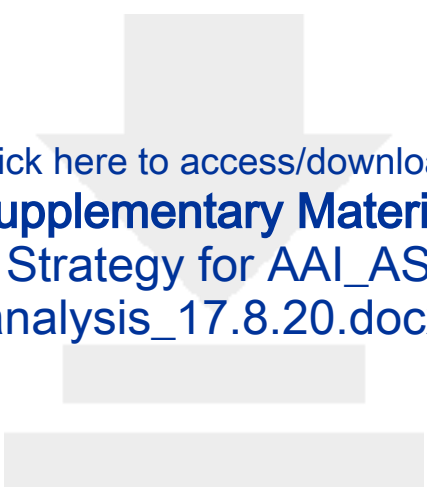


[Click here to access/download](#)

Supplementary Material

List of References Excluded at Full Text_17.8.20.docx





Click here to access/download
Supplementary Material
Search Strategy for AAI_ASD meta
analysis_17.8.20.docx